INSTRUCTIONS
A. M. I. No. 100 A

CAMBRIDGE

Aero Mixture Indicators

TYPES

S-I-A, S-IFR-A, D-I-A, D-I-AL, X-IV-AS, X-IV-AL

INSTRUCTIONS

CAMBRIDGE INSTRUMENT COMPANY
GRAND CENTRAL TERMINAL
NEW YORK, N. Y.

INSTRUCTIONS

for the

INSTALLATION, OPERATION, MAINTENANCE, AND REPAIR

of the

CAMBRIDGE AERO MIXTURE INDICATOR

AIRPLANE	MANUFACTURER'S TYPE	DESCRIPTION
North American Aviation HARVARD TRAINERS	S-IFR-A	Single engine indicator, parts #10292-1 or #10292-2 Duplicating indicator for rear cockpit, parts #10293-1 or #10293-2 One analysis cell, part #8363
Lockheed HUDSON BOMBERS	D-I-A D-I-AL	Dual engine indicator, part #8500-10 Two analysis cells, part #7977, #10555, or #10555-1
Boeing B-17C FLYING FORTRESSES	X-IV-AS	Four engine indicator, part #8833 Four analysis cells with sealed spirals, part #10957
Cessna MODEL T-50 AIRPLANE	D-I-A	Dual engine indicator, part #8500-12 Two analysis cells, part #10555
Short-Stirling MODEL II BOMBERS	X-IV-AL	Four engine indicator, part #12180 Four analysis cells, part #12190
Commonwealth Aircraft WIRRAWAY TRAINERS	S-I-A	Single engine indicator, part #8570-9 One analysis cell, part #8363 or #12223

Please quote serial number of instrument in all correspondence regarding any question of operation, repair, or maintenance.

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INTRODUCTION

The handbook contains descriptive data and instructions for the operation, maintenance, and repair of the Cambridge Aero Mixture Indicator.

GENERAL DESCRIPTION

FUNCTION.

By analysis of the exhaust gas this instrument shows the mixture on an indicator scaled in fuel-air ratio with a range of .11 to .066.

PRINCIPLE OF OPERATION.

Operation of the instrument is based on the well known thermal conductivity principle wherein four platinum spirals forming the four arms of a Wheatstone bridge circuit are employed, two being exposed to the gas under test and two being exposed to a gas of known heat conductive capacity. The known or "standard" gas in this instance is moisture saturated air which is contained in the small chambers where the "comparison" spirals are located. The spirals are heated a definite amount by an electric current and they will remain in balance as long as they are surrounded by gases of similar conductivity and thus are at like temperatures. However, when the "test" spirals are exposed to exhaust gases of different mixtures, their temperature will be changed and the bridge will become unbalanced, resulting in a deflection of the galvanometer pointer to an extent comparable with the variation in the constituents of the gas and in this manner it is possible to determine the mixture ratio directly.

COMPONENT PARTS.

The complete instrument comprises:

1. The required number of analysis cells, one for each engine.
2. One indicator unit containing an independent scale and pointer for each cell, thus affording simultaneous readings for all engines. Type S-IFR-A has, in addition, one duplicating indicator to furnish a duplicate indication for the second cockpit.
3. The necessary accessories for conducting a sample of the exhaust gas from the engine through the cell, including sampling nipples, copper tubing and rubber connectors, and,
4. In the case of single engine instruments, shielded cable to connect the analysis cell to the indicator. No cable is furnished with instruments for multi-engine planes as existing conduits are usually employed.

Complete layouts for the six types are shown in Figures #1 (type S-IFR-A), #1a (type D-I-A and type D-I-AL), #1b (type X-IV-AS), #1c (type X-IV-AL), and #1d (type S-I-A).

INSTALLATION

THE ANALYSIS CELL, the dimension of which are shown on Figure 2 herewith, should be mounted on suitable brackets adjacent to the engine; in a single engine plane on the fire wall or other convenient location (but not within the cabin where a possible gas leak would be dangerous), and in a multi-engine plane at some suitable place in the nacelle. To insure good drainage of condensate from the cell, it should be so positioned that the inlet pipe points directly upward. Care should be taken that no obstructions adjacent to the cell prevent its free movement within the limits of the rubber shock mounts. Suffix L in the type designation indicates the cell is without shock mounts, in which case the cell is mounted rigidly.

GAS SAMPLING SYSTEM. Figures 3, 4, and 5 show preferred gas sampling arrangements respectively, for cases where there is sufficient length of tail pipe to accommodate the sampling nipples, and where these nipples must be placed in a collector ring exhausting underneath and overhead. The nipples are screwed into the threaded flanges which are welded to the tail pipe or ring, the inlet nipple being turned upstream and the outlet nipple downstream, and 3/8" copper tubing is connected to the nipples by flange fittings and to the cell by means of 3" rubber couplings as shown. To prevent transmitted vibrations from the gas line to the cell there should be, in the joints, a space of at least 1" between the end of the tubing and the inlet and outlet pipes of the cell.

Good drainage of condensate from the gas sampling system is essential to a satisfactory flow of gas through the cell, and it is therefore necessary to keep the gas at a temperature above the dew point in any section of the line where the gas flows upward; otherwise the line might become water-locked, thus stopping gas flow. To this end, the upward leg of the line should not be more than 18" in length and well insulated with asbestos loom or tape. On the other hand, to assure the desired water saturated gas sample in the cell, it is necessary to have not less than four feet of bare tubing between the highest point in the line and the inlet of the cell for cooling purposes. This section of the line may take the form of a coil, but there should be no low spots in the coil that would form a water trap. The temperature in the filter chamber of the cell should not exceed 125° F. nor should any portion of the gas sampling system be exposed to freezing temperatures, as ice will form from the condensate and stop the gas flow. In cases of extreme heat the cell may be cooled by a blast tube, and in cases of extreme cold, correction may be made by partially insulating the cell and waste line.

If not possible to return the waste gas from the cell to the tail pipe or collector ring, it may be vented to atmosphere in which case the outlet tip should be cut at an angle to provide suction and should be protected against freezing temperatures.

The best practice is to locate the sampling nipples in the tail pipe, if such is available, where a composite sample from all cylinders at uniform pressure is obtained. If the tail pipe is sufficiently long, the inlet nipple should be placed at least 12" from the outlet of the pipe, for where the nipple is placed near the end of the tail pipe it may receive gas diluted, at low engine speeds, by the outside air. An inlet nipple located in the collector ring should be so placed as to receive a gas sample under positive pressure from the greatest number of cylinders possible, and the outlet nipple where the greatest suction is obtained. Be sure a flow of gas through the cell is obtained adequate to cause quick response of the instrument upon a change in mixture. If in doubt, check the pressure drop across the cell with a differential manometer. A pressure between 1/4" and 4" of water will provide proper flow.

THE INDICATOR UNIT, Figures #6 (type S-IFR-A), #6a (type D-I-A), #6b (X-IV-AS), #6c (X-IV-AL), and #6d (S-I-A), should be mounted on an instrument panel, preferably cushioned against vibration and where it may be easily observed. It should be so placed that its face is vertical and the scale is in normal position for reading.

THE ELECTRICAL CONNECTIONS should be made in accordance with Figure #1 for the appropriate model. Extreme care should be exercised in this, and connections should be thoroughly checked before turning on the current.

After completion of the installation, the mechanical and electrical zeros are to be adjusted according to paragraphs 5, 6, and 7 under Inspection and Maintenance, Routine Servicing.

OPERATION

USE OF INSTRUMENT

After the foregoing instructions have been carried out, the instrument is ready for use and with the engine running will correctly indicate the fuel-air ratio. The instrument will normally show response to a change in mixture in about 5 or 6 seconds, and elapse of this time should be allowed before taking a reading. The current should be left on continuously while the plane is in use.

The instrument may be relied upon for accuracy with mixtures leaned out to a maximum of .068 fuel-air ratio. When leaning out, should the pointer, in approximately this range, reverse and move back towards the "A" point, it is indication that the mixture is lean beyond the range of the instrument, and should be made richer.

A correct fuel-air ratio indication should not be taken as lessening the importance of the head temperature indicator in guarding against overheating the engine. Even though the engine manufacturer's recommendations with respect to mixture ratio are being observed, the head temperatures should receive the usual close attention. Should detonation occur, the pointer of the mixture indicator will move erratically, generally towards the rich end of the scale.

To facilitate adjustment to the correct mixture for different values of horse power developed by the engine, a manifold pressure scale is frequently employed in addition to the fuel-air ratio scale, in which case the two scales are properly correlated in accordance with the recommendations of the engine manufacturer. It should be understood that the mixture indicator does not measure manifold pressure, the scale being used solely for the purpose of reference. In using, the operator observes the existing pressure from the manifold pressure gauge and then adjusts the mixture to cause the pointer of the mixture indicator to move to the corresponding pressure, whereupon the optimum fuel-air ratio is obtained. In other cases segmented scales are employed, wherein segments marked "Take Off", "Cruise Climb", "Cruise Level", etc. are properly placed opposite the fuel-air ratio desired for such operations. Where such correlation data is not available, the instrument is scaled in fuel-air ratio only, and the general instructions on proper mixtures, furnished by the engine manufacturer, should be followed.

When carburetor heat is applied, it becomes necessary to lean out the mixture to restore the former fuel-air ratio. Conversely, when the heat is turned off, it is necessary to enrich the mixture, but be sure to make the mixture richer before the heat is turned off, else the mixture might become too lean.

If the engine is equipped with a carburetor that does not automatically compensate for variations in atmospheric pressure, it is necessary when descending to gradually richen the mixture. When 500 feet above the airport the mixture should be set at full rich regardless of the type of carburetor.

INSPECTION AND MAINTENANCE

ROUTINE SERVICING

It is necessary periodically to perform the service operations enumerated below. While it is suggested that this be done every 100 hours, such routine may be adjusted to the regular inspection periods of the particular operator.

1. The sampling nipples and gas line should be cleaned out and joints tightened where necessary. A drill of the proper size welded to the end of a length of tachometer shaft forms a good clean-out tool, or the gas line may be removed from the plane and the carbon deposit burned out with a blow torch, which will also serve to anneal the line.

2. Renew rubber shock mounts of the analysis cell where necessary.

3. Remove filter wool and wash with gasoline or replace with new wool if necessary. Also clean out filter chamber.

4. Test the indicator unit for pointer stiction by noting the pointer position with the current off. Then turn the current on to cause a movement of the pointer (it may be necessary that there be exhaust gas in the cell to cause this movement), and then off again. The pointer should return to its original position. If it does not and the indicated stiction is greater than .002 fuel-air ratio, the unit should be repaired at the earliest opportunity.

5. Wet the wick in the vapor plug (No. 6, Figures #1, #1a, #1c, and #1d), make sure the breather hole (size #80 drill) in the plug is open, and replace. Note that the analysis cell used on the X-IV-AS assembly does not employ a vapor plug and wick, as the comparison spirals are sealed for best compensation. Disregard maintenance instructions in connection with the vapor plug when applied to this type.

6. Mechanical Zero Adjustment. With the current off, the pointer should stand at "A" on the scale. If it does not, adjust to this position by means of the zero screw on the indicator front.

7. Electrical Zero Adjustment. The position of the pointer on the electrical zero is the same as on the mechanical zero.

To check:

a. First see that the mechanical zero is properly set.

b. Wet the wick in the vapor plug (No. 6, Figures #1, #1a, #1c, and #1d) of the analysis cell. (For type X-IV-AS see paragraph 5 above.)

c. Remove cover and steel wool from filter chamber of the analysis cell, allowing time for any residual gas to be displaced by fresh air. Then place inside this chamber a clean, wetted rag that has been slightly wrung out, and replace the cover.

d. Now, with the current on, allow the instrument to stand thus for about 30 minutes, at the end of which time the pointer should stand at "A" on the scale. If it does not, adjust to this position by means of rheostat (No. 3, Figures #1, #1a, #1b, #1c, and #1d) in the analysis cell. The wetted rag should then be removed from the filter chamber and the steel wool and cover replaced. When replacing the wool, push in sufficiently to clear the opening of the inlet pipe.

ADJUSTMENTS AT MAJOR OVERHAUL PERIODS

1. Check in the following manner the current which is regulated in the indicator unit and supplied to the bridge in the analysis cell. With the units connected, insert in series with the current supply lead to the analysis cell (#4 or "U" or "D") an ammeter of 0.1 ohm or less resistance, capable of measuring 180 milliamperes to an accuracy of plus or minus 0.5%. The battery voltage should be not less than the voltage marked on the indicator name plate, nor should it exceed the marked voltage by more than one volt. The current under these conditions should be 180 milliamperes, but if it is not, bring it to this value by adjusting the slide wire resistor in the indicator unit.

2. As indicated in paragraph 7(d) above, a rheostat in the analysis cell is employed to balance the bridge. As the bridge shifts at times and may reach a degree of unbalance beyond the range of the rheostat, the following treatment should be applied which will restore or partially restore the balance. Disconnect all external wires from the analysis cell and connect two #6 dry cells (3 volts) in series across terminals #1 and #4, or "R" and "U", or "A" and "D", and allow the current to flow through the cell for 15 to 20 seconds. Should the bridge be in balance with the rheostat in approximately the center of its travel, this treatment is unnecessary.

3. Anneal the copper sampling tube.

4. If desired, the calibration of the analysis cell may be checked. This may be done by one of two methods. First, by employing the Cambridge Standard Gas Test Outfit which provides a gas of known composition which, when passed through the cell, will produce a certain reading on the indicator unit. Or, second, by comparing the cell under test with another instrument known to be properly calibrated and in good working order. In this method

the cells are placed in series to receive the same gas sample and checks may be made at any point in the range merely by varying the gas mixture at the source of supply which may be any gasoline engine. Should such tests reveal the calibration to be off, adjustment is made by means of the variable slide wire resistor (not the rheostat) in the analysis cell.

Major repairs should not be attempted unless adequate facilities are available.

TROUBLE SHOOTING

Augmenting the information contained in the preceding sections, the following may be of assistance in the event of trouble.

1. If no response or "kick" of the pointer results upon switching the current on:

   a. There may be an open circuit in the current supply or galvanometer wires.

   b. The ballast tube in the indicator unit may be burned out.

2. If indicator pointer deflects violently to one end or the other end of the scale when the current is switched on:

   a. The wires may be connected up wrong or there may be a ground. Check all connections and if in doubt "ring out" all wires between the units to see if they are rightly connected. Make sure no strands of wire are touching adjoining terminals or are grounded. Test for grounds in the usual manner, disconnecting both battery leads. If a ground is not found in the wiring connecting the units, it may be traced to the individual unit by disconnecting the wires to each unit in turn.

   b. There may be an open circuit in the bridge spirals. To verify that the trouble is in the analysis cell, a spare cell should be installed and the instrument checked.

3. If the instrument does not properly respond to a change in mixture ratio:

   a. The analysis cell may not be getting a sample of the exhaust gas, due to the inlet sampling nipple being improperly placed; water or ice in the sampling system; clogged gas line or filter; back pressure

on the gas outlet from the cell. These points should be checked and corrected where necessary.

b. The galvanometer wires may be reversed where connected at the analysis cell, which would cause the indicator pointer to move in a direction opposite to normal.

c. There may be pivot stiction in the galvanometer or there may be some obstruction preventing free movement of the pointer.

d. The mechanical or electrical zero may be off. Check in accordance with paragraphs 6 and 7, page 5.

DISASSEMBLY, INSPECTION, ASSEMBLY, AND TESTING

All operations given in this section should be performed by a skilled mechanic only, and in a dust and dirt free room.

A. ANALYSIS CELL

Disassembly

1. Remove the cover by the six screws around the periphery.

2. Remove the two nuts and the attached screws and lift the terminal panel out, thus exposing the lugs to which the platinum spirals are soldered.

3. Unsolder all eight of the spiral leads and remove the three screws which hold the brass block to the main plate.

4. Lift the block away from the plate and remove. It may be necessary to insert some sharp instrument, such as a screwdriver, between the block and the plate to break the block loose. Handle the block with care, as sharp jars may damage the spirals.

5. The rheostat may be removed by first loosening the set screw which holds the head on the shaft with a square wrench and then removing the two mounting screws.

Inspection and Testing

1. Check the spiral block for broken wires or open circuit in the spirals by a resistance meter. The spirals should be approximately 5 ohms each.

2. Check the 25 ohm circular rheostat for circuit and resistance.

3. Check the 15 ohm slide wire resistor for circuit. Do not disturb its adjustment except as outlined on page 10, Calibration Check.

4. Check the 100 ohm resistance coil (item #19, Figure 11) for resistance.

5. Check the 87 ohm resistance coil (item #18, Figure 11) for resistance.

6. Check wiring against diagram.

Assembly

Clean and blow out all filter passages with the block removed.

No particular precautions are necessary in the assembly except to take care that a new gasket is used before the spiral block is replaced. Assemble other units in reverse order of the disassembly. Use tool #3 (Figure 8) in setting grommets on the vibration dampers.

Calibration Check

Whenever a meter block has been replaced, the calibration must be checked. For this purpose a secondary standard, consisting of a similar instrument of known accuracy, may be employed, or gas from a tank which has been certified may be passed through the instrument and the calibration effected in this manner. When the latter is used, the procedure is as follows:- Remove the filter wool and air the filter chamber for one-half hour to remove all fumes. Replace the filter wool with a cloth or new filter wool wetted with clean water and leave this in place until the tank tests are completed. Insert resistors as shown in figure 9. These resistances are a substitute for the leads in the actual installation and will not be necessary if the above calibration is carried on with the units mounted in position on the aircraft.

Adjust the mechanical zero of the galvanometer as given under "Inspection and Maintenance, Routine Servicing", paragraph 6, and set the electrical zero as in "Inspection and Maintenance, Routine Servicing", paragraph 7.

A convenient source of gas is from cylinders of certified mixtures of carbon dioxide in nitrogen and hydrogen in nitrogen. A mixture of 12 to 13% carbon dioxide in nitrogen will give a reasonable deflection on the lean side and 4 to 5% hydrogen in nitrogen will give a reasonable rich deflection.

Connect the regulator outlet on the lean mixture tank by means of a short length of metal tubing to the inlet of the instrument using short lengths of rubber tubing for couplings. The outlet of one analysis cell may be connected to the inlet of a second one, etc., if it is desired to check more than one unit at a time. A bubbler should be interposed in order not to waste the tank gas. Two or three bubbles per second will provide a satisfactory sample. A steady deflection will be obtained in 10 to 15 minutes, and if the reading is not the same as the tank certificate, the 15 ohm variable slide wire resistor in the analysis cell is adjusted until the reading is correct.

A second certified sample of hydrogen may then be used to check the deflection of the instrument to the rich side. This is done in like manner to the above and the resistor adjusted to give the least mean error.

If certified tank samples are not available, a bench test equipment as shown in figure 9 can be set up, modified as follows: Select a Cambridge indicator and an unused analysis cell and maintain these as your standard of reference, or use a Cambridge

Laboratory Model Exhaust Gas Tester. Instead of tanks of mixed gases, separate tanks of carbon dioxide and hydrogen may be in turn mixed with compressed air in the inlet sample line to the standard cell and this mixture proportioned to give the deflection desired. The cells, if arranged in series as illustrated, may then all be set to check the reference standard, either with their own individual indicators or against the second movement in a multiple indicator as illustrated.

Alternately, if compressed gas is not available, the gas to be used in the calibration may be obtained from any gasoline engine, the fuel-air ratio being adjusted so that the standard indicator gives a steady deflection, about full scale, either rich or lean. The 15 ohm variable slide wire resistor on the analysis cell being checked is then adjusted so that the indication is the same as that of the standard. The sample gas flow should be kept below a head of 4 inches of water to prevent velocity errors.

B. INDICATOR UNIT.

Disassembly

1. Remove the fastenings holding rear panel to back of case. Remove case.

2. Unsolder all lamp wires in cases where an indicator lamp is employed.

3. Remove the four screws which support the movement assembly and carefully withdraw movement.

4. Unsolder the leads from the galvanometers to the electrical connector socket and coils.

5. Remove the two retaining nuts and carefully raise the complete moving system from the magnet. Do not lay the system down, but place it on tool #4, Figure 8.

6. Unsolder the upper control spring from the lug on the torsion head, using a very small soldering iron and being careful that the iron does not come in contact with any other part.

7. Remove the two screws holding the torsion head in position on the bakelite molding and remove.

8. Unsolder the lower control spring from the soldering lug.

9. Remove the control springs by unsoldering at the copper tangs on the moving coil. This step is not necessary if replacement of pivots and jewels is required.

10. Remove the pivots by using tool #1 (Figure 8) warmed,

to unscrew them. Care should be exercised in this operation so that the coil is not distorted by too much pressure from the hands, etc.

11. Remove the coil and pointer assembly from the core.

12. The pointer may now be removed by warming the joint slightly with an iron and pulling off.

13. Balance weights may be removed by grasping with warm tweezers and sliding full off.

14. Jewels may be removed from the iron core by loosening the clamp screw and pressing them out. The clamp screw projects from the front of the iron core.

Inspection and Testing.

The following tests should be performed before disassembly and after assembly.

1. Check for pivot stiction (friction to free swinging of the coil) as follows:- If the indicator is mounted in the plane and fully connected, turn supply current on and see that the indicator deflects from the former reading. Disconnect supply current again and note reading of indicator. It should read the same as originally if pivot stiction is not present. If the reading differs from the original by more than 1/2 division of the scale, the stiction is excessive. If the indicator is to be tested for stiction while removed from the plane proceed as above, except that a deflecting current must be furnished the galvanometer. This may be supplied from a dry cell in series with 1000 ohms fixed and 100,000 ohms variable resistors or from any suitable current supply of about 0.5 milliampere.

2. Check for mechanical balance. This must be done with the indicator removed from the plane. Note first the position of the pointer on the scale. Tip the indicator directly backward through 90 degrees or until the window is uppermost and note the pointer position again. A change in pointer position of 0.002 fuel-air ratio (1 scale division) is considered allowable. Return the indicator to its normal position and then rotate through 90 degrees. A change in pointer position of 0.002 fuel-air ratio is again allowable. If more than 1 division is obtained in either of the above tests, the movement must be rebalanced. Proceed as described under "Assembly", paragraph 12.

3. Check for pointer freedom. Connect a dry cell in series with a 1000 ohm fixed and a 100,000 ohm variable resistor and connect to one set of galvanometer leads at a time (an extra electrical connector plug will facilitate making these connections). Refer to the respective wiring diagrams for the individual galvanometer terminal posts and their polarity. Increase

the current slowly and note if the pointer sticks at any point along the scale. Reverse the connections and repeat on the other side of the scale. If the freedom is restricted, the obstruction must be removed. Look for fine hairs or minute bits of foreign material.

After disassembly, perform the following tests and inspection:-

1. Inspect the jewels under a high powered magnifying glass or microscope for cracks, pits, or worn spots. If found faulty, replace with new jewels.

2. Examine the pivots under a microscope and, if the points are worn off or broken, replace with new ones.

3. Check the moving coil for circuit by connecting a resistance meter across the two copper tangs where the hair springs are soldered.

4. Check the ballast tube for circuit with resistance meter. This may be done without disassembly of the main case by unscrewing the cover cap and then unscrewing ballast tube. To facilitate removal of the ballast tube, relieve pressure of the coil spring around the lamp base with the thumb nail before attempting to unscrew the tube. This coil spring locks the tube in place.

5. Check the wiring of the unit by referring to diagram.

6. Check series and shunt coils for circuit.

7. Check variable slide wire resistor.

8. Check lamp resistor (opposite slide wire resistor).

Assembly

1. Press jewel case into the center of the iron core and tighten the clamp screw. Thoroughly clean the jewels with a pointed piece of wood such as a toothpick.

2. Mount pointer on moving coil warming the joint with an iron to soften the shellac. Hold the iron on the joint until all the solvent has been boiled off.

3. Balance weights should next be mounted by grasping with a pair of warm tweezers and sliding on the cross arm above the coil.

4. Holding moving coil in the hand, start the pivots into their positions, stopping before the pivot points extend beyond the coil inside. Warm tool #1 and use for screwing in the pivot. The coil should now be placed over the core and a

bit of lintless paper wedged between the coil and the core to restrain its motion. Now very carefully screw in one pivot at a time until, with the paper wedge removed, the coil swings freely, and the coil is centered about the core. Great care must be taken in this operation as the pivot points may be damaged and stiction may result.

5. Replace the paper wedge and solder control springs to copper tangs of the coil. Hold the outer end of the spring with a pair of tweezers and swing the coil. The turns of the spring should remain concentric about the pivot center. If they move off concentricity, the center turn should be adjusted by bending, or, if necessary, resoldering until concentricity is maintained. This adjustment should be carefully made as sensitivity will be impaired if badly operating control springs are used.

6. Solder outside turn of lower control spring to soldering lug. Bend the outer turn of the spring until it lays naturally against the lug and then solder. Do not attempt to solder the turn to the lug and adjust it by bending later. If the correct procedure is followed, very slight bending operations should bring the spring into proper shape. Remove the paper wedge and swing the moving coil. The control spring turns should remain concentric about the pivot center at all times.

7. Mount torsion head to bakelite molding and solder outside of upper control spring to lug on torsion head similarly to the manner in which the lower spring was connected.

8. If the magnet has been removed, it must next be properly positioned. Tighten down clamp screws until they hold the magnet, then back off the screws until the magnet may be moved freely. Mount the jig #2 (Figure 8) in place of the moving system and tighten down the magnet screws. Remove the jig. The north (red) pole of the magnet is positioned back of the rich end of the S-IFR-A indicator and back of the lean end of the D-I-A, X-IV-AS, X-IV-AL, and S-I-A indicators.

9. Carefully mount the moving system upon the two brass studs, being very careful that the coil is not struck against anything in so doing. Tighten nuts, holding in position. The coil should swing freely in the gap.

10. Solder the galvanometer leads to the coils and indicator terminals as indicated on wiring diagrams.

11. The pivots should now be adjusted so that a barely perceptible amount of shake at the pointer is present. Too much shake will cause fouling of the coil and too little will result in severe stiction.

12. Check the balance as described on page 12 under Inspection and Testing of Indicator Unit, paragraph 2. If, when tipped directly backward, the pointer moves to the right, the left balance weight must be moved away from the pivot center. Wedge

the coil with paper, as explained previously and grasp the weight with warm tweezers and pull out very gently, else the pivots will be damaged. If the pointer moves left on this test, the right balance weight must be moved out.

On the second test, where the indicator is rotated through 90 degrees, if the pointer moves up, the balance weight opposite the pointer must be moved in, and if the pointer is heavy (moves down), the balance weight must be moved out.

13. To replace the lamp socket in the molded bakelite front, proceed as follows:- Place a warm iron on the socket front and remove the old socket. The socket is cemented in with flexible shellac which will soften at a moderately high temperature. Feed the wires from the new socket through the molding and warm the socket with an iron, being careful not to melt the soldered joints. "Tin" the socket with flexible shellac and press into position in the instrument front. Allow to cool without moving.

14. Carefully replace the molded bakelite front, making certain that the zero adjusting fork on the moving system properly meshes with its mating part. Exercise care to see that the pointers are not struck in this operation. Replace the four screws holding the movement assembly in place.

15. Resolder the lamp wires to the terminals in accordance with respective wiring diagrams.

16. Replace the metal shield housing, tightening the fastenings.

17. Check the indicator for pointer freedom as explained in Inspection and Testing of Indicator Unit, paragraph 3, page 12.

18. After making any repairs to the moving system, the sensitivity must be checked, and proper consideration must be given to the galvanometer circuit resistance. The net resistance of any indicator including installation wiring, connected to the analysis cell, must be 4.8 ohms at the analysis cell terminals. Thus, in the case of the master and duplicating indicators, this refers to the parallel resistance of the units, and in the case of the D-I and the X-IV types, refers to the individual galvanometer and its pair of wires up to the analysis cell terminals. For resistance and current sensitivities of each of the various types see the tabulation on Figure 10. One of the following methods of checking indicator sensitivity may be employed, depending upon the equipment available.

a. The Ammeter Method: - An external circuit, consisting of a #6 dry cell connected in series with a fixed resistor (R1, Figure 10), a 1000 ohm variable resistor and a sensitive milliammeter (one that will read 0.475 milliampere) is connected across the galvanometer terminals. See figure 10 and appropriate

wiring diagrams. Adjust the current to value designated in table on Figure 10 by means of the 1000 ohm variable resistor and note the pointer position on the scale. If the galvanometer deflects beyond .09, the sensitivity must be decreased. The galvanometer shunt must be adjusted until the galvanometer reads correctly. A convenient method of determining the proper value is to insert a variable resistance box instead of the shunt and after a value of the resistance has been obtained, adjust the nickel shunt coil to this determined value.

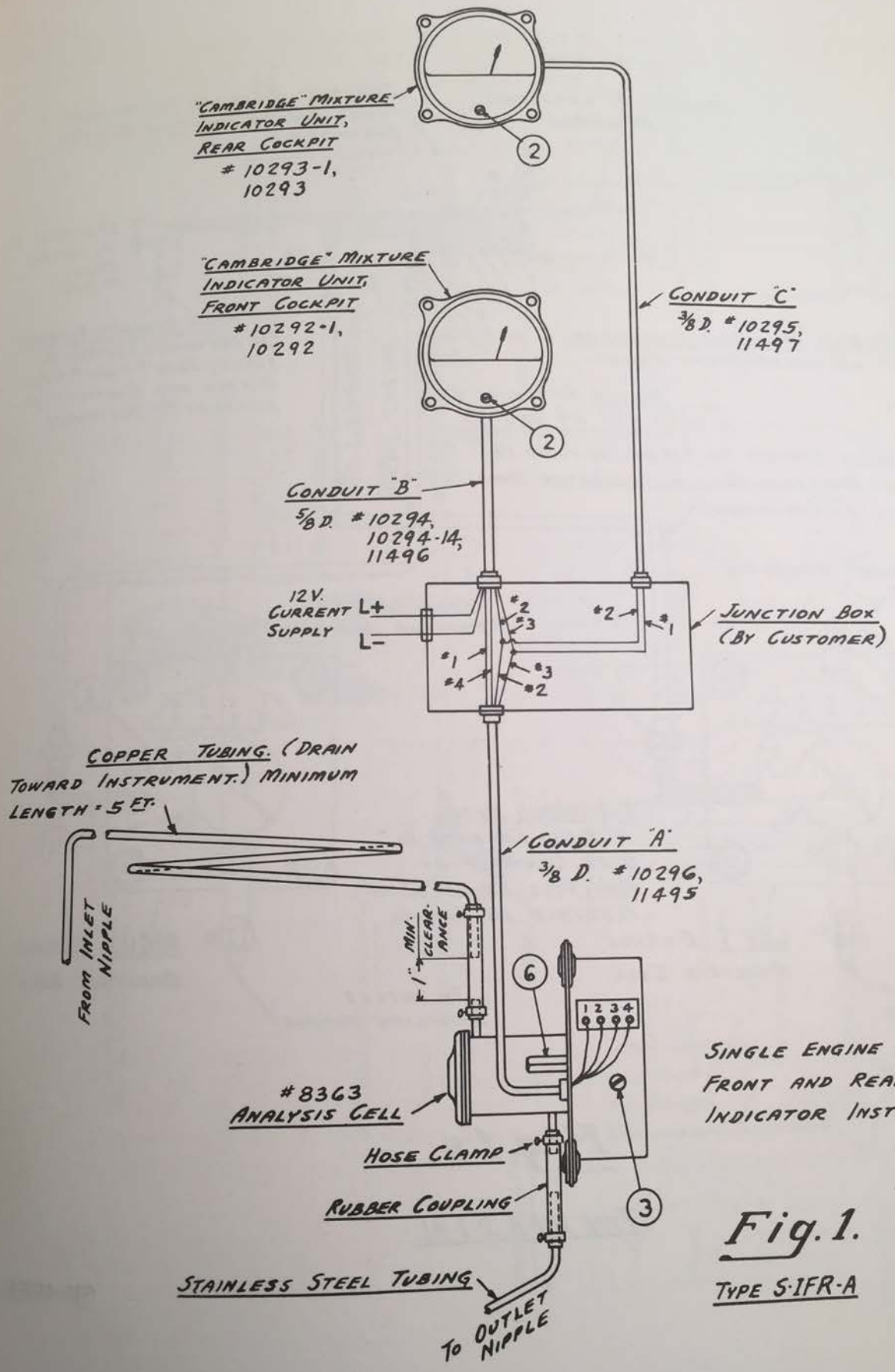
The indicator metal shield cover must be in place when determining this resistance and when checking. Confirm this value after assembly and closing of the instrument. When this adjustment has been correctly made, the external circuit should be removed and the internal series resistor adjusted until the resistance has the value tabulated for specific type on Figure 10.

Each of the galvanometers should be similarly adjusted.

b. The Potentiometer Method:- The required circuit in this method is also shown on Figure 10. 90 millivolts are supplied to one galvanometer terminal and one side of R2. Adjust the shunt coil until the pointer deflects from "A" to .090. A resistance box in place of the shunt may be employed here similarly to the previous method. Be sure the metal shield case is in position in making these tests. After having made this adjustment, disconnect the external circuit and adjust the galvanometer resistance at the indicator terminals by the internal series resistor to the value as tabulated for specific type on Figure 10.

19. After renewing the ballast lamp, the bridge current must be checked. This may be done on the completed installation in the plane. Insert an ammeter (0.1 ohm or less in resistance), which will measure 180 milliamperes to an accuracy of plus or minus 1/2%, in series with lead #4, "U", or "D" on an analysis cell (refer to appropriate wiring diagram) and turn on the current voltage supply. The battery voltage for a 12 volt installation should be 13 volts (for a 24 volt installation, the battery voltage should be 26 volts) and the current 180 milliamperes. If the current is not correct, it should be brought to the correct value by adjusting the variable slide wire resistor in the indicator unit.

When it is desired to check the ballast tube on the service bench, connect the complete system as described in "Calibration Check", page 10, and connect a 13 volt supply to the battery terminals for a 12 volt installation (connect a 26 volt supply for a 24 volt installation). Set the current to 180 milliamperes as above.



SINGLE ENGINE AERO MIXTURE, FRONT AND REAR COCKPIT INDICATOR INSTALLATION.

Fig. 1.

TYPE S-IFR-A

SK-4632

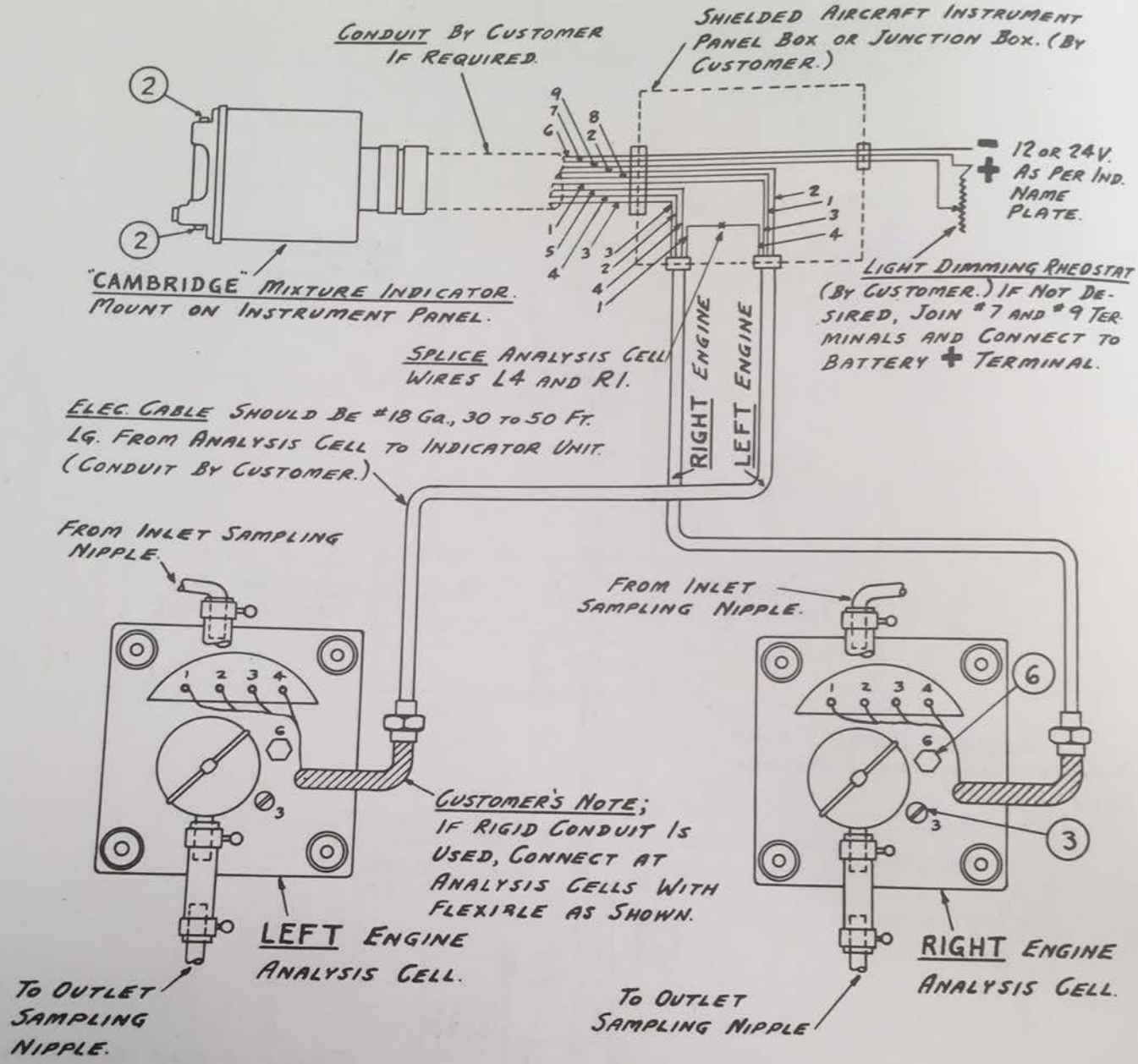


Fig. 1a.

TYPE D·I·A, D·I·AL

SK-4555

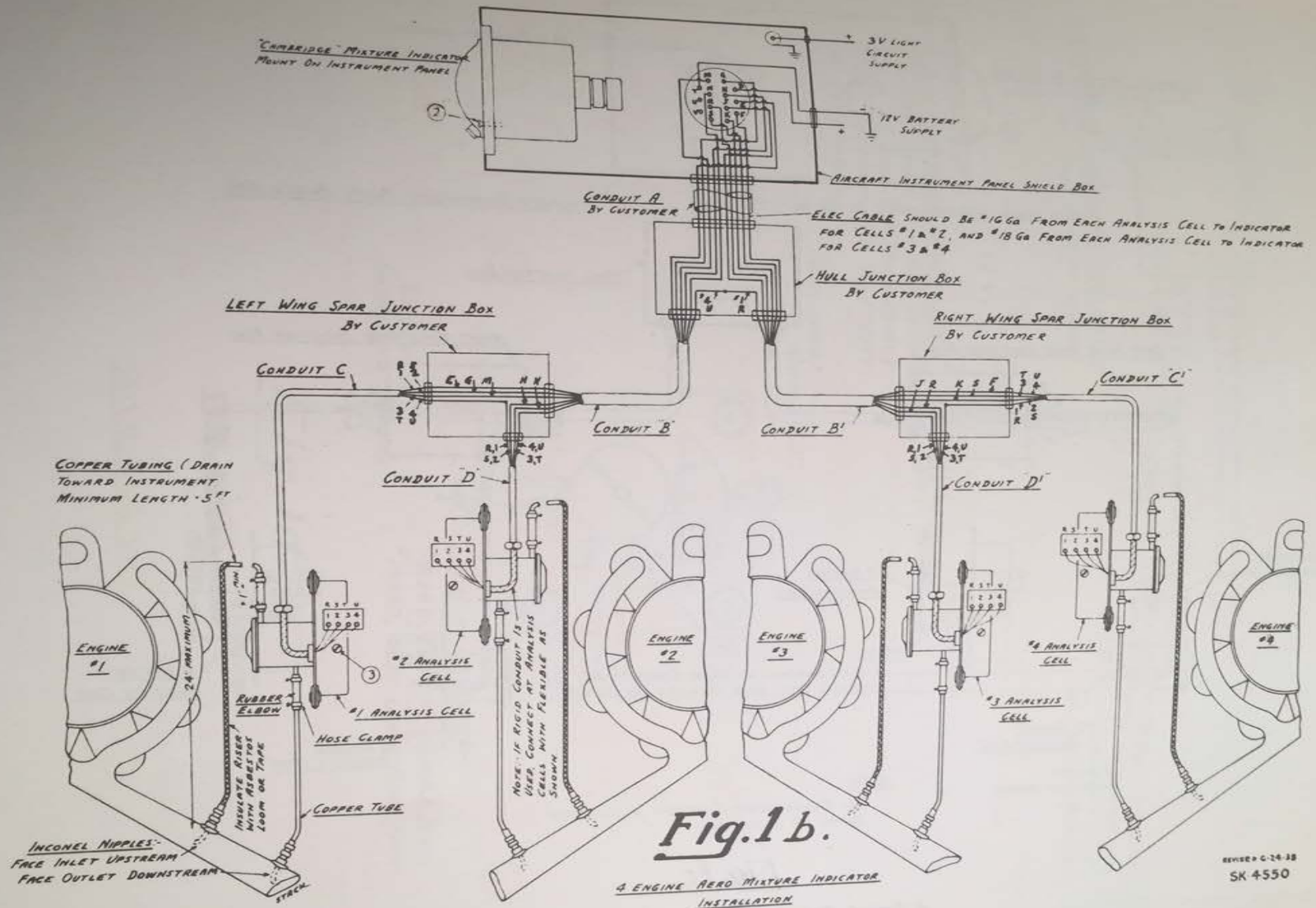


Fig. 1b.

4 ENGINE AERO MIXTURE INDICATOR INSTALLATION

TYPE X-IV-AS

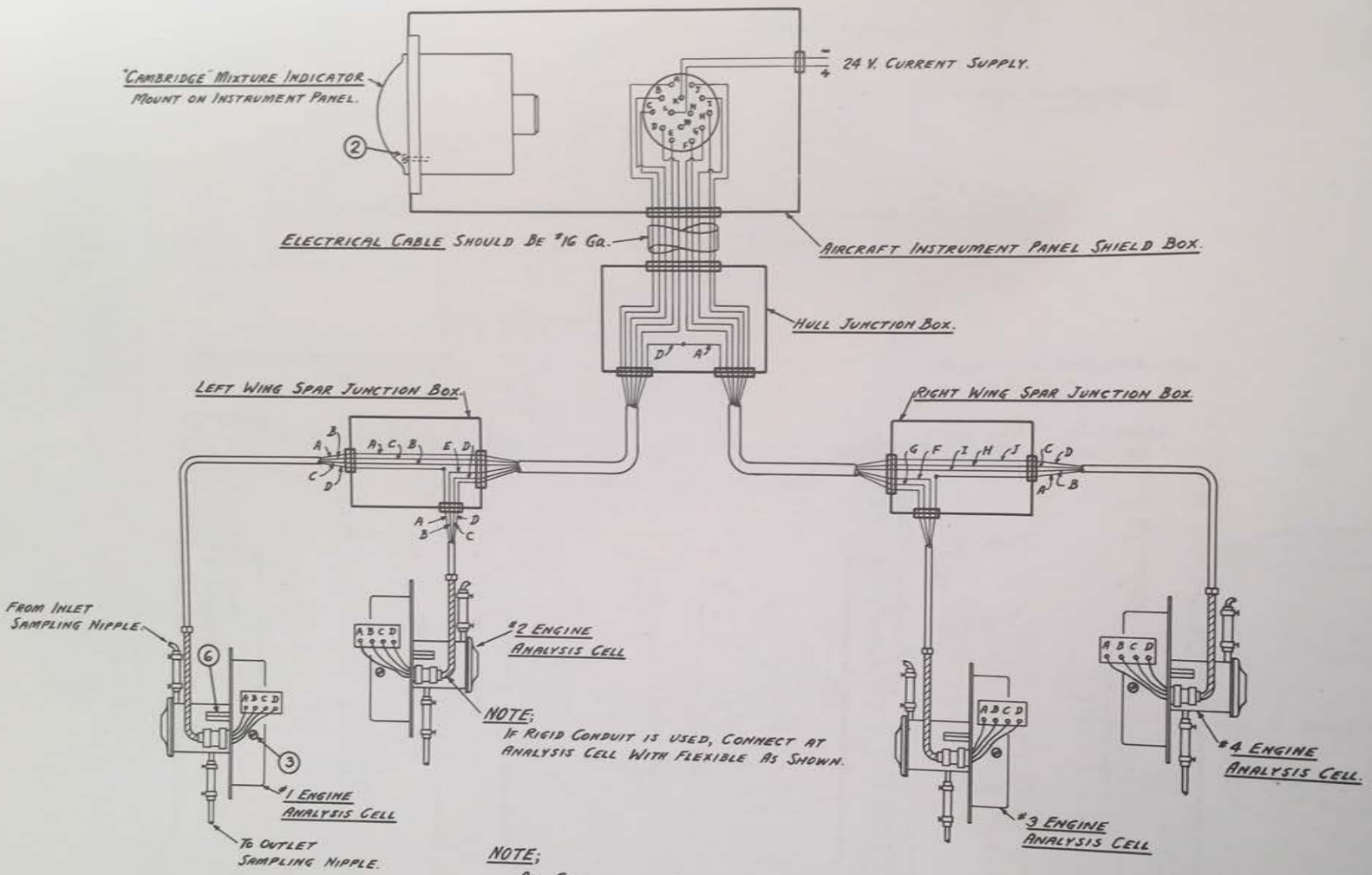


Fig. 1c.

CAMBRIDGE INSTRUMENT CO, INC.
NEW YORK, N.Y.

4 ENGINE AERO MIXTURE INDICATOR INSTALLATION.
TYPE X-IV-AL

SK-6233

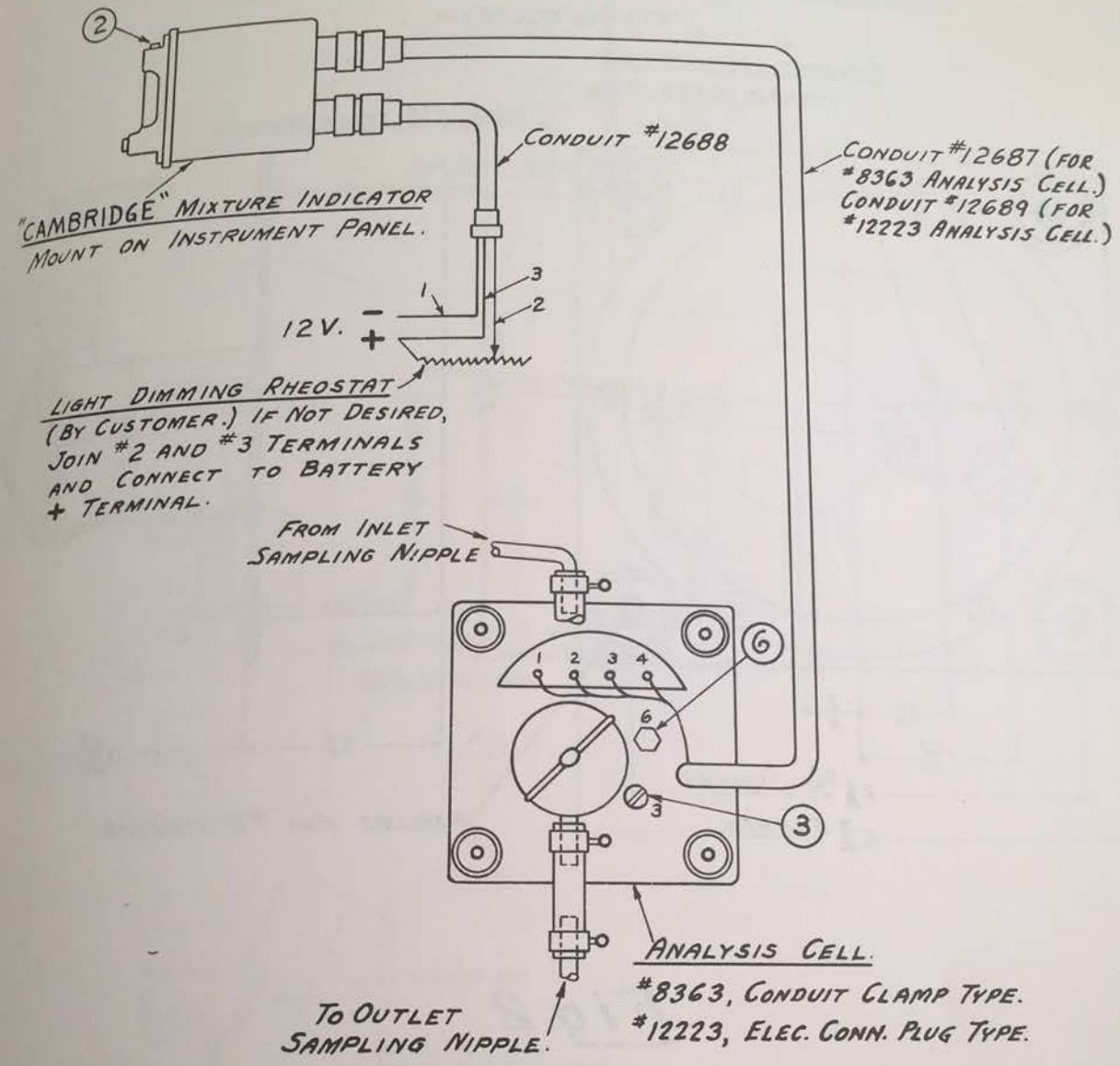


Fig. 1d.

TYPE S-1-A

SK-4556

CAMBRIDGE AERO MIXTURE INDICATOR ANALYSIS CELL
TYPES "A" & "AT" & "AS" & "AL"

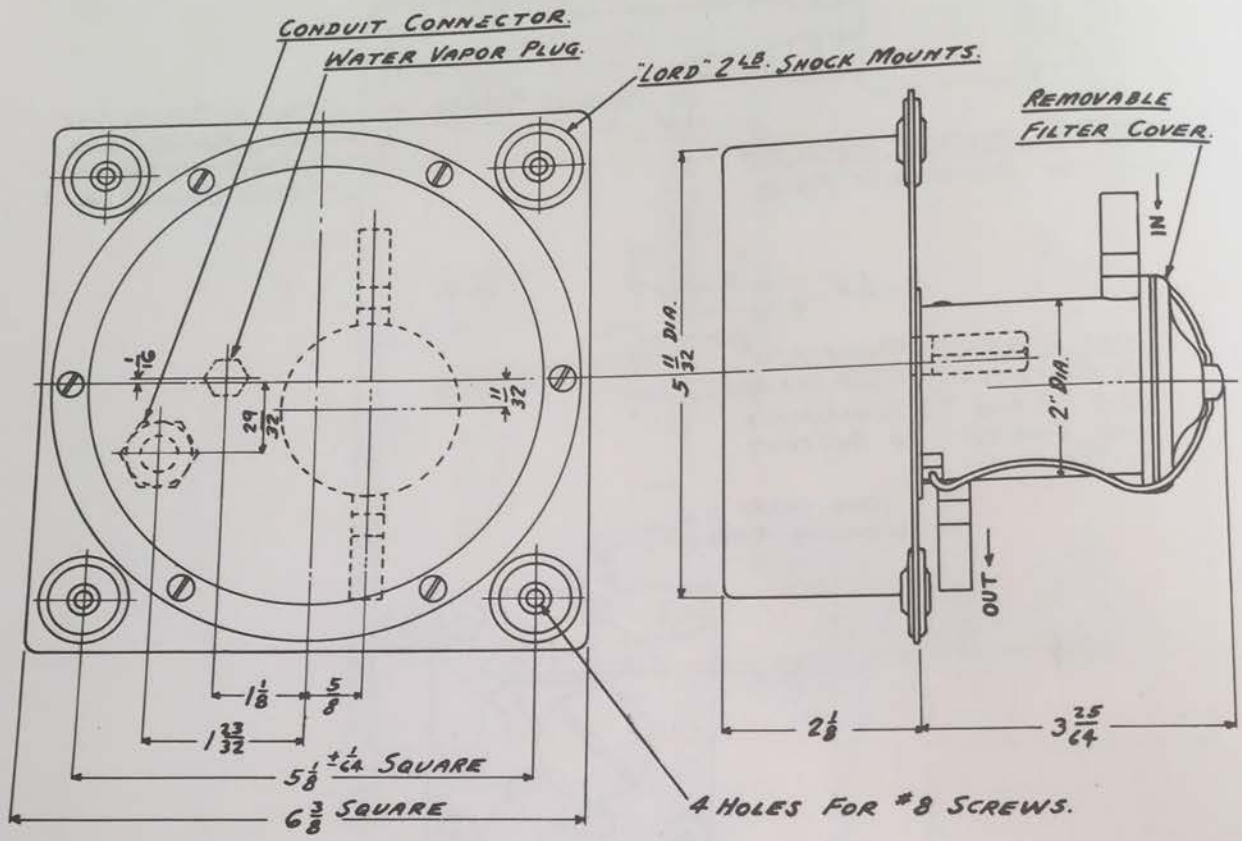


Fig. 2.

WEIGHT = 2 LB. 12 OZ.

FRACTIONAL DIMENSIONS APPROXIMATE UNLESS OTHERWISE NOTED.

SK-4559

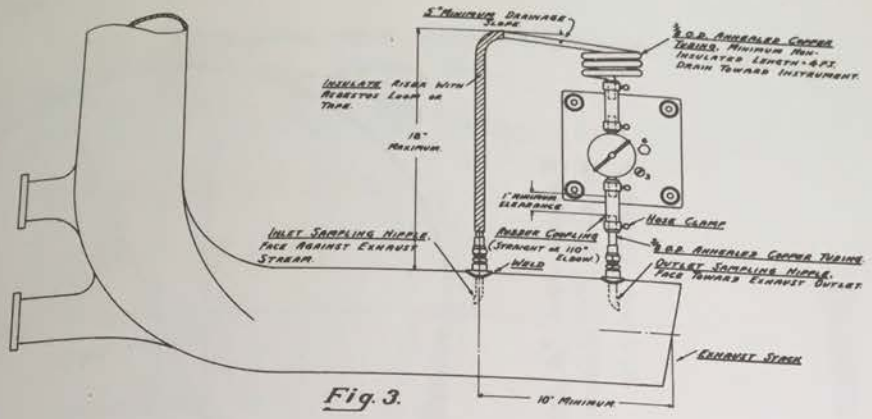


Fig. 3.

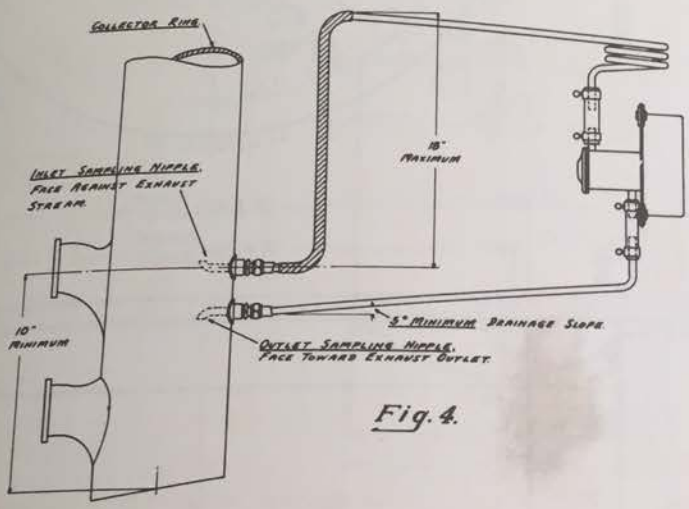


Fig. 4.

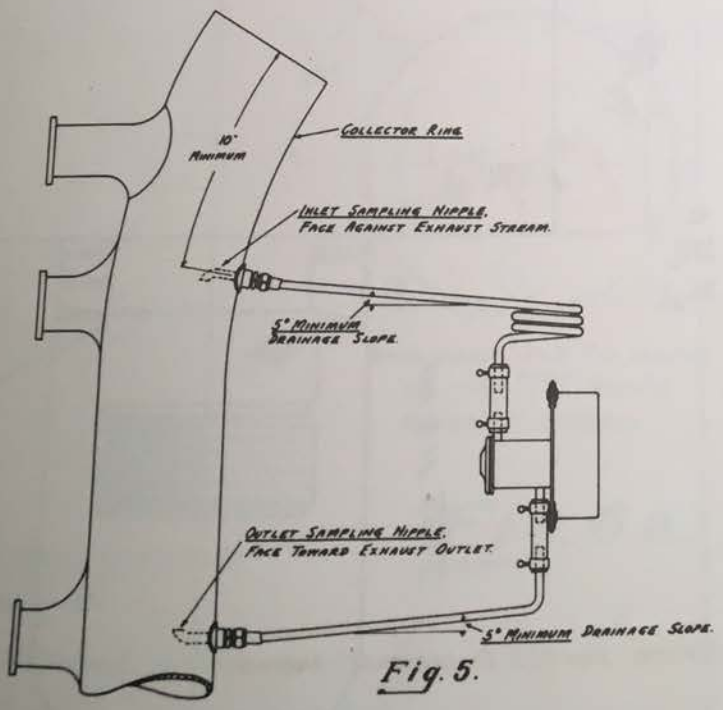


Fig. 5.

SK-4551

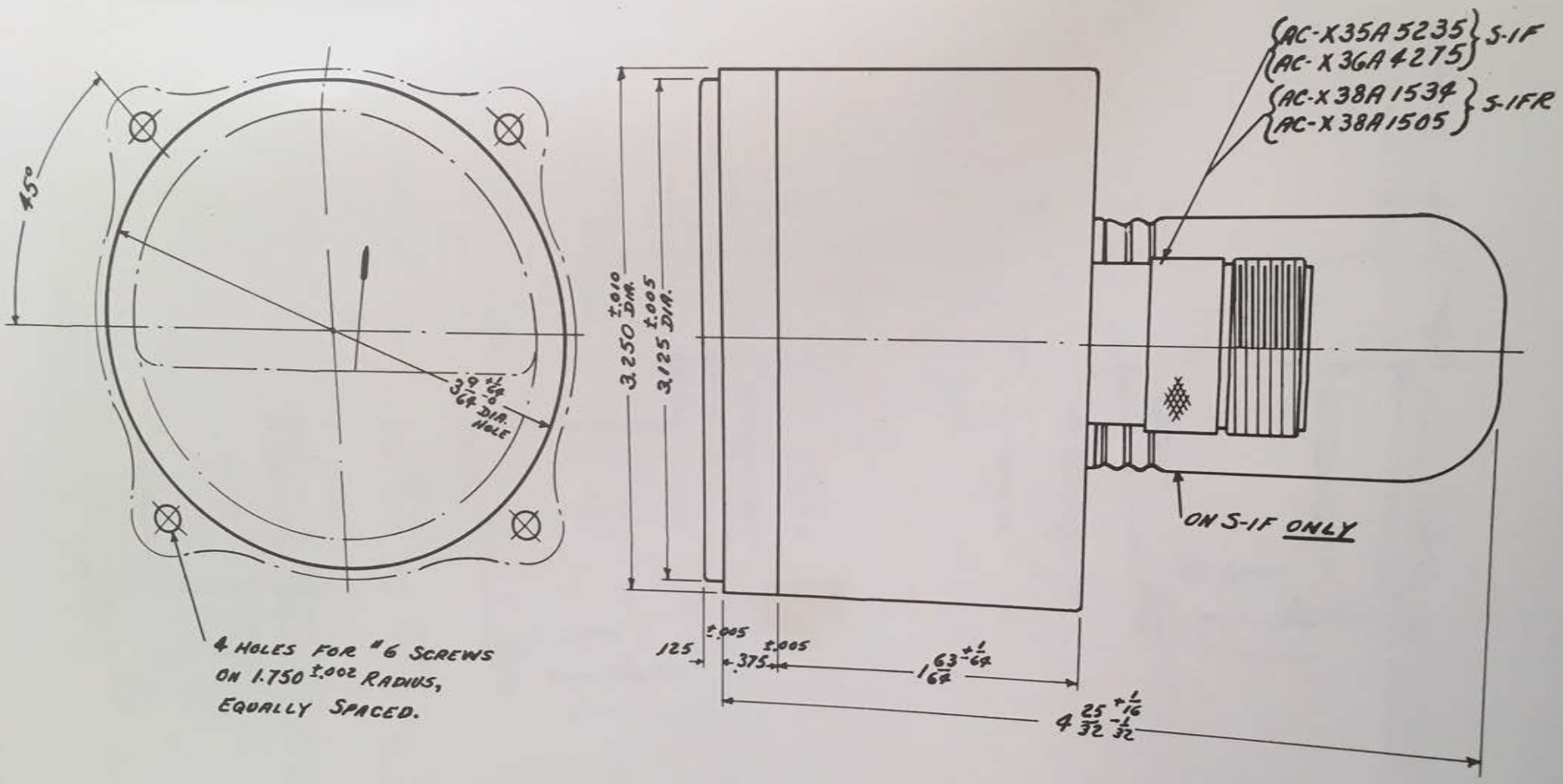


Fig. 6.

"CAMBRIDGE" MIXTURE INDICATOR UNIT, TYPE S-1F, 10292-1, 10292-2, WEIGHT - 1 LB. 7½ OZ.

"CAMBRIDGE" DUPLICATING MIXTURE INDICATOR UNIT, TYPE S-1FR, 10293-1, 10293-2, WEIGHT - 1 LB. 4 OZ.

CAMBRIDGE AERO MIXTURE INDICATOR
TYPE D-1

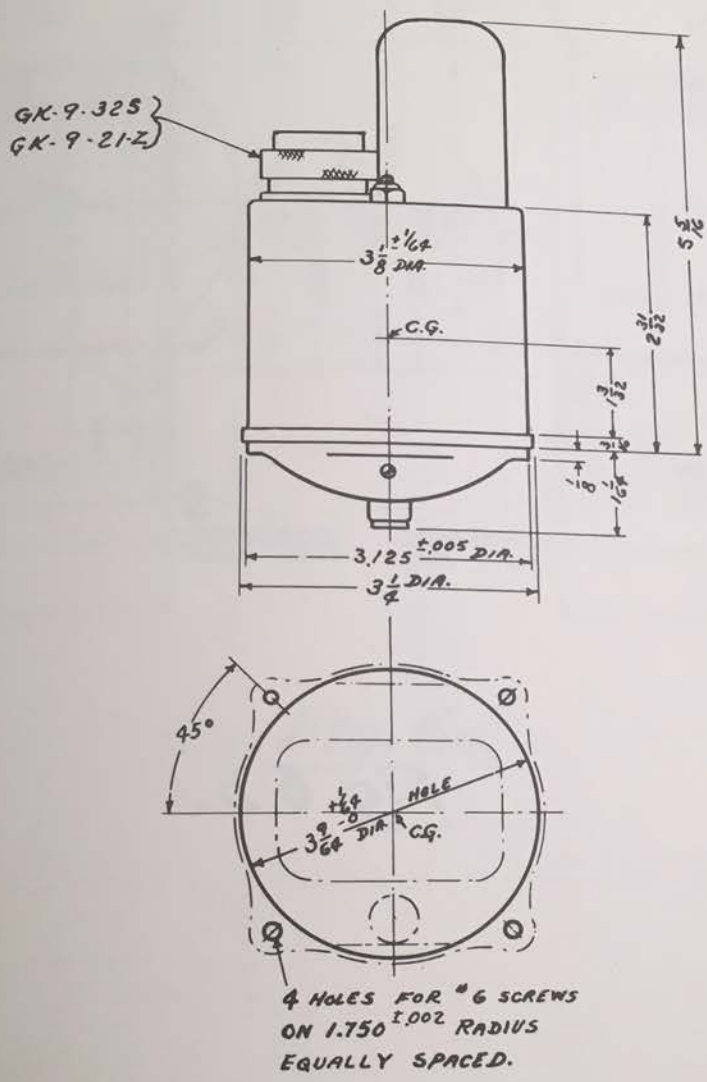


Fig. 6a.

CENTER OF GRAVITY = C.G.

WEIGHT = 2 LB. 2 OZ.

FRACTIONAL DIMENSIONS APPROXIMATE UNLESS OTHERWISE NOTED

SK-4678

CAMBRIDGE AERO MIXTURE INDICATOR

TYPE X-IV

B/M 8833
B/m 8833-1

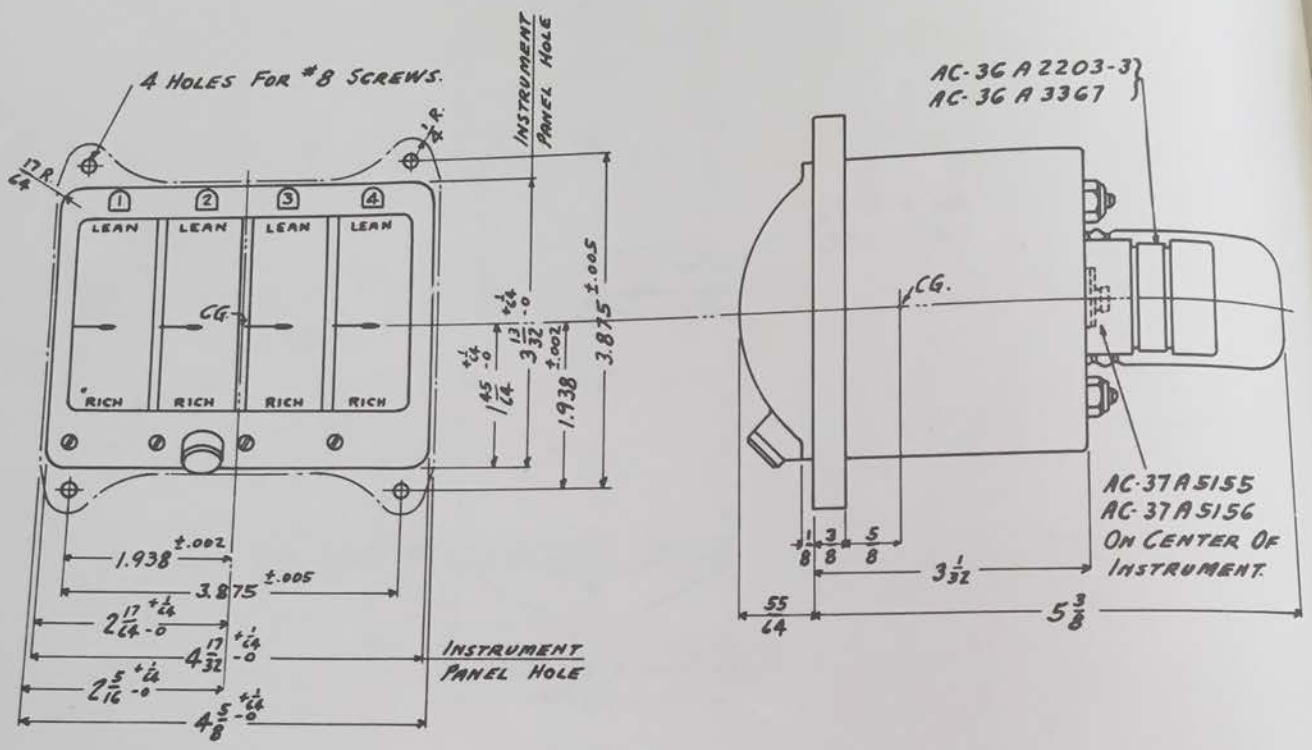


Fig. 6 b.

CENTER OF GRAVITY = CG.

WEIGHT = 3 LB. 12 OZ.

SK-4285

FRACTIONAL DIMENSIONS APPROXIMATE UNLESS OTHERWISE NOTED.

CAMBRIDGE AERO MIXTURE INDICATOR

TYPE X-IV

B/M 12180

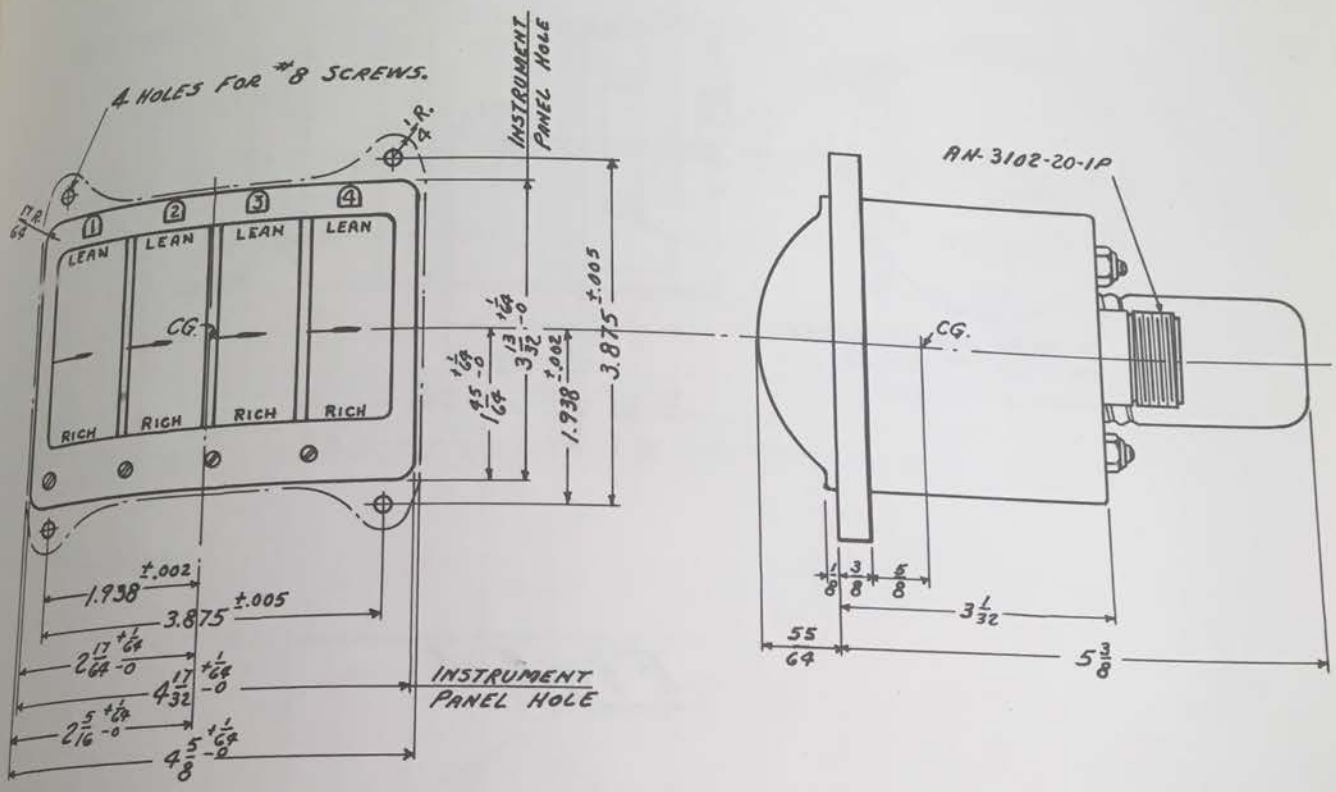


Fig. 6c.

CENTER OF GRAVITY = CG.

WEIGHT = 3 LB. 12 OZ.

FRACTIONAL DIMENSIONS APPROXIMATE UNLESS OTHERWISE NOTED.

SK-6232

CAMBRIDGE AERO MIXTURE INDICATOR.
TYPE S-I

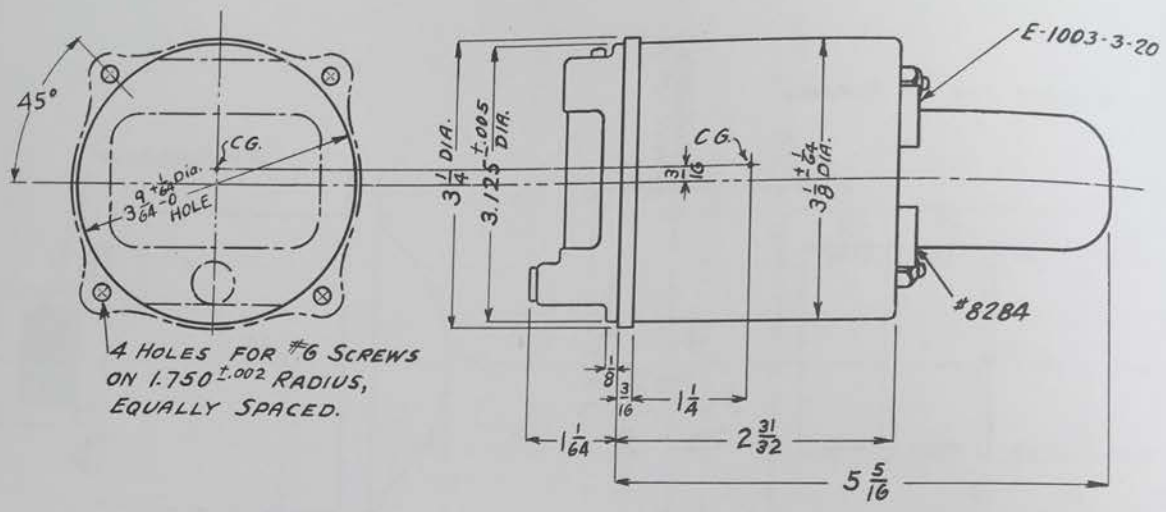


Fig. 6d.

CENTER OF GRAVITY = CG.
WEIGHT = 1 LB. 12 OZ.
FRACTIONAL DIMENSIONS APPROXIMATE UNLESS OTHERWISE NOTED

SK-4558

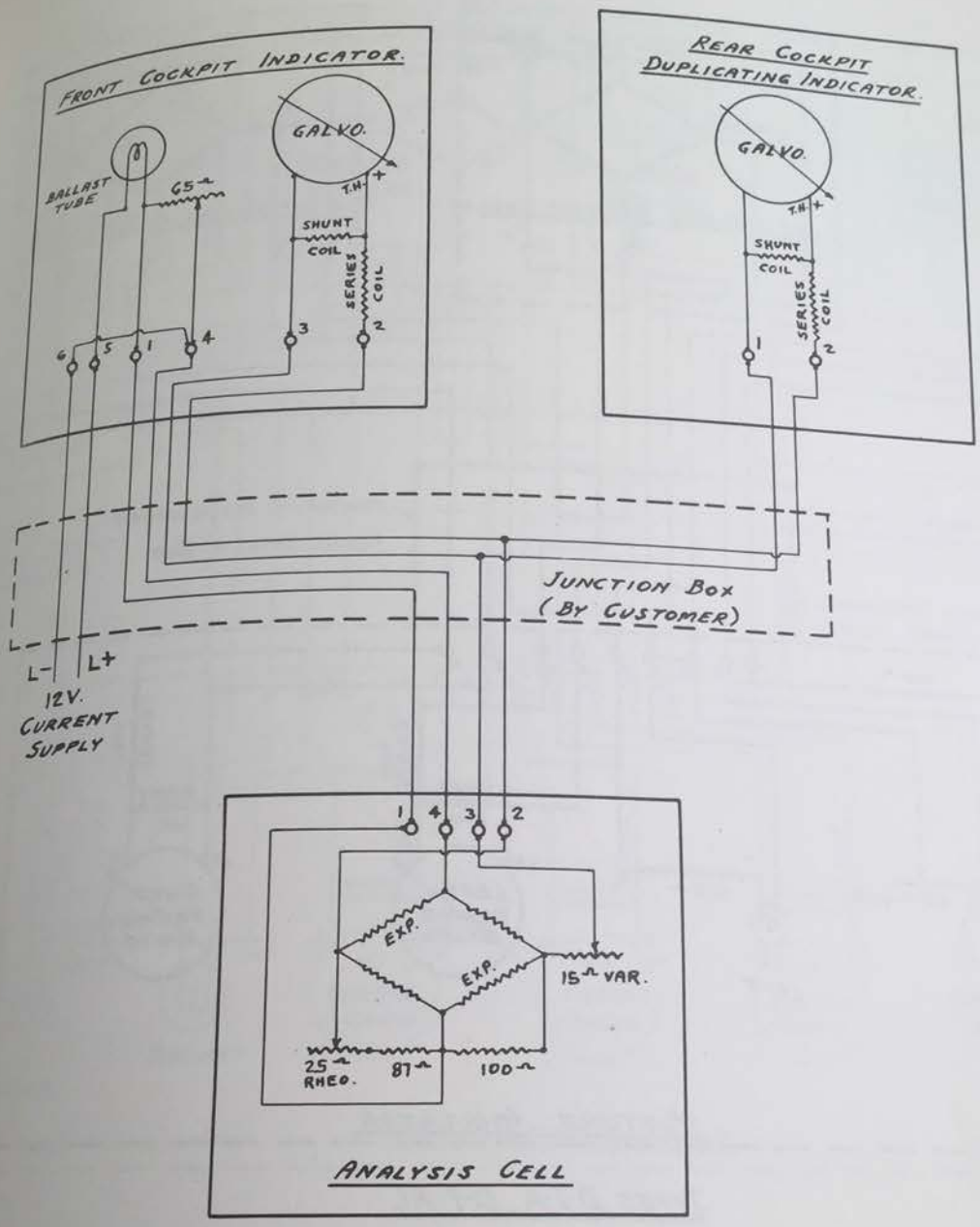
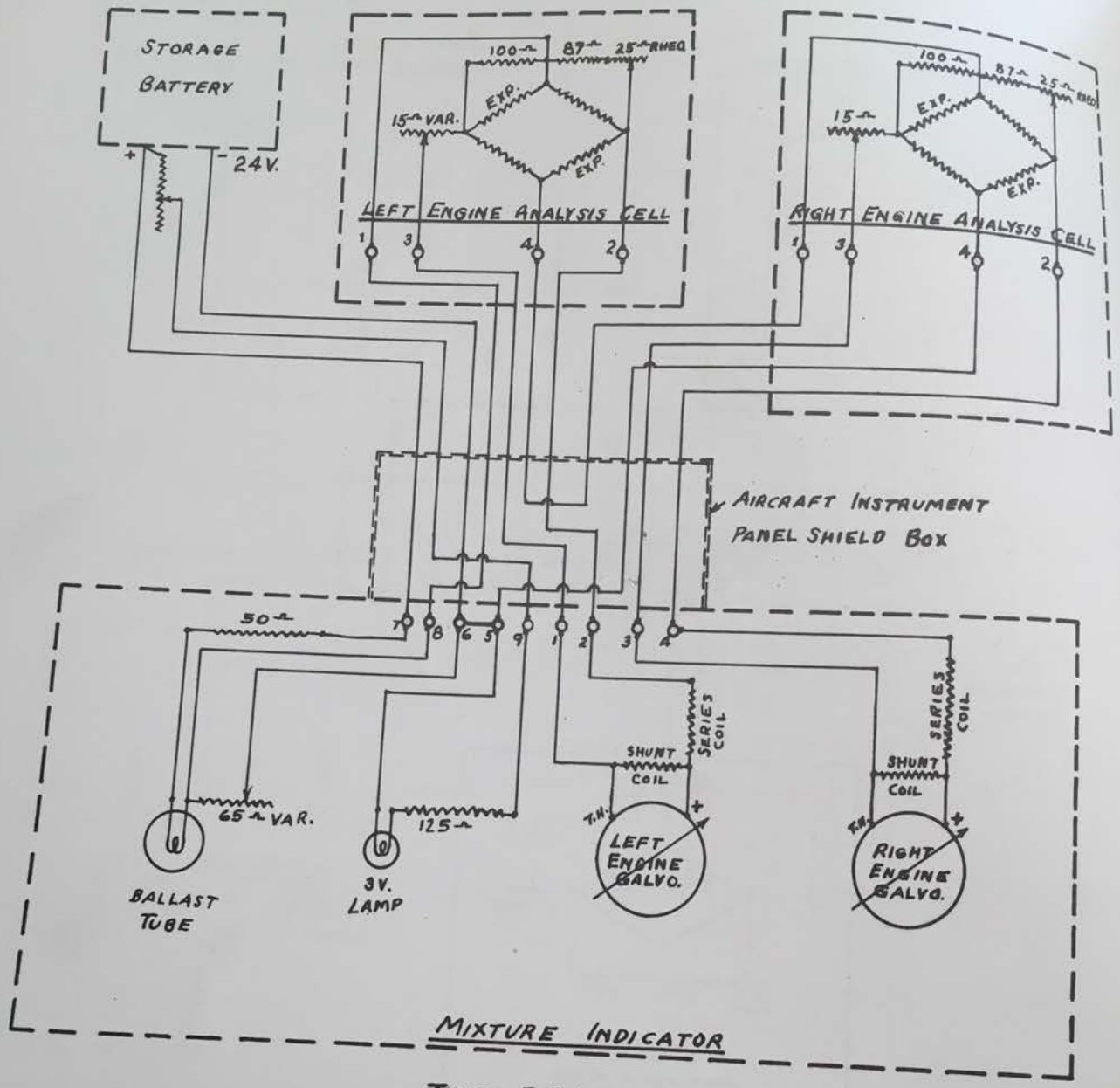


Fig. 7.

TYPE S-IFR-A

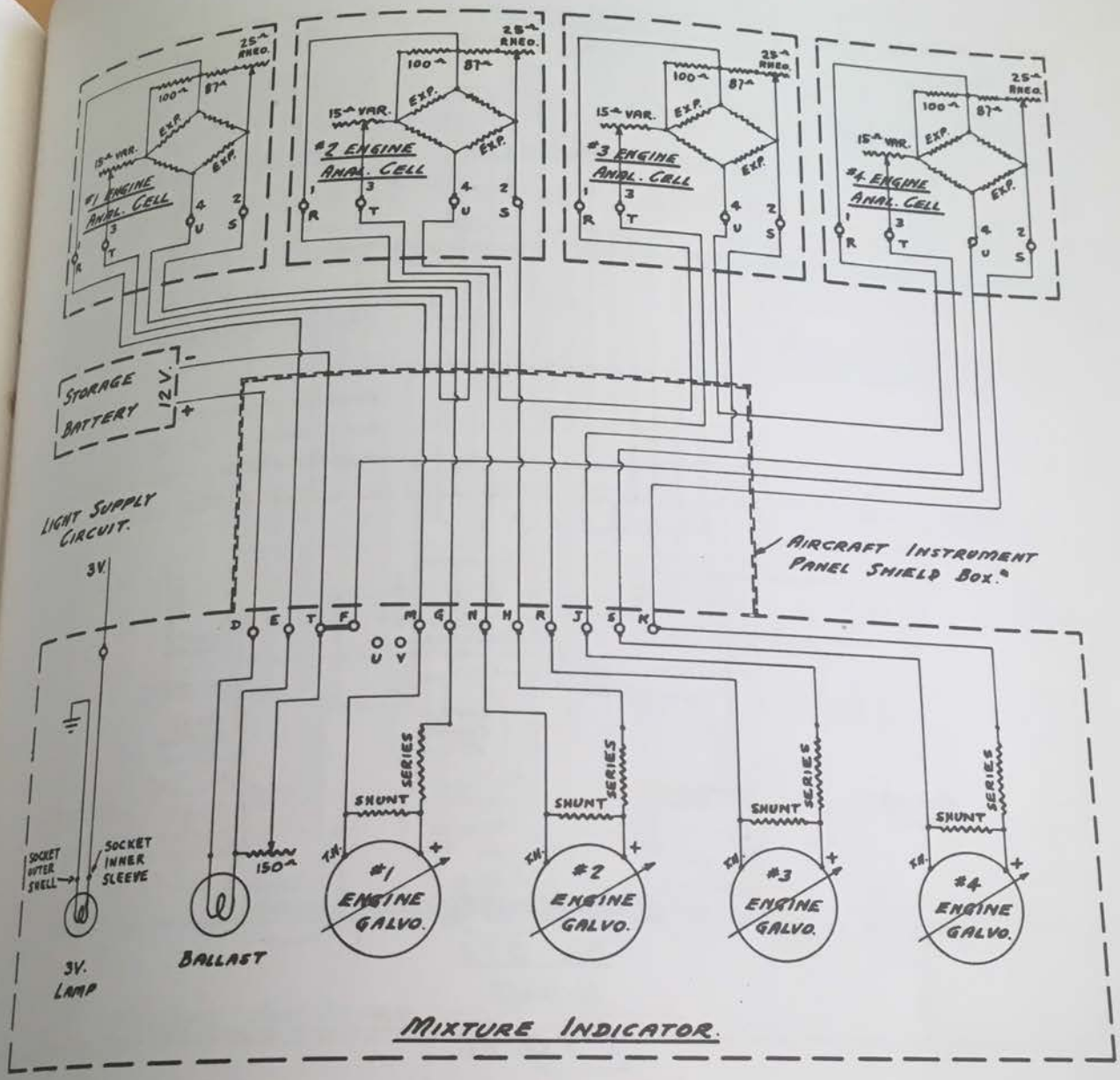


TYPES D·I·A, D·I·AL

Fig. 7a.

LOCKHEED HUDSON BOMBERS.

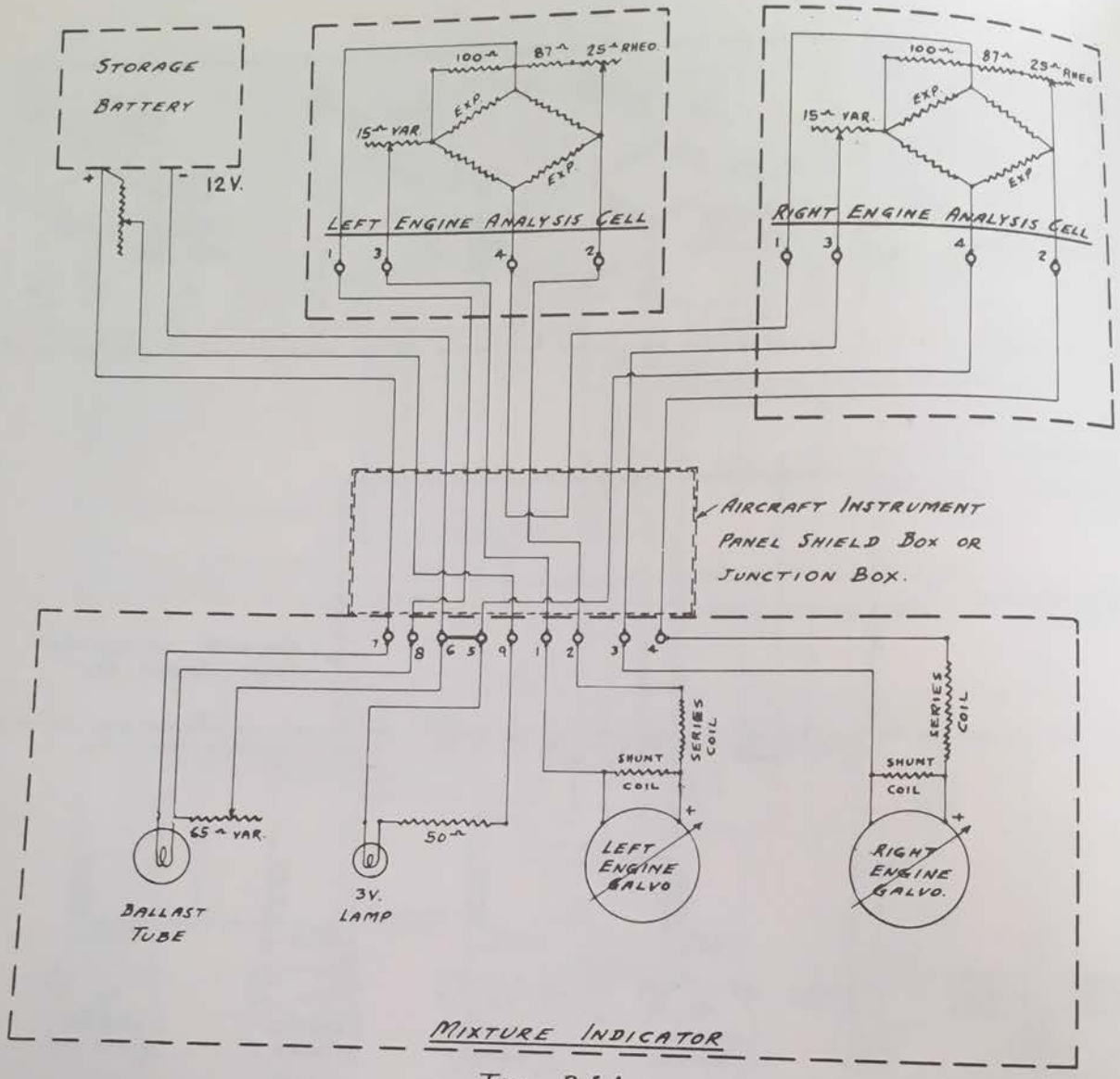
SK·4069



TYPE X-IV-AS

Fig. 7 b.

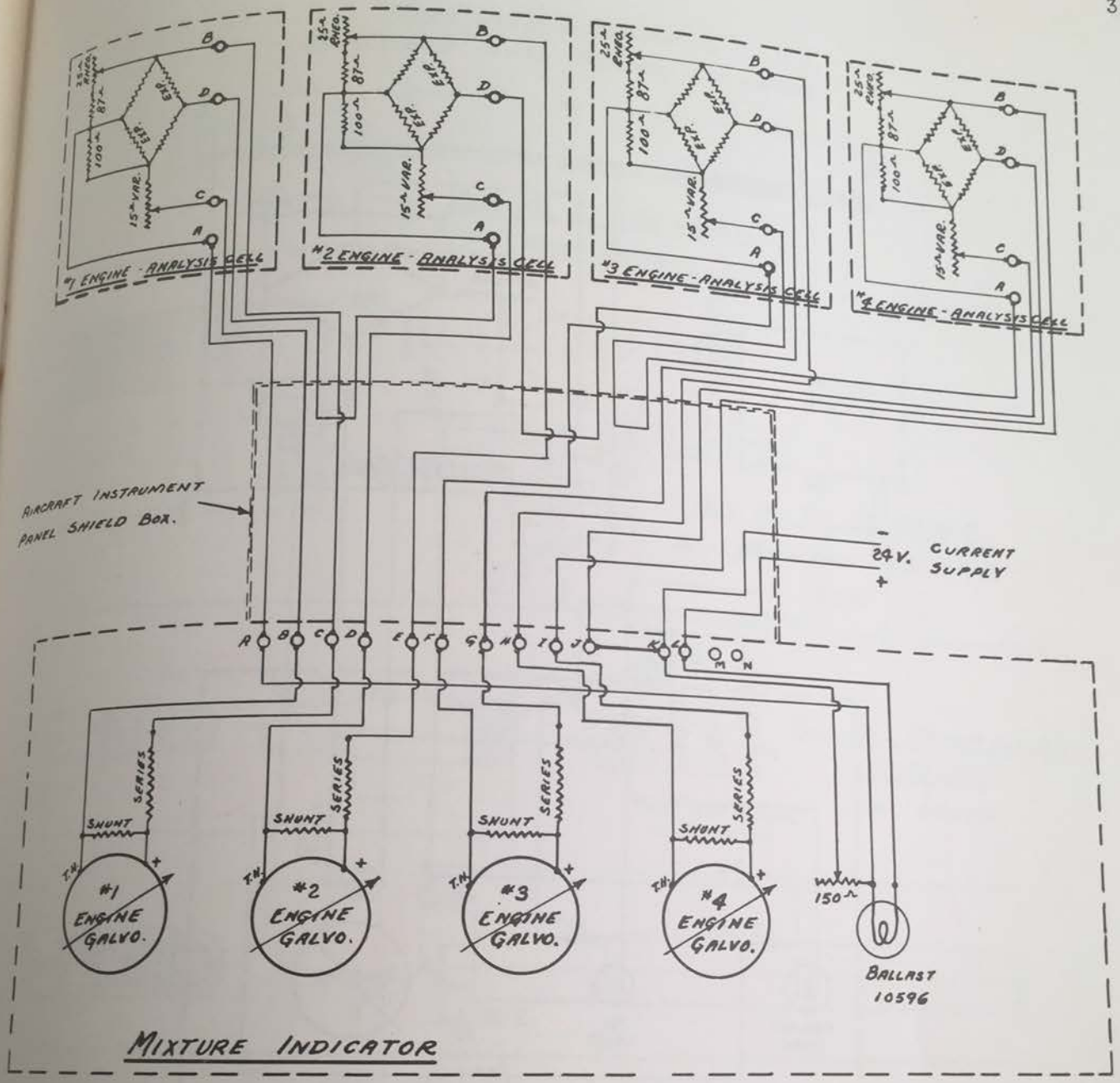
BOEING B-17C FLYING FORTRESSES.



TYPE D-I-A
12 VOLTS

Fig. 7c.

CESSNA T-50



TYPE X-IV-AL

Fig. 7d.

SHORT-STIRLING MODEL II BOMBERS.

SK-6162

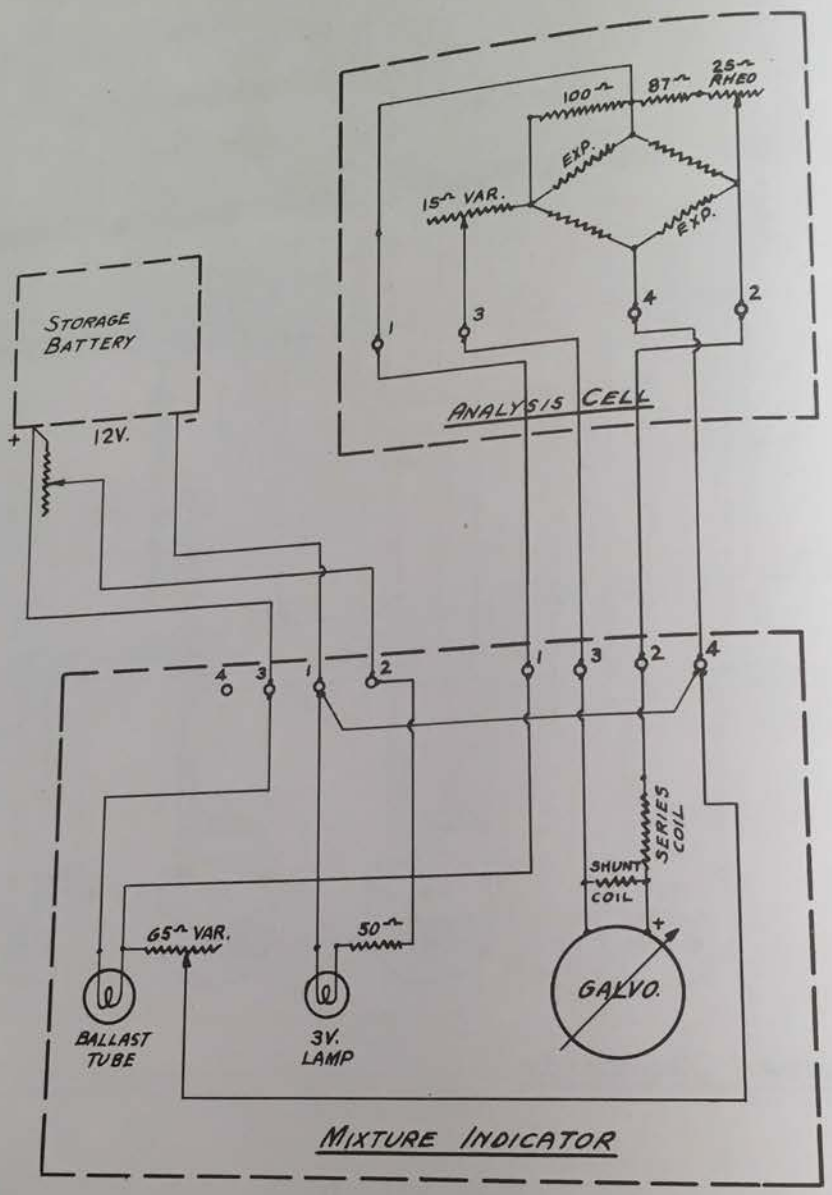
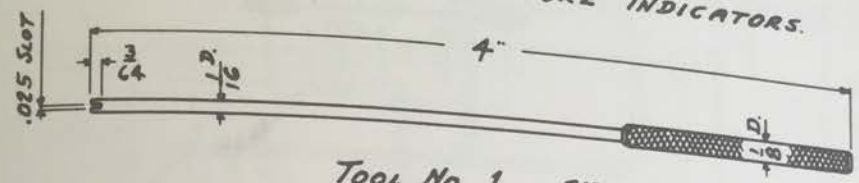


Fig. 7e.

TYPE S-1-A

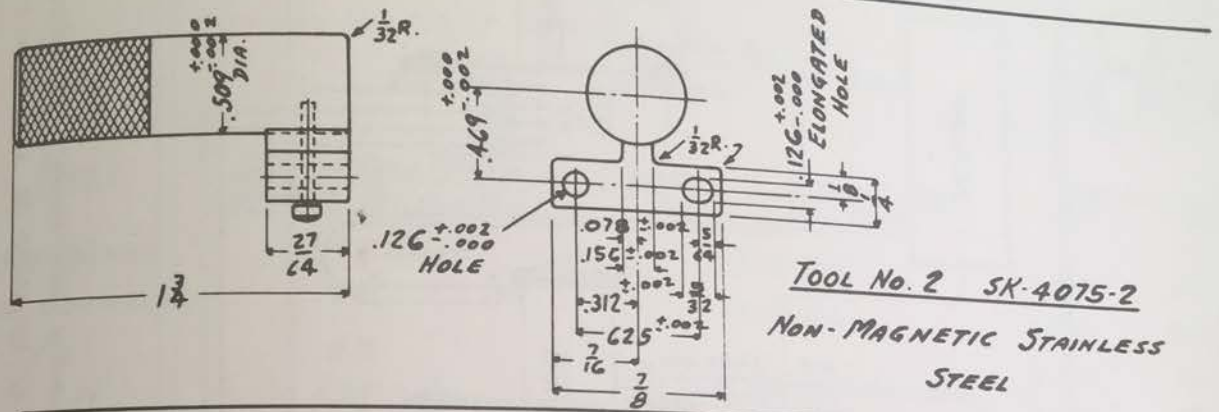
SK-4100

Tools Used In Repairing "Cambridge" Aero Mixture Indicators.



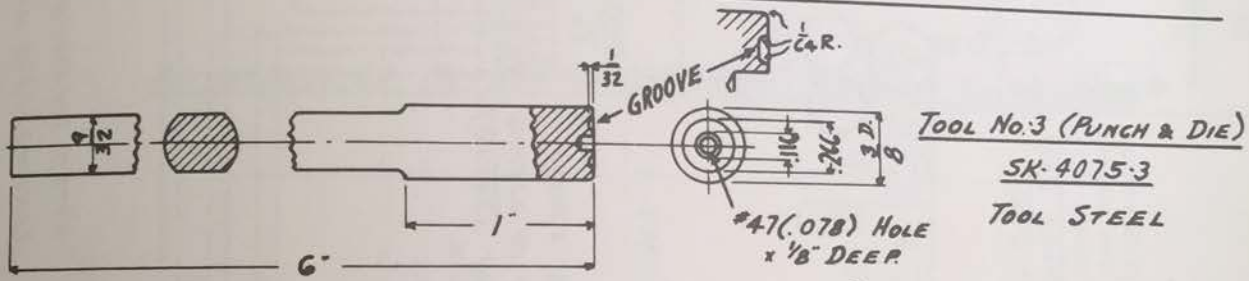
Tool No. 1. SK-4075-1

Tool Steel



Tool No. 2 SK-4075-2

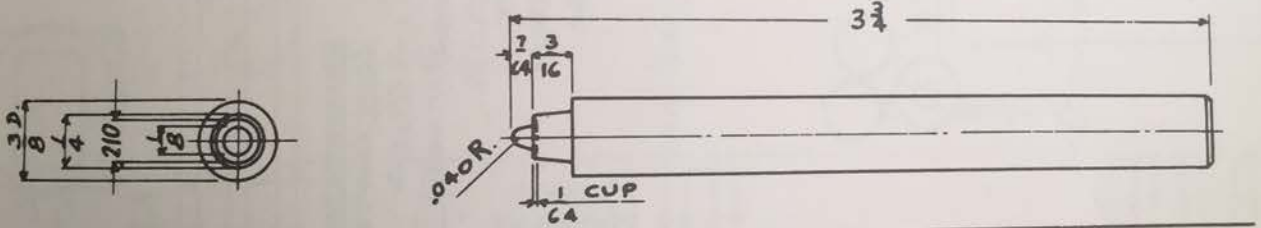
Non-Magnetic Stainless Steel

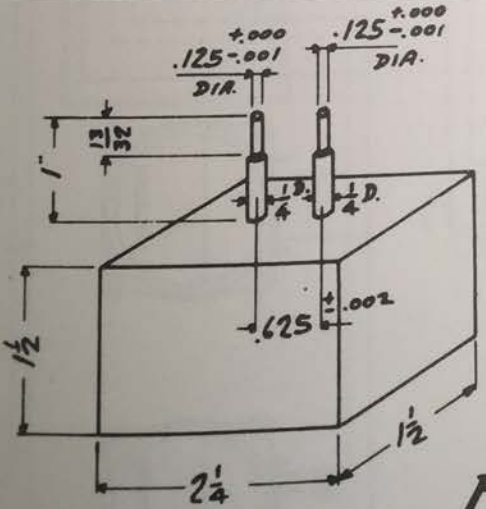


Tool No. 3 (Punch & Die)

SK-4075-3

Tool Steel





Tool No. 4 SK-4075-4

Cold Rolled Steel

Fig. 8.

SK-4075

BENCH TEST EQUIPMENT, SHOWING HOW STANDARD "CAMBRIDGE" AERO MIXTURE INDICATORS MAY BE USED AS TEST INSTRUMENTS IN CHECKING ANY NUMBER OF "CAMBRIDGE" AERO ANALYSIS CELLS.

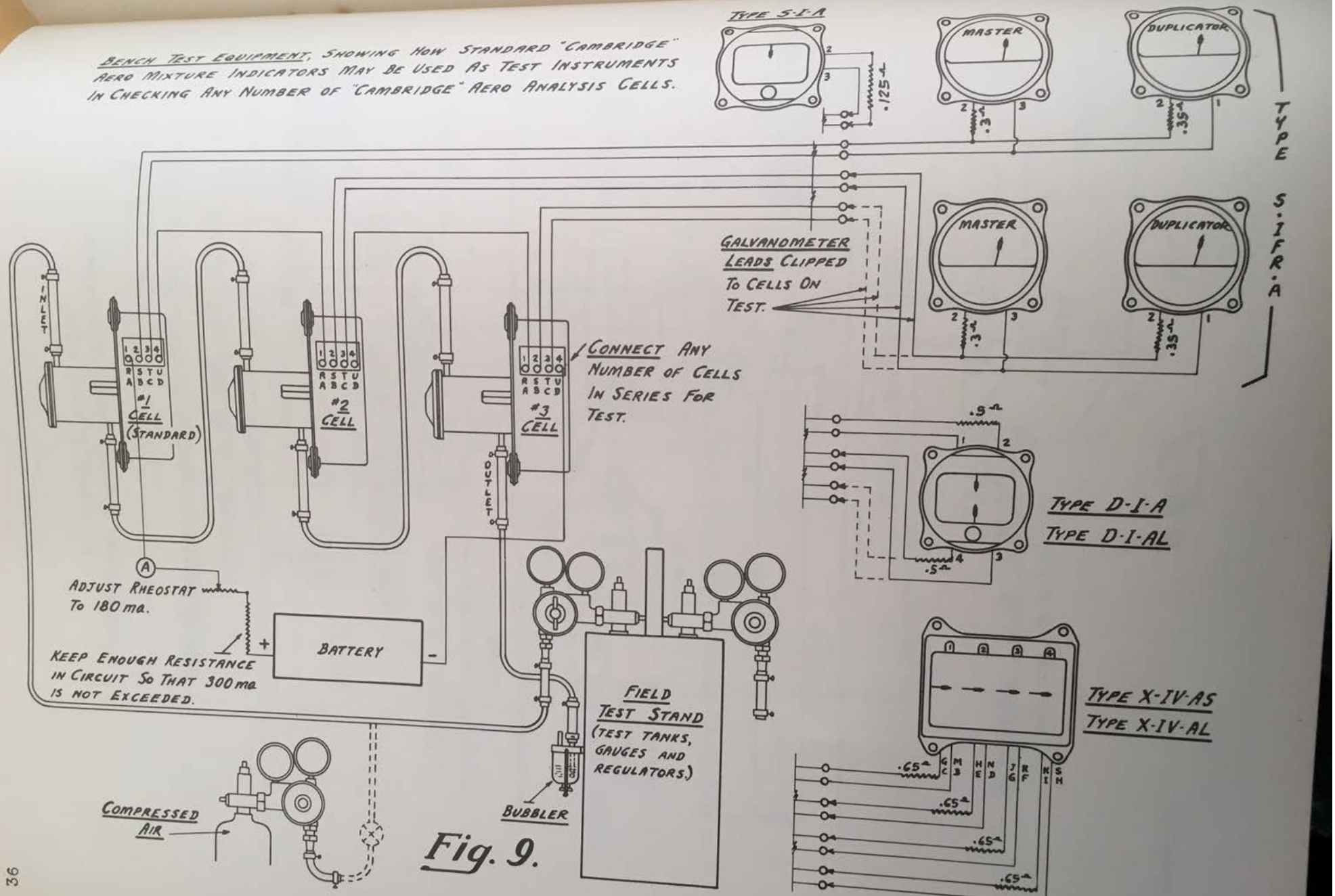
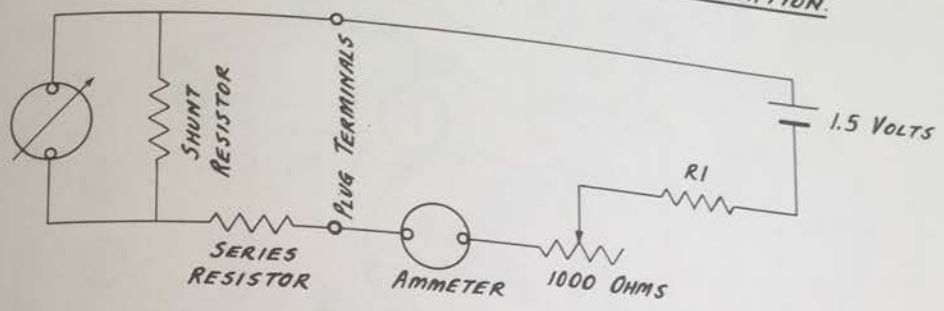


Fig. 9.

SK-4250

AMMETER METHOD OF CHECKING INDICATOR CALIBRATION.



TYPES	GALVO. RESISTANCE AT PLUG TERMINALS.	CURRENT TO DEFLECT FROM POINT "A" TO .09 F/A	R1	R2
S-IF MASTER	9.5 OHMS	.2375 ma	6,000 Ω	370 Ω
S-IFR DUPLICATING	9.4 "	.2375 ma	6,000 Ω	370 Ω
S-I, D-I	4.3 "	.475 ma	3,000 Ω	184 Ω
X-IV	4.25 "	.475 ma	3,000 Ω	184 Ω

POTENTIOMETER METHOD OF CHECKING INDICATOR CALIBRATION.

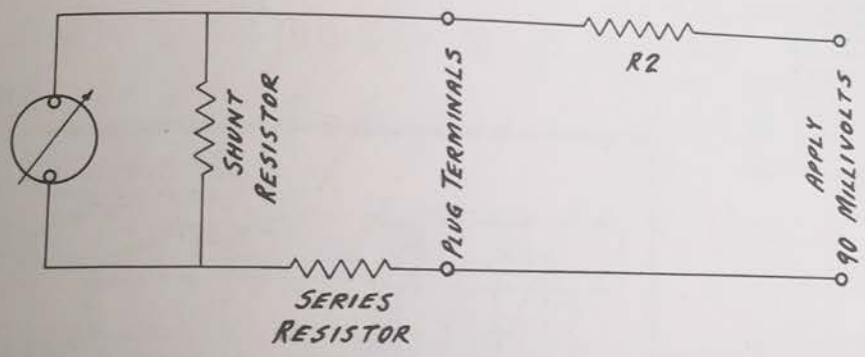


FIGURE 10.

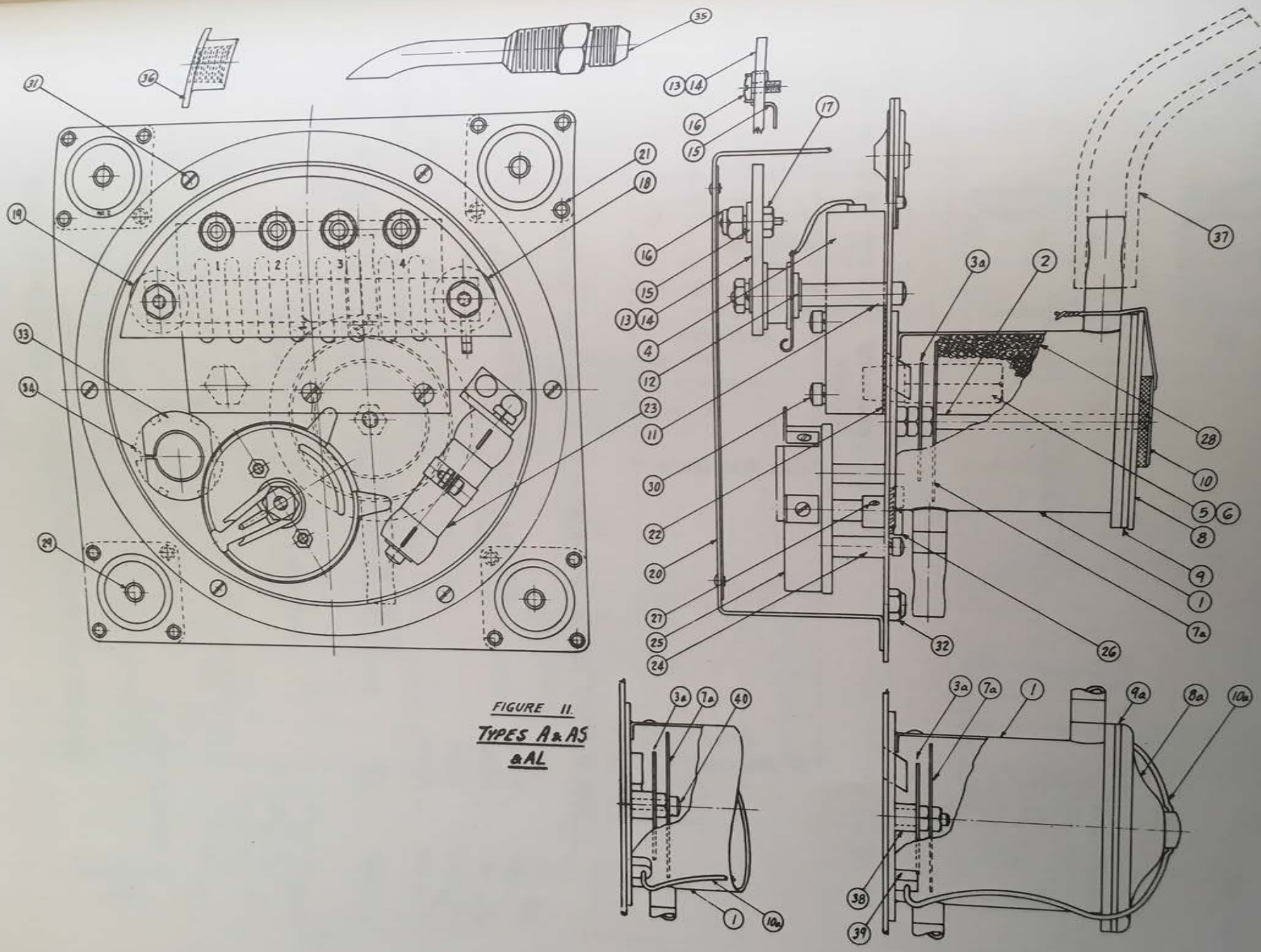


FIGURE 11.

TYPES A & AS & AL

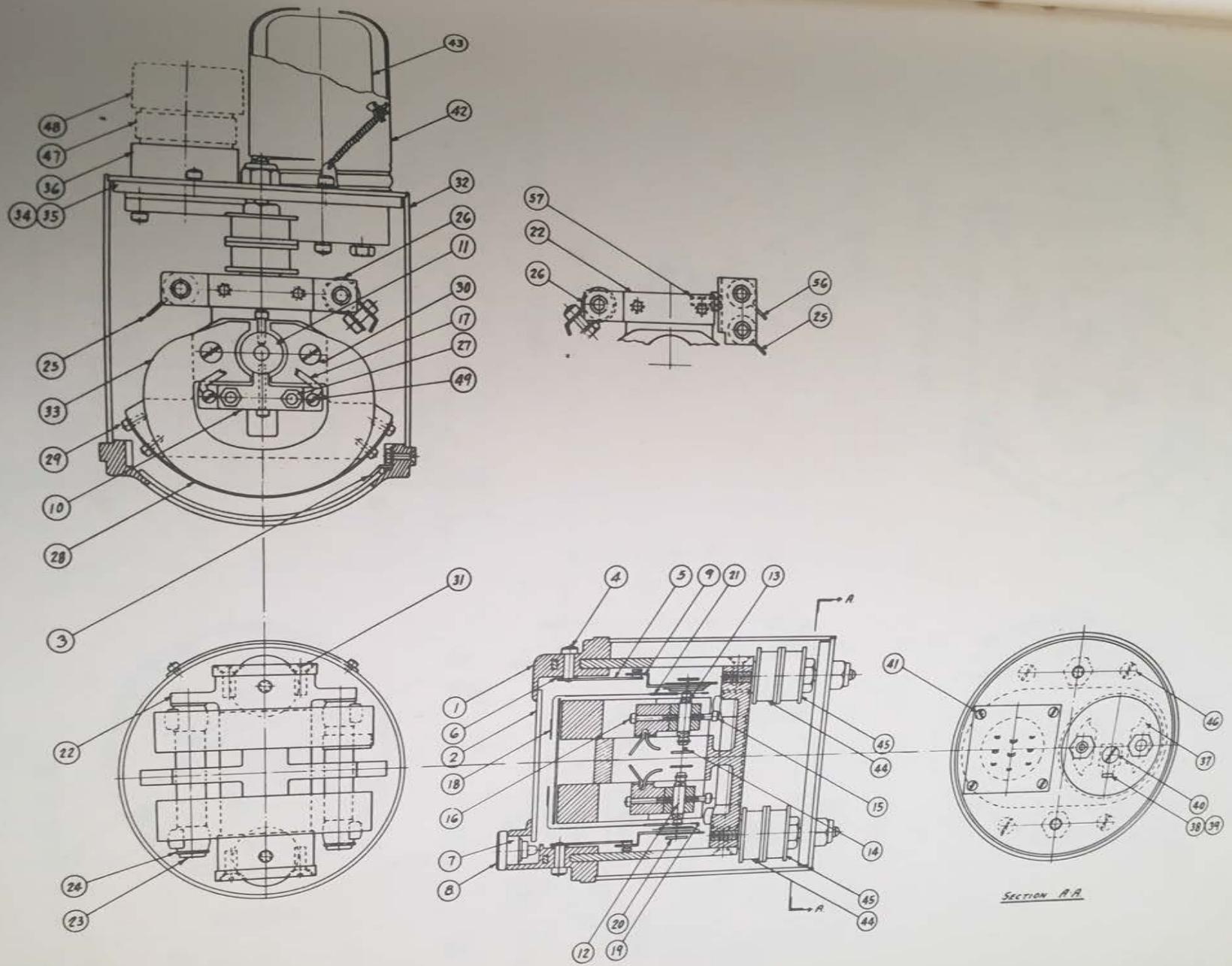


FIGURE 12
TYPE D-I

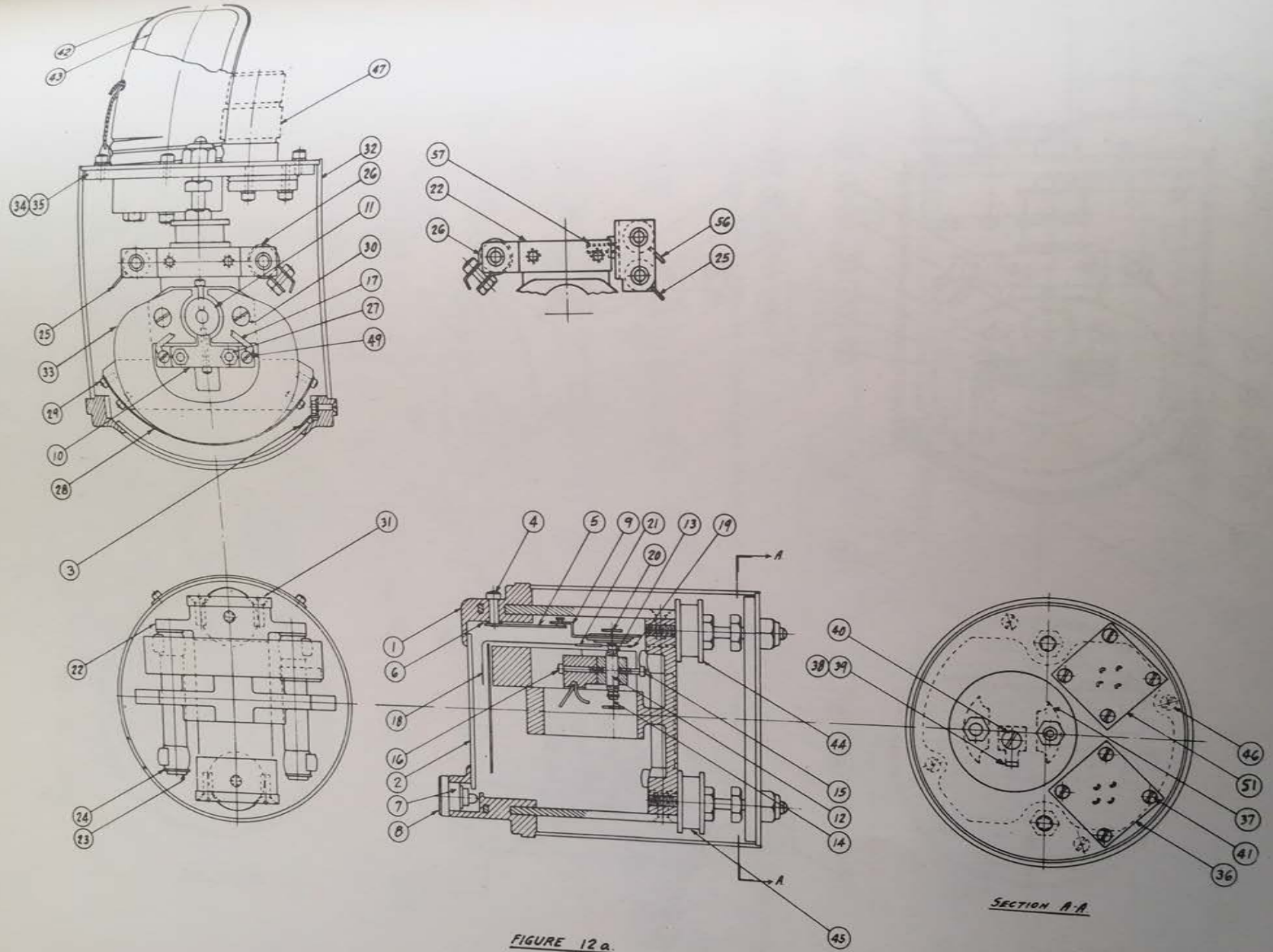
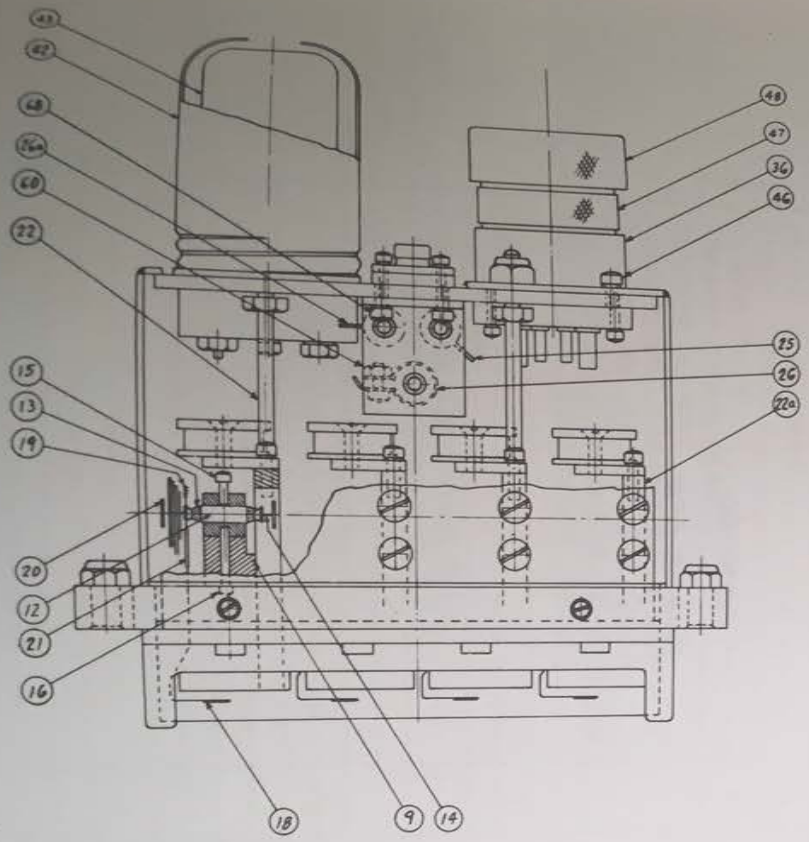
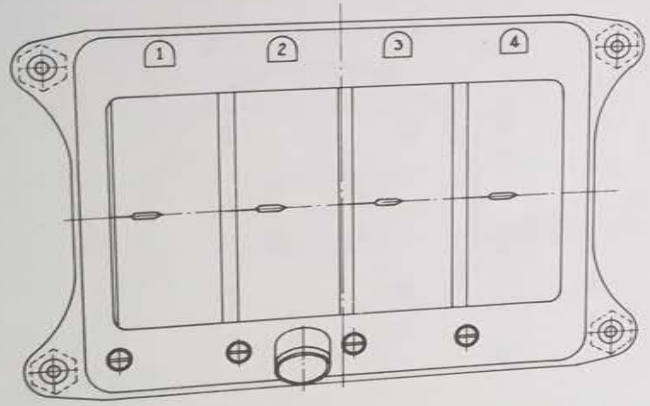
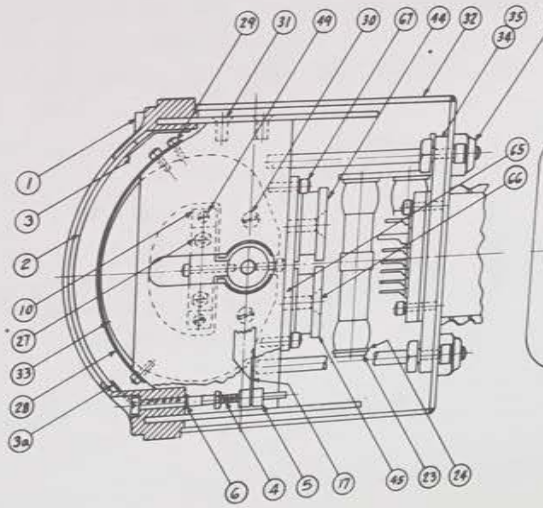


FIGURE 12a.
TYPE S-I







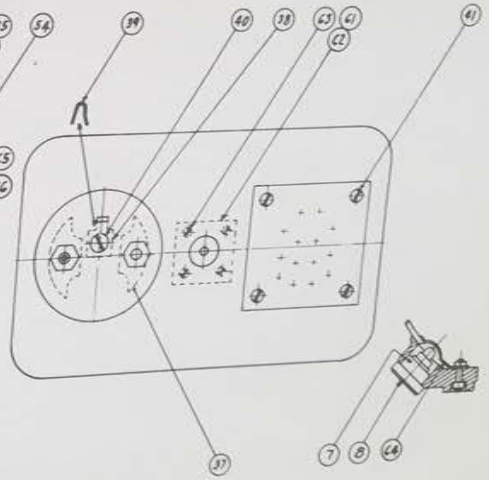


FIGURE 12e.
TYPE X-IV

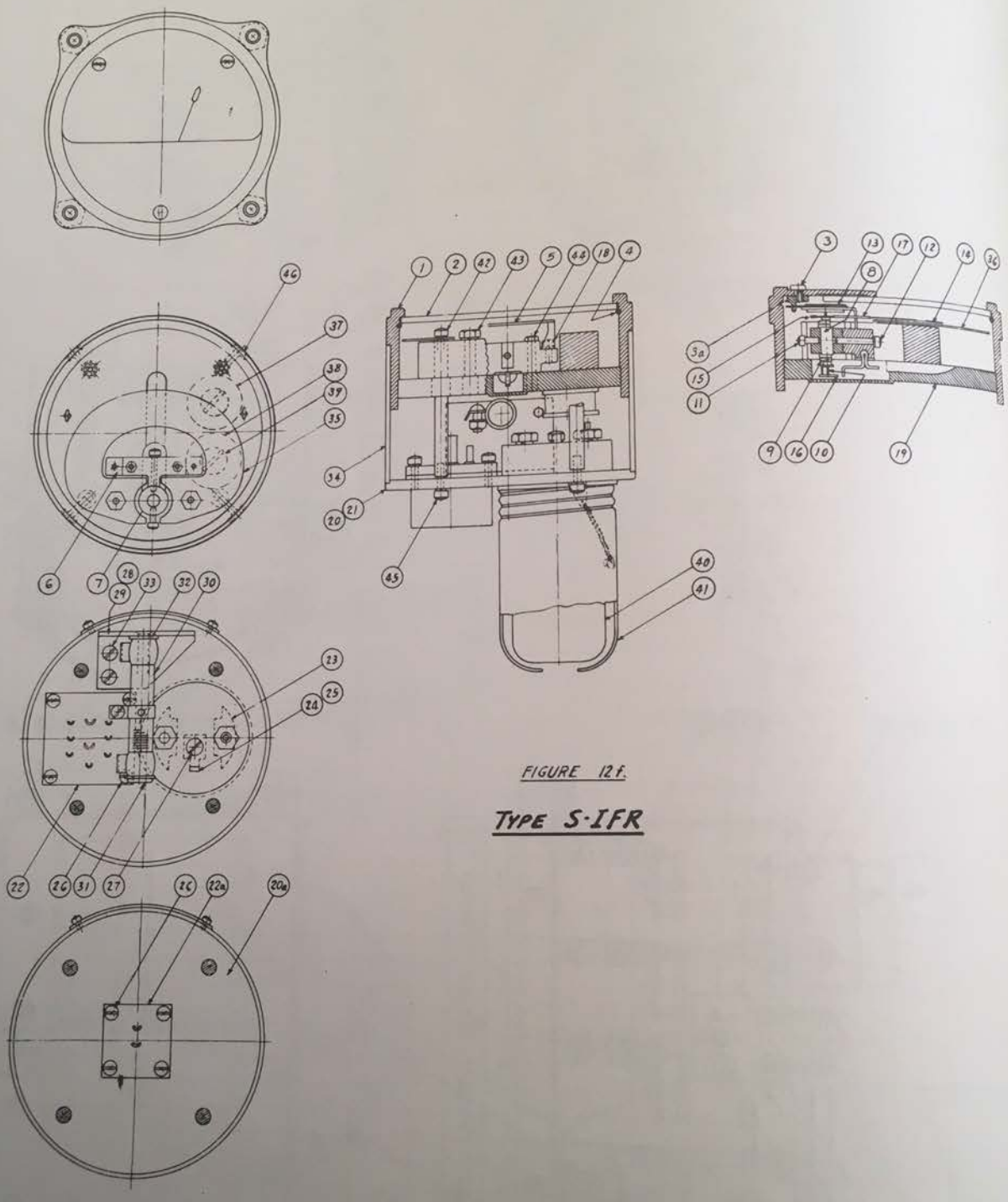


FIGURE 12.f.

TYPE S-IFR

REPLACEMENT PARTS LIST

ANALYSIS CELLS; TYPES "A", "AL", "AS"

FIG NO. 11

ITEM NO	PART No	No. USED	DESCRIPTION	7977 "A"	8363 "A"	10555 "A"	10555-1 "AL"	10957 "AS"	12190 "AL"	12223 "A"	
		1	PLATE & FILTER ASSEMBLY								
1	7978	1	" " " "	x							
1	7890-F3	1	" " " "		x						
1	10554	1	" " " "			x					
1	12242	1	" " " "				x				
1	10980	1	" " " "					x			
1	12193	1	" " " "						x		
1	12225	1	" " " "							x	
		1	BAFFLE PLATE								
3a	8853	1	METER BLOCK ASSEMBLY	x	x	x	x	x	x	x	
4	6762	1	METER BLOCK ASSEMBLY (SEALED SPIRALS)	x	x	x	x	x	x	x	
4	8198	1	MOISTURE VAPOR PLUG						x	x	
5	6492	1	MOISTURE WICK	x	x	x	x	x			
6	8291	1	FILTER SCREEN	x	x	x	x		x	x	
7a	8852	1	FILTER COVER	x	x	x	x		x	x	
8a	8695	1	FILTER COVER GASKET	x	x	x	x	x	x	x	
9a	8696A	1	SNAP LOCK	x	x	x	x	x	x	x	
10a	8698	2	TERMINAL PANEL POSTS	x	x	x	x	x	x	x	
11	7885	2	TERMINAL PANEL POSTS	x	x						
11	10286	1	TERMINAL STRIP ASSEMBLY			x	x	x	x	x	
12	SK-2652	1	TERMINAL PANEL ASSEMBLY	x	x	x	x	x	x	x	
13	7874	1	TERMINAL PANEL	x	x						
14	7883	4	TERMINAL STUDS	x	x						
15	7884	1	COIL - 87 OHMS	x	x						
18	7081-F5	1	COIL - 87 OHMS	x	x	x	x		x	x	
18	7081-F9	1	COIL - 100 OHMS					x			
19	7081-F6	1	METER COVER	x	x	x	x	x	x	x	
20	6772-F1	1	METER COVER	x	x						
20	10285	1	GROMMETS			x	x	x	x	x	
21	8289	16	METER BLOCK GASKET	x	x	x		x		x	
22	6774	1	RESISTOR - 15 OHM VARIABLE	x	x	x	x	x	x	x	
23	8290	2	RHEOSTAT POSTS	x	x	x	x	x	x	x	
24	6776	1	RHEOSTAT	x	x	x	x	x	x	x	
25	7901	1	RHEOSTAT HEAD	x	x	x	x	x	x	x	
26	7902	1	FILTER CARTRIDGE	x	x	x	x	x	x	x	
28	7964	4	SHOCK MOUNTS	x	x	x	x	x	x	x	
29	8391	6	CLINCH NUTS	x	x	x		x		x	
32	DC140A	1	CONDUIT CONNECTOR	x	x	x	x	x	x	x	
33	28-0376	1	CONDUIT CLAMP	x							
33	78-0375	1	ELECTRICAL CONNECTOR RECEPTACLE		x						
33	MK-4-32S	1	ELECTRICAL CONNECTOR SOCKET			x	x				
33	E-1003-3-10	1	ELECTRICAL CONNECTOR RECEPTACLE					x			
33	AN3102-18-4P	1	ELECTRICAL CONNECTOR SOCKET						x		
33	E1003-3-20	1								x	
34	6-0312	1	CONDUIT NUT	x							
34	79-0375	1	CONDUIT NUT		x						
34	E-1002-3-10	1	ELECTRICAL CONNECTOR PLUG					x			
34	AN3106-18-4S	1	ELECTRICAL CONNECTOR PLUG						x		
38	11632	4	RIVETS							x	

REPLACEMENT PARTS LIST

INDICATOR UNITS; PART NO. 8500-10, 8500-12. TYPE; D-I FIG. NO. 12

ITEM No.	PART No.	No. USED	DESCRIPTION	8500-10	8500-12
1	7891F2	1	INDICATOR FRONT ASSEMBLY	x	x
2	7632	1	WINDOW	x	x
3	8061	2	WINDOW CLIPS	x	x
4	7882	2	ZERO ADJUSTOR STUDS	x	x
5	7875	2	ZERO ADJUSTOR ASSEMBLIES	x	x
6	6723	2	ZERO ADJUSTOR SPRING WASHERS	x	x
7	8285	1	LAMP SOCKET	x	x
8	71A	1	LAMP	x	
9	7876	2	MOVEMENT SYSTEMS		x
9	7876-1	2	MOVEMENT SYSTEMS	x	x
10	7867	2	COCKPIECES	x	x
11	7868	2	MAGNET CORES	x	x
12	8599	2	JEWEL ASSEMBLIES	x	x
13	7160	2	MOVEMENT COIL ASSEMBLIES	x	x
14	8598	4	PIVOT ASSEMBLIES	x	x
17	7182	2	TORSION ASSEMBLIES	x	x
18	6714	2	POINTERS	x	x
19	7110	2	BALANCE WEIGHTS	x	x
20	7425	4	HAIR SPRINGS	x	
20	8969	4	HAIR SPRINGS		x
21	7129	2	POINTER COUPLINGS	x	x
22	8782	1	GALVO. SUPPORT BRACKET ASSEMBLY	x	
22	8488	1	GALVO. SUPPORT BRACKET ASSEMBLY		x
23	8232 F1	2	RIVETS OR SCREWS 640-130-32-3		x
23a	8659	2	RIVETS	x	
24	7228	x	INSULATING WASHERS	6	4
25	8287 F1	1	RESISTOR - 125 OHMS	x	
25	8287	1	RESISTOR - 50 OHMS		x
26	8489 F1	1	RESISTOR - 65 OHM VARIABLE	x	x
28	8171 F5	1	SCALE (WRIGHT ENG. G-102A, G-205A - 90 OCTANE)	x	
28	8860 F5	1	SCALE (WRIGHT ENG. G-205A - 90 OCTANE)	x	
28	10972	1	SCALE (PRATT & WHITNEY R1830-SC3G-87 OCTANE)	x	
28	11711	1	SCALE (JACOBS L4-73 OCTANE) SUPERSEDES 10924		x
32	10360	1	COVER ASSEMBLY	x	x
33	7191	2	MAGNETS	x	x
34	10363	1	ELECTRICAL PANEL ASSEMBLY	x	x
35	10362	1	MOLDED PANEL	x	x
36	10365	1	CONNECTOR RECEPTACLE	x	x
37	8243	1	SOCKET ASSEMBLY		
38	8241	1	CONTACT	x	x
39	8252 F1	1	CONTACT SPRING	x	x
42	8490	1	BALLAST TUBE COVER	x	x
43	8297	1	BALLAST TUBE	x	x
44	8527-2.5	2	SERIES COILS	x	x
45	8492-11	2	SHUNT COILS	x	x
47	GK-9-21-Z	1	CONNECTOR PLUG	x	x
47	GK-9-21-5/8B	1	CONNECTOR PLUG	x	
56	8287	1	RESISTOR - 50 OHMS		x

REPLACEMENT PARTS LIST

INDICATOR UNIT ; PART NO. 8570-9.

TYPE; S-I FIG. NO. 12a

Item No.	Part No.	No. Used	Description
	7824	1	INDICATOR FRONT ASSEMBLY
1		1	WINDOW
	7632	2	WINDOW CLIPS
2	8061	1	ZERO ADJUSTOR STUD
3	7882	1	ZERO ADJUSTOR ASSEMBLY
4	7875	1	SPRING
5	6723	1	LAMP SOCKET
6	8285	1	LAMP
7	71-A	1	MOVEMENT SYSTEM
8	7876-1		
9		1	COCKPIECE
	7867	1	MAGNET CORE
10	7868	1	JEWEL ASSEMBLY
11	8594	1	MOVEMENT COIL ASSEMBLY
12	7160	2	PIVOT ASSEMBLIES
13	8598	1	TORSION ASSEMBLY
14	7182	1	POINTER
17	6714	1	BALANCE WEIGHT
18	7110	2	HAIR SPRINGS
19	8969		
20		1	POINTER COUPLING
	7129	1	GALVO SUPPORT BRACKET ASSEMBLY
21	8488		
22			
23	8232 FI	2	RIVETS OR SCREWS C40-130-32-3
		4	INSULATING WASHERS
24	7228	1	RESISTOR - 50 OHMS
25	8287		
		1	RESISTOR - 65 OHM VARIABLE
26	8489 FI		
		1	SCALE (PRATT & WHITNEY R1340-S1H1-G, 87 OCTANE
28	10440		
		1	COVER ASSEMBLY
32	8240		
		1	MAGNET
33	7191	1	TERMINAL PANEL ASSEMBLY
34	8566		
		1	MOLDED PANEL
35	8565		
		1	CONNECTOR SOCKET
36	8284	1	SOCKET ASSEMBLY
37	8243	1	CONTACT
38	8241	1	CONTACT SPRING
39	8252-FI	1	BALLAST TUBE COVER
42	8490	1	BALLAST TUBE
43	8297	1	SERIES COIL
44	8527-2.5	1	SHUNT COIL
45	8492-11	1	CONNECTOR SOCKET E-1003-3-20
51			

REPLACEMENT PARTS LIST

INDICATOR UNITS; PART NO. 8833, 12180. TYPE; X-IV FIG. NO. 12e

ITEM No.	PART No.	No. USED	DESCRIPTION	8833	12180
1	8506	1	INDICATOR FRONT ASSEMBLY	×	
1	12182	1	INDICATOR FRONT ASSEMBLY		×
2	8656	1	WINDOW	×	×
3	8509	2	WINDOW CLIPS	×	×
3a	8655	2	WINDOW CLIPS	×	×
4	8503F1	4	ZERO ADJUSTOR SCREWS	×	×
5	8507	4	ZERO ADJUSTOR COUPLINGS	×	×
6	8511	4	SNAP RINGS	×	×
7	8285	1	LAMP SOCKET	×	
8	71A	1	LAMP	×	×
9	8530	4	MOVEMENT SYSTEMS	×	×
10	7867	4	COCKPIECES	×	×
12	8599	4	JEWEL ASSEMBLIES	×	×
13	7160	4	MOVEMENT COIL ASSEMBLIES	×	×
14	8598	8	PIVOT ASSEMBLIES	×	×
17	8524	4	TORSION ASSEMBLIES	×	×
18	8528	4	POINTERS	×	×
19	7110	4	BALANCE WEIGHTS	×	×
20	7425	8	HAIR SPRINGS	×	×
21	7129	4	POINTER COUPLINGS	×	×
22	8515	2	#1 & 3 MOVEMENT MOUNTING PLATE ASSEM.	×	×
22a	8516	2	#2 & 4 MOVEMENT MOUNTING PLATE ASSEM.	×	×
23	8659	1	RIVET	×	×
24	7228	2	INSULATING WASHERS	×	×
26	10403	1	RESISTOR- 150 OHM VARIABLE	×	×
28	10188	4	SCALES (F/A .066-.11)	×	
28	8898	4	SCALES (WRIGHT GR2600-A5B1-90 OCTANE)		×
32	8517	1	COVER	×	×
33	7191	4	MAGNETS	×	×
34	8521-F1	1	ELECTRICAL PANEL ASSEMBLY	×	
34	12185	1	ELECTRICAL PANEL ASSEMBLY		×
35	8520-F1	1	MOLDED PANEL	×	
35	12184	1	MOLDED PANEL		×
36	E-1003-1-10	1	ELECTRICAL CONNECTOR SOCKET	×	
36	AN3102-20-1P	1	ELECTRICAL CONNECTOR RECEPTACLE		×
37	8243	1	SOCKET ASSEMBLY	×	×
38	8241	1	CONTACT	×	×
39	8252-F1	1	CONTACT SPRING	×	×
42	8490	1	BALLAST TUBE COVER	×	×
43	8297	1	BALLAST TUBE	×	×
43	10596	1	BALLAST TUBE	×	
44	8834-2.5	4	SERIES COILS		×
45	8785-11	4	SHUNT COILS	×	×
47	E-1002-1-10	1	ELECTRICAL CONNECTOR PLUG	×	×
47	AN3106-20-1S	1	ELECTRICAL CONNECTOR PLUG	×	
48	8666	1	PLUG CAP		×
60	10274	1	RESISTOR BRACKET ASSEMBLY	×	
61	E-1003-15-10	1	ELECTRICAL CONNECTOR SOCKET	×	×
64	8510	1	LIGHT SHIELD	×	
65	8784	4	COIL PANELS	×	
				×	×

REPLACEMENT PARTS LIST.

INDICATOR UNITS, TYPES S-IF AND S-IFR.

FIG. No. 12f.

Item No.	Part No.	No. Used	Description	10292-1 S-IF	10292-2 S-IF	10293-1 S-IFR	10293-2 S-IFR
		1	INDICATOR FRONT ASSEMBLY	x	x	x	x
1	10300	1	WINDOW	x	x	x	x
2	10301	1	ZERO GUIDE (SUPERSEDES 10303)	x	x	x	x
3	10327	1	ZERO HEAD (SUPERSEDES 10303)	x	x	x	x
3A	10338	1	SNAP RING	x	x	x	x
4	10302	1	MOVEMENT SYSTEM	x	x	x	x
5	10304	1	COCKPIECE	x	x	x	x
6	7867	1	MAGNET CORE	x	x	x	x
7	7868	1	JEWEL ASSEMBLY	x	x	x	x
8	8599	1	MOVEMENT COIL ASSEMBLY	x	x	x	x
9	10375	2	PIVOT ASSEMBLIES	x	x	x	x
10	8598	1	TORSION ASSEMBLY	x	x	x	x
13	10305	1	POINTER	x	x	x	x
14	10306	1	BALANCE WEIGHT	x	x	x	x
15	7110	2	HAIR SPRINGS (SUPERSEDES 10309)	x	x	x	x
16	8969	1	POINTER COUPLING	x	x	x	x
17	7129	1	GALVANOMETER SUPPORT DISK	x	x	x	x
19	10307	1	ELECTRICAL PANEL ASSEMBLY	x	x		
20	10308	1	ELECTRICAL PANEL			x	x
20A	10334	1	MOLDED PANEL	x	x		
21	10333	1	ELECTRICAL CONNECTOR SOCKET	x	x		
22	F-1003-5-20	1	ELECTRICAL CONNECTOR SOCKET			x	x
22A	F-1003-13-20	1	SOCKET ASSEMBLY	x	x		
23	8243	1	CONTACT	x	x		
24	8241	1	CONTACT SPRING	x	x		
25	8252 F1	1	RESISTOR BRACKET ASSEMBLY	x	x		
28	10336	1	BRACKET ANGLE	x	x		
29	10335	1	RESISTOR - 65 OHM VARIABLE	x	x		
30	8489 F1	1	RIVET	x	x		
31	8659	1	INSULATING WASHERS	x	x		
32	7228	2	COVER	x	x	x	x
34	10339	1	MAGNET	x	x	x	x
35	7191	1	SCALE (PRATT & WHITNEY ENG. R1340-S3H1G.)	x		x	
36	10354	1	SCALE (JACOBS ENGINE LG.)		x		x
36	11494	1	SERIES COIL (SUPERSEDES 10376)	x	x	x	x
37	8834-3.1	1	SHUNT COIL (SUPERSEDES 10377)	x	x	x	x
38	8785-30	1	BALLAST TUBE	x	x		
40	8297	1	BALLAST TUBE COVER	x	x		
41	8490						

REPLACEMENT PARTS LIST
ACCESSORIES

PART No.	DESCRIPTION	TYPES					
		S-IFR-A	D-I-A D-I-AL	X-IV-AS	X-IV-AL	S-I-A	
10242	SAMPLING TUBE ASSEMBLY			x			
10367	" " "		x				
8498	" NIPPLE ASSEMBLY	x FLEET			x	x	
10496	" TUBE "	x NORTH AMERICAN x NOORDUYN x DOM. of CANADA					
				x			
10241	SAMPLING NIPPLE FLANGE						
		x	x	x			
8021	RUBBER TUBE COUPLING	x	x	x	x	x	
8167	RUBBER ELBOW COUPLING	x	x	x	x	x	
8033	HOSE CLAMP		x	x		x	
8032	COPPER TUBING		x	x		x	
8032-F1	" "				x		
8032-F2	" "						
11746	STAINLESS STEEL TUBING	x NORTH AMERICAN					
11746-1	" " "	x NOORDUYN x DOM. of CANADA					
11747	COPPER TUBING	x NORTH AMERICAN					
11747-1	" "	x NOORDUYN x DOM. of CANADA					
10294	CONDUIT ASSEM.- FRONT COCKPIT INDICATOR	x NORTH AMERICAN					
10294-14	" " " " "	x NOORDUYN x DOM. of CANADA					
11496	" " " " "	x FLEET					
10295	" " - DUPLICATING INDICATOR	x NORTH AMERICAN x NOORDUYN x DOM. of CANADA					
11497	" " " "	x FLEET					
10296	" " - ANALYSIS CELL	x NORTH AMERICAN x NOORDUYN x DOM. of CANADA					
11495	" " " "	x FLEET					
12687 OR 12689	" " " "					x	
12688	" " - BATTERY					x	
8022	CARTON of 6 FILTER CARTRIDGES, #7964	x	x	x			