GROUP 2A
FUEL CONTROL, CONTENT GAUGES AND INDICATORS

(Completely revised)

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Introduction

1. This group contains a description, including the method of operation, of the fuel cock control, fuel contents and fuel pressure warning circuits installed in the aircraft, together with the necessary servicing information to maintain the equipment in an efficient condition. Routeing and theoretical diagrams of the installations are also included. For a general description of the aircraft's instrument installation, reference should be made to Group 1.A.

2. The fuel cock control, fuel contents and fuel pressure warning equipment employed in this aircraft is listed in Table 1, together with the appropriate Air Publications which give a detailed description and servicing instructions to maintain them in an efficient condition:-

DESCRIPTION

Fuel content gauges and fuel cock control (Code FC)

3. This is a 28-volt d.c. electronic installation. The two fuel content gauges, one for the port tank system and another for the starboard tank system, are located on the cabin starboard shelf. Irrespective of the aircraft's attitude the fuel gauges give a continuous indication of fuel available to the engine, except that carried in the outboard drop tanks, thus:-

(a) All tanks *(summation)*.

(b) Front and rear tanks *(should pressure fail in the wing and inboard drop tanks)*.

(c) Front, wing and inboard drop tanks *(should pressure fail in the rear tanks)*.

(d) Front tank only *(should pressure fail in the rear, wing and inboard drop tanks)*.

4. The port and starboard tank systems are entirely independent except for the common d.c. supply and differ only in the internal arrangements of the cable boxes due to differing coaxial cable lengths. The gauges, which are engraved in pounds *(mass)*, are supplied from strap type capacitor gauge units fitted within each tank, via two 'external' fuel relay boxes attached to nose rib H in the wings and two 'internal' fuel relay boxes and amplifier units mounted in the radio bay. The 'internal' fuel relay boxes are controlled by relays A.1, B.1, L.1 and M.1 located on the supply panel. These relays, are in turn, controlled by four pressure switches positioned one on each rear and wing tank fuel outlet lines at frames 29 and in each stub wing.

5. Two transfer pressure magnetic indicators, together with two fuel cock position magnetic indicators, are located on the cabin starboard shelf adjacent to the fuel gauges. The transfer pressure indicators are controlled by relays A.1, B.1, L.1 and M.1 and the fuel cock position indicators are governed by relays J.1 and K.1 situated on the supply panel. Relays J.1 and K.1 also control the operation of the fuel cock actuators mounted between frames 26 and 27. These relays are operated by the tank selector switch positioned on the cabin starboard shelf and by the low level float switches mounted in each rear fuel tank.

Operation

Power OFF condition

6. As the port and starboard fuel content gauge and cock control systems are separately fused and provided with independent control equipment it is necessary only to follow the operation of the port system to understand both installations.

TABLE 1

Equipment type and Air Publication reference

Equipment Type	Air Publication
Content gauges, Smith Waymouth Type A0.62 Gauge Amplifiers, Smith Waymouth Type F.C.A. Relay boxes, Smith Waymouth Type BW.43, BW.44 and BT.20-16 Tank units, Smiths Waymouth Type TC.94, TC.95, TC.127, TC.180, TC.181, TC.182, TC.183 and 65TN	A.P.1275A, Vol.1, Sect.18
Pressure switch, Thermal Control Type TP. 1200 or 5252/1 Low level switch, Flight Refuelling Type C.3504100/38 Forward tank float switches, Flight Refuelling Type D.3504100/47 or Hawker Pt.No.D.215808 Drop tank float switches, Flight Refuelling Type 3504100/36 or 3504100/153	A.P.1275A, Vol.1, Sect.24
Tank selector switches, C.W.C. Type X.D.776	A.P.4343C, Vol.1, Book 1, Sect.1
Relays A1, B1, L1 and M1, Type Q, No.1 Relays T1, U1, V1 and W1, Type SM.5 Relays J1 and K1, Type S	A.P.4343C, Vol.1, Book 2, Sect.3
Fuel cock actuators, Plessey Type CZ.54709/5/F	A.P.4343D, Vol.1, Book 3, Sect.16
Transfer pressure failure indicators, Dowty Type C.5165Y, Mk.7 Drop tanks empty indicators, Type B.2 Engine fuel pressure warning lamp, Type A Fuel low level warning lamps, Type B Fuel cock position indicators, Plessey Type CZ.74109/2	A.P.4343E, Vol.1, Sect.18

The theoretical diagram *(fig.1)* shows the condition found when the aircraft is at rest on its alighting gear with the engine and electrical supply switched off, but with the fuel tanks full. In this condition all the relays will be de-energized and the pressure switch, together with the float switch will be open. The fuel cock actuator will be holding the fuel cock in the position that allows fuel to flow from the rear tank to the front tank and the fuel cock position indicator will show this state. The transfer pressure indicator will indicate 'no flow' and the fuel gauge will read zero.

Power ON engine not running

7. When the battery master switch is closed, prior to starting the engine, the amplifier and gauge will commence operation. The gauge will indicate the contents of the front tank only as the capacitor unit in this tank is always connected to the amplifier and the system is not yet pressurized. Dummy capacitances, one located in the 'internal' fuel relay box matching the 'tank empty' values of the rear and wing tank units, and another in the 'external' fuel relay box matching the 'tank empty' value of the inboard drop tank are also in circuit. If the tank selector switch is in the 'REAR' or 'AUTO' position the cock control relay J.1 will remain de-energized causing the fuel cock and fuel cock indicator to remain in the rear tank to front tank position. If however, the tank selector

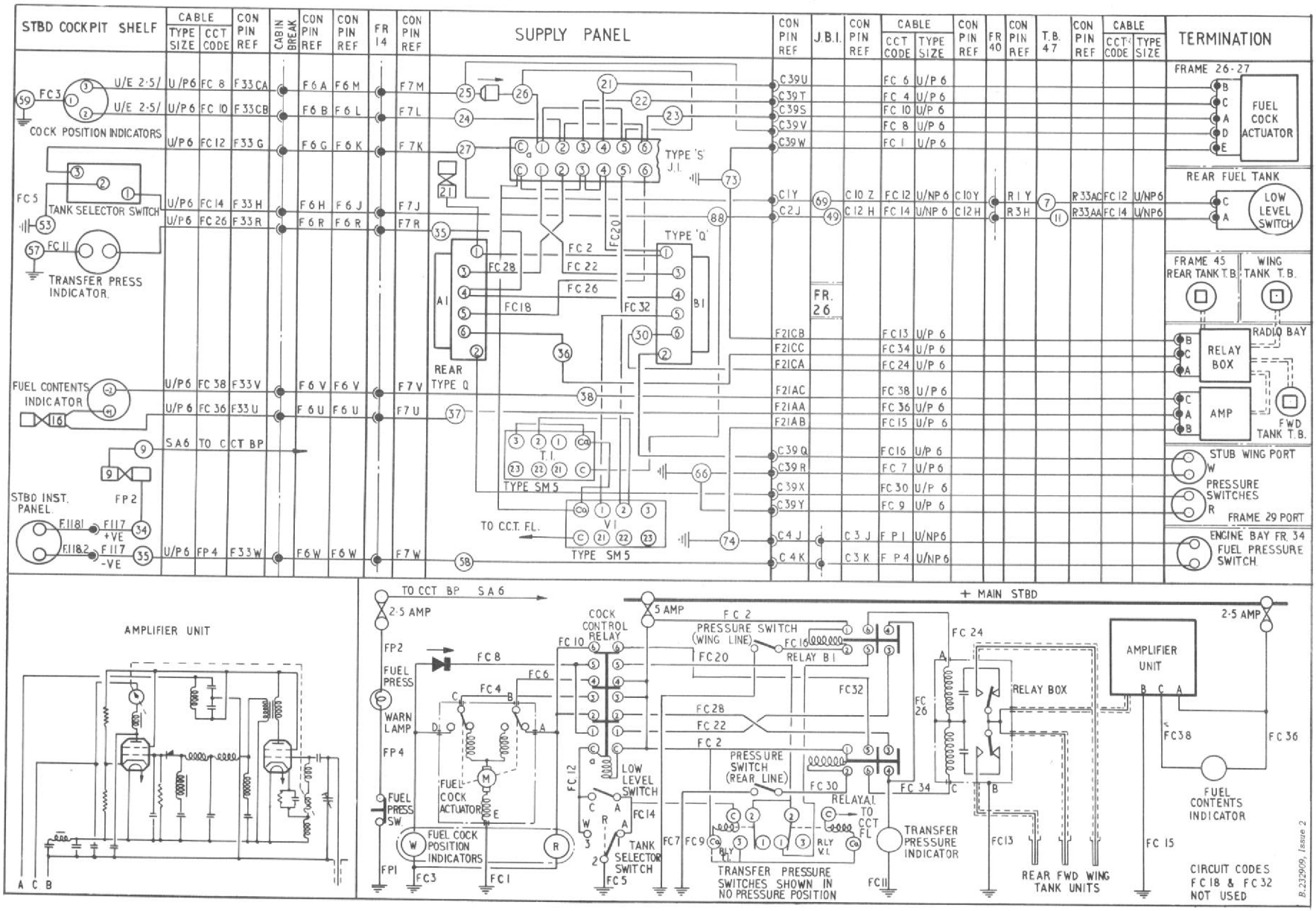

Fig. 1 Fuel content gauge, pressure and cock control (port)

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switch is placed in the WING position the cock control relay J.1 will be energized causing the fuel actuator to move the fuel cock, thus enabling fuel to be transferred, when pressurized, from the wing and drop tanks to the front tank. The fuel cock position indicator will also be energized to indicate the changed position of the fuel cock.

Engine running 'AUTO' selected

8. When the engine is started with the fuel tank selector switch placed in the 'AUTO' position, which is the normal condition, all tanks are pressurized and both fuel pressure switches are closed. Fuel is now available to the engine in the sequence, front and rear tanks with automatic changeover to front and wing, which includes drop tanks, when the rear tank is empty. The automatic changeover is governed by the operation of the low level switch in the rear tank. The pressure switches complete the circuits of the transfer pressure, relays A.1 and B.1 which in turn control relays in the 'internal' fuel relay box. The supply to relays A.1 and B.1 is via the cock control relay contacts, the fuel cock actuator limit switch, contacts of the unenergized relay V1 and the transfer pressure relay contacts. The rear, wing and inboard drop tanks capacitor units are now connected to the amplifier. The fuel gauges will read the summation of front, rear, wing and inboard drop tank contents.

Automatic fuel cock

9. The low level switch closes as the rear tank empties and completes the circuit of the cock control relay via the AUTO position of the tank selector switch. Contacts 3-3a of the cock control relay complete a circuit through the fuel cock actuator, which operates to connect the wing tank line to the front tank and to disconnect the rear tank from the front tank. While the actuator is operating, contacts 4-4a and 6-6a of the cock control relay break the power supply to the relays within the 'internal' fuel relay box. This supply is made again via contacts 3-3a and 5-5a of the cock control relay when the actuator has completed its travel and its limit switch closes across contacts C and D. This circuit arrangement ensures that faulty operation of the actuator will result in a 'fail safe' state of indication by causing the fuel gauges to indicate the contents of the front tank only. When the rear tank is again filled and the selector switch returned to AUTO the actuator will run in a reverse direction after the low level switch opens, to restore normal starting conditions.

REAR or WING selected

10. When the engine is started with the tank selector switch at REAR the fuel gauge again reads the summation of front, rear, wing and inboard drop tanks contents. Fuel will be fed to the front tank from the rear tank but operation of the rear tank low level switch will NOT now result in automatic changeover to the wing tank supply. Observation of the falling indication of the fuel gauge and operation of the fuel low level warning lamp will give warning of necessity to select WING on the tank selector switch. When this switch is closed the coil of the cock control relay will be energized via the WING position of the switch independent of the rear tank fuel low level switch. The fuel cock actuator will then operate, as described in paragraph 9, connecting the wing and inboard drop tanks to the front tank.

Fuel transfer indication

11. When the transfer pressure line switches and relays operate, a supply is fed to the transfer pressure indicator via contacts of the fuel cock control relay and a limit switch of the fuel cock actuator. This supply circuit changes over automatically when the tank selector switch is in AUTO and the low level switch in the rear tank operates to give indication of continuous fuel transfer.

Fuel pressure warning (Code FP)

12. The operation of the fuel pressure warning is such that when the engine pump delivery pressure falls below 3-3½ lb/sq.in., the engine fuel pressure switch contacts close and complete the supply to energize the indicator lamp, mounted on the starboard instrument panel, which will show to give warning of this condition.

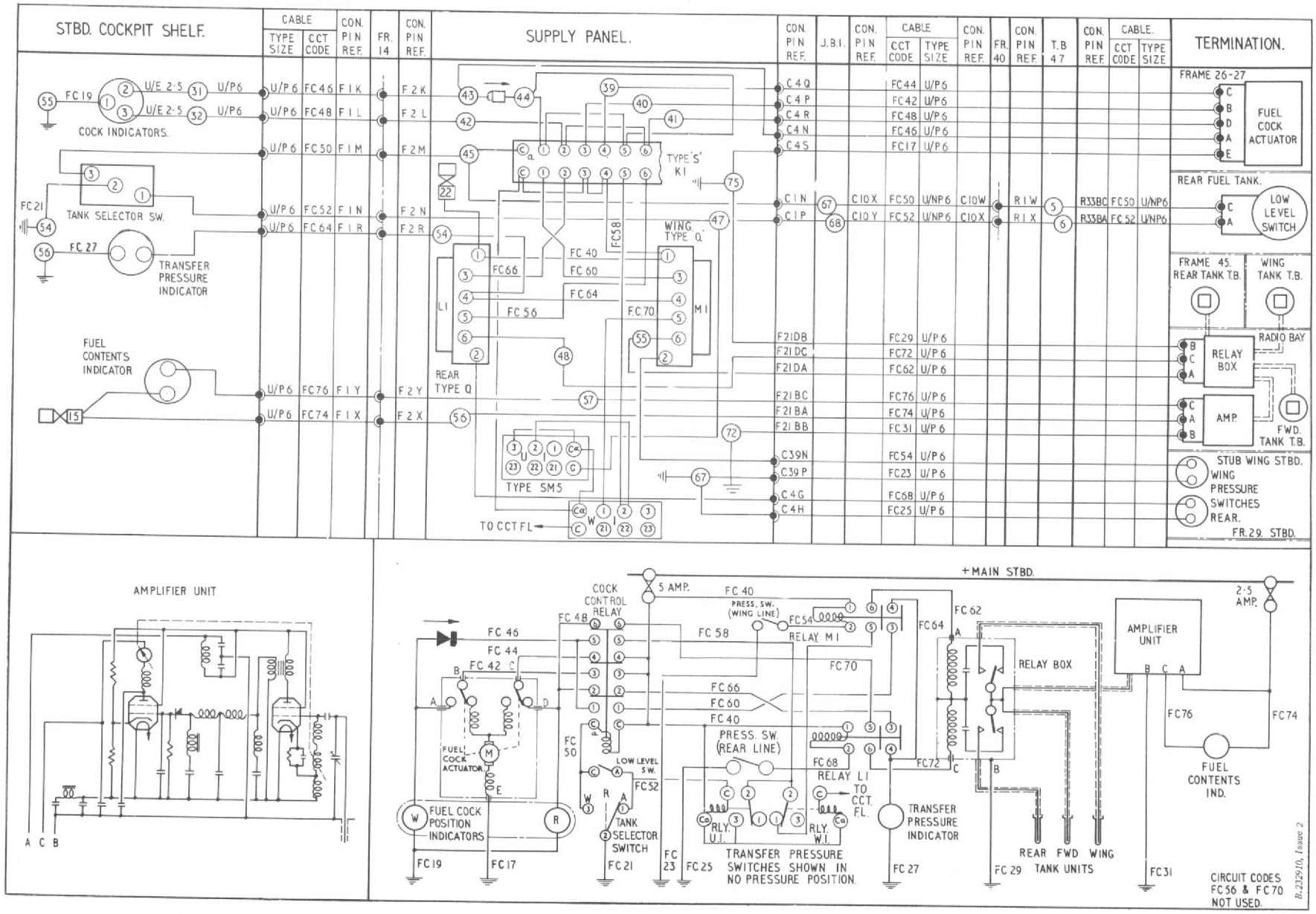

Fig.2 Fuel content gauge and cock control (starboard)

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Fuel low level warning (Code FL)

13. A pair of warning lamps, which are mounted on the starboard glare shield, adjacent to the camera warning lamps, in the cabin, are provided to indicate when the fuel in the port and starboard forward tanks is at a low level. These lamps are operated by the lower switch of the double fuel level float switch installed in each front tank. The upper switch of this unit is employed in the pressure refuelling circuit *(Sect.5, Chap.1, Group C.3)*.

Operation

14. The operation of the port and starboard forward fuel low level warning systems are similar, therefore, only the function of the port system will be described. When the fuel in the tank drops to 650 lb. the contacts of the lower switch are made and a supply is fed to the coil of relay V.1. With relay V.1 energized, current is fed from the circuit fuse through the warning lamp to earth via the closed contacts 22-23 of the relay. Thus the lamp will light giving an indication of fuel low level. A routeing and theoretical diagram of the fuel low level warning circuit is given in fig.3.

Outboard drop tanks empty indicators *(Code FC)*

15. Two magnetic indicators are fitted on the cabin starboard shelf to give the pilot a visible indication when the outboard drop tanks are empty. These indicators are controlled by float switches located one in each outboard drop tank. The contacts of each switch are made as long as there is fuel in the tank and the indicator is energized to show BLACK. As the outboard drop fuel tanks are ungauged and feed into the wing tanks the fuel content gauges will show 'full contents' until the drop tanks are empty.

Operation

16. The operation of the outboard drop tanks empty indicator circuit should be self-evident once reference has been made to the circuit diagram *(fig.4)*. For a full description of the indicators and float switches reference should be made to the Air Publications listed in Table 1.

SERVICING

General

17 Apart from the servicing information given in the following paragraphs, all other servicing and the standard serviceability tests, together with the equipment to be used and the method of conducting the tests are contained in the appropriate sections of A.P.1275A, Vol.1 and A.P.1275T Vol.1. Before servicing or removing any of the electrically, operated instruments the aircraft must be rendered electrically safe *(Sect.5, Chap.1, Group A.1)*.

Fuel contents gauges

Data and tolerances of units

18. The following figures are given in order that the units may be checked individually. The equipment listed below should be used for carrying out the tests and must be of the accuracy stated:-

(1) Variable capacitor -
Range 100 to 2300 pF.
Accuracy ± 1 pF at any point on its range.

(2) Milliammeter * -
Range 0 to 7.5 mA, 0 to 15mA, 0 to 30 mA.
Accuracy to BS89 precision grade.

(3) Voltmeter -
Range 0 to 40 Volts.
Accuracy to BS89 precision grade.

(4) F.C.A. amplifier -
Tested using the above instruments for conformation to the limits given in paragraph 26.

(5) 250 volt d.c. insulation resistance meter -

*Alternatively, a d.c. potentiometer and standard resistance may be used.

Tank units

19. The initial capacitance quoted in Table 2 is measured with the tank unit moist but thoroughly drained of all fuels. Measurements must be carried out with the unit well clear of metal objects, and with the leads a minimum of six inches apart. The capacitance of flexible tank units fitted with non-detachable leads should be measured taking care to keep the unit remote from any structure which will affect the capacitance value. The unit should be suspended in air by the anchor plate, remote from the leads, at least twelve inches from any object. The live

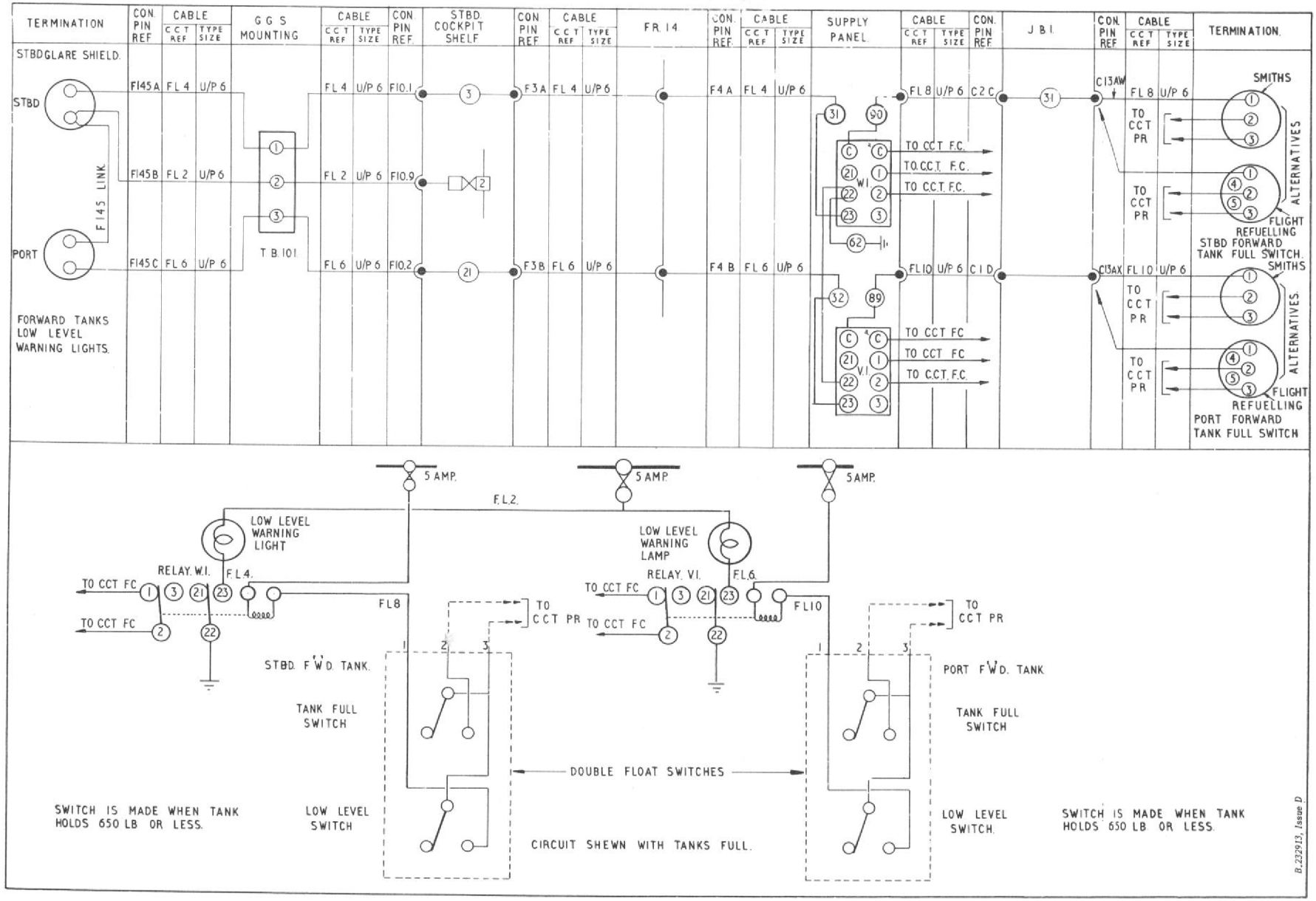

Fig.3. Fuel low level warning

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lead attached to the tank unit should be rolled up into a coil ¾ in. in diameter and kept as far away from the earth lead as possible. The earth lead may be left free. Insulation resistance of at least 20 megohms should be obtained for a new or replacement unit before installation.

TABLE 2
Tank units

Code	Initial capacitance (pF)	Tank
TC.94	227 ± 3	Front
TC.95	287 ± 3	Front
TC.127	124 ± 10	Rear
TC.180	50 ± 3	Wing
TC.181	74 ± 3	Wing
TC.182	74 ± 3	Wing
TC.183	118 ± 3	Wing
65.TN	252 ± 5	Drop

Note . . .

The values and tolerances given in Tables 2, 3 and 4 are based on the use of a precision air capacitor, i.e. Sullivan Air Capacitor or Smiths Test Set Code QC129 (Ref.6C/2214). If the Smiths Test Set Code QAA (Ref.6C/864) is used, each tolerance should be increased by 10% of the tank unit value plus the tolerance in Table 2, 3 or 4.

Tank terminals

20. The capacitance of the tank terminals is given below. The terminals should have an insulation resistance of at least 20 megohms.

Code JM 14 Capacitance 23 ± 3 pF.
Code JU 6 Capacitance 23 ± 3 pF.

Complete tank with tank terminal

21. The capacitance values for the tanks complete with terminals is given in Tables 3 and 4. The insulation resistance of a complete tank installation measured at the tank terminal coaxial socket should not be less than 1 megohm. Tanks should be completely drained of all fuel before carrying out the check. Flexible fuel tanks must be measured in the form they take installed in the aircraft and under no circumstances must they be folded during capacitance tests.

Coaxial cables

22. Coaxial cables should have an insulation resistance of at least 20 megohms whether new or installed. Cable details are given in Table 5.

Cable boxes, Code BW.43 and BW.44

23. All the capacitance figures given in Tables 6, 7 and 8 should be measured at the front socket. Before checking the range values of a box, the trimmers must be adjusted to their nominal value. The range into, and out of, the box is the increase in the capacitance above 2 mA, while the capacitance out of the box figure is the "tanks empty" capacitance of the amplifier less the capacitance of the connecting cable. When checking the box input minimum or maximum values, it is useless to check one trimmer in a group as they are complementary to each other in that group. To check the box input capacitance, ALL the trimmers in that group must be adjusted to their minimum or maximum value. As each cable box contains an internal circuit connected to earth, it is useless to subject them to an insulation resistance test. These units may be considered serviceable if they conform to the capacitance figures given in the tables.

Coaxial connectors

24. Coaxial connectors should have an insulation resistance of at least 20 megohms. Connector details are given in Table 9.

Cable boxes, Code BT.20-16

25. The capacitance values for these cable boxes are given in Table 10. An insulation resistance check may be made by using a 250 volt d.c. insulation tester to check the resistance between each of the coaxial connector central conductors and bodies with the cable box relay initially energized then de-energized. The measured resistance should not be less than 20 megohms.

Amplifiers, Code F.C.A.

26. The relationship between the indicator current and capacitance with a power supply of 28 volts is given in Table 11. The amplifiers contain a 150 volt working condenser, which would be damaged by the higher megger voltage, thus an insulation resistance test must not be carried out on these units. They may be considered serviceable if they conform to the capacitance/indicator current test figures given in the table using the accurate test equipment *(para.18)*.

Power supply -

Nominal voltage 28 volts.
Current at 28 volts 0.7 amps. (approx.)

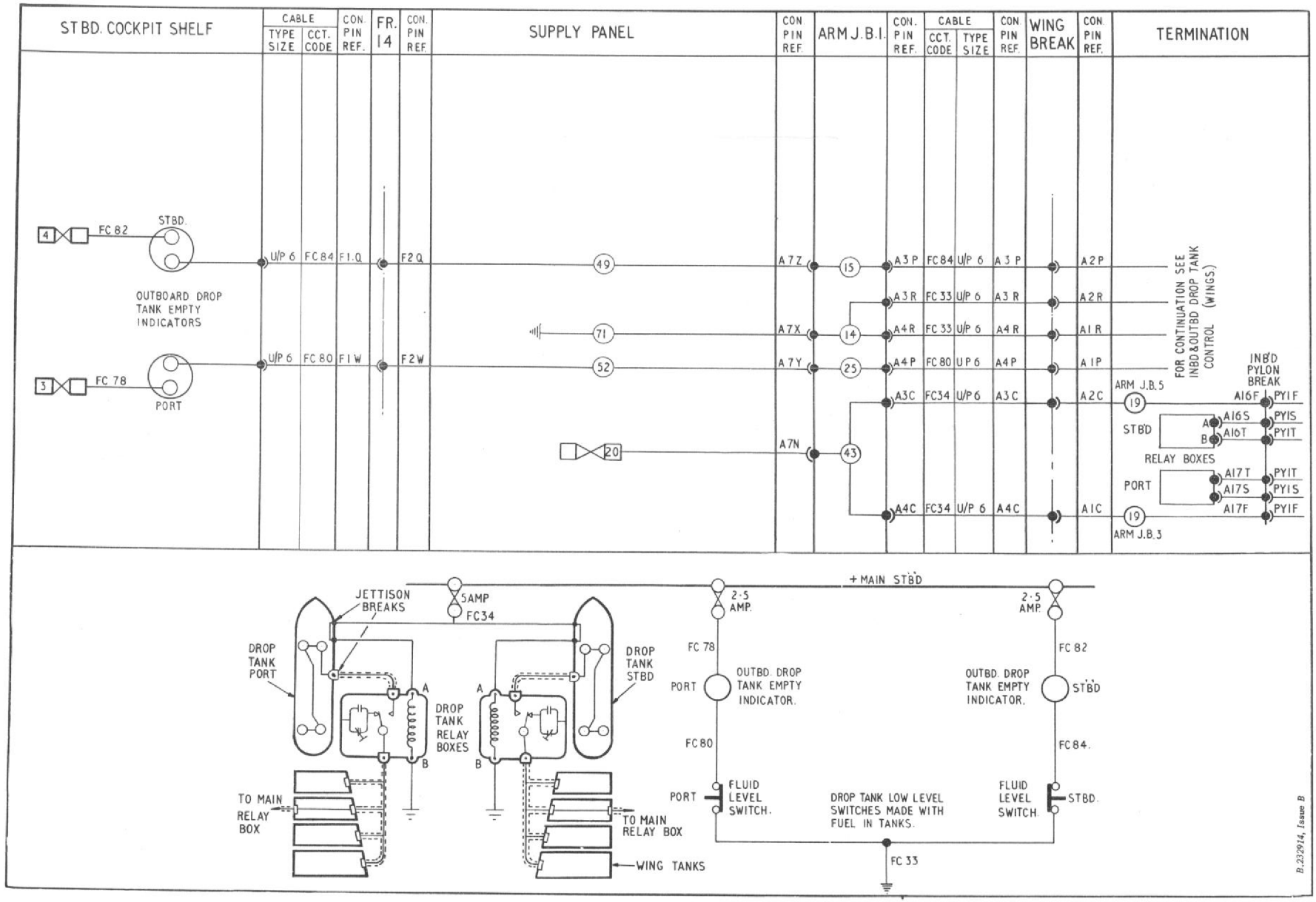

Fig.4. Outboard drop tanks empty indication and inboard drop tanks gauging

TABLE 3

Fuselage tanks

(Port and starboard)

Tank	Empty, out of aircraft	Installed, wet and pressurized
Front	593 ± 20 pF	638 ± 25 pF
Rear	200 ± 15 pF	220 ± 20 pF

◀ See note after Table 2 ▶

Capacitance -

Initial (or tanks empty) 1500 pF.
Tanks full 2500 pF.

Coaxial harness, Code CGB1

27. The capacitance of the coaxial harness is 235 ± 10 pF and it should have an insulation resistance of at least 20 megohms.

Accuracy of the fuel gauge installation

28. The accuracy of the system depends on the supply voltage being maintained at the required figure and the physical properties of the fuel conforming to specification. The calibration of the fuel gauges is based on a kerosene fuel having a permittivity of 2.10 and a specific gravity 0.779 at a temperature of 20 deg.C.

Errors of the fuel gauge in normal flight

29. The following Tables 13 and 14 will enable an operator to obtain an approximate error from true reading caused by system inaccuracies and by various conditions of temperature, supply voltage, fuel permittivity and density. All errors are expressed as a percentage of indicated fuel contents per deg.C.

TABLE 4 Wing tanks (Port and starboard)

Tank	Empty, out of aircraft	Installed dry	Installed, wet and pressurized
No.1	158 ± 15 pF	172 ± 15 pF	190 ± 15 pF
No.2	116 ± 15 pF	133 ± 15 pF	152 ± 15 pF
No.3	149 ± 20 pF	173 ± 20 pF	207 ± 20 pF
No.4	88 ± 15 pF	102 ± 15 pF	110 ± 15 pF
Drop	1305 ± 53 pF	1305 ± 53 pF	1305 ± 53 pF

◀ **Note . . .**

See note after Table 2. Wet and dry values for a drop tank are as for an empty tank, due to un-usable fuel not being in contact with gauging unit. ▶

Note . . .

(A) The fuel contents gauge is calibrated for a supply voltage of 28 volts d.c. To obtain maximum accuracy the voltage must be adjusted to this figure.

Note . . .

(B) The figure given in Table 15 will enable an operator to calculate errors when using fuel differing in permittivity and density from those for which the gauge is calibrated (para.28). It should be noted that the errors listed in column (4) of Table 15 are not extreme errors to be expected when using the fuels defined in column (1). The errors given are those which may be present when using fuels conforming to the permittivities and densities listed in columns (2) and (3). The errors have been calculated from the highest and lowest values obtained by laboratory measurement of fuel samples

TABLE 5
Coaxial cables

Code	Length (ins.)	Capacitance (pF)
CJ.136	136	227 ± 23
CJC.65	65	109 ± 11
CJC.166	166	277 ± 28
CR.30	30	54 ± 3
CR.65	65	117 ± 3
CR.154	154	277 ± 5
CR.192	192	346 ± 5
CR.228	228	411 ± 5
CRC.54	54	97 ± 3
CRC.146	146	262 ± 5
CRP.36	36	65 ± 3
CS.21	21	38 ± 3

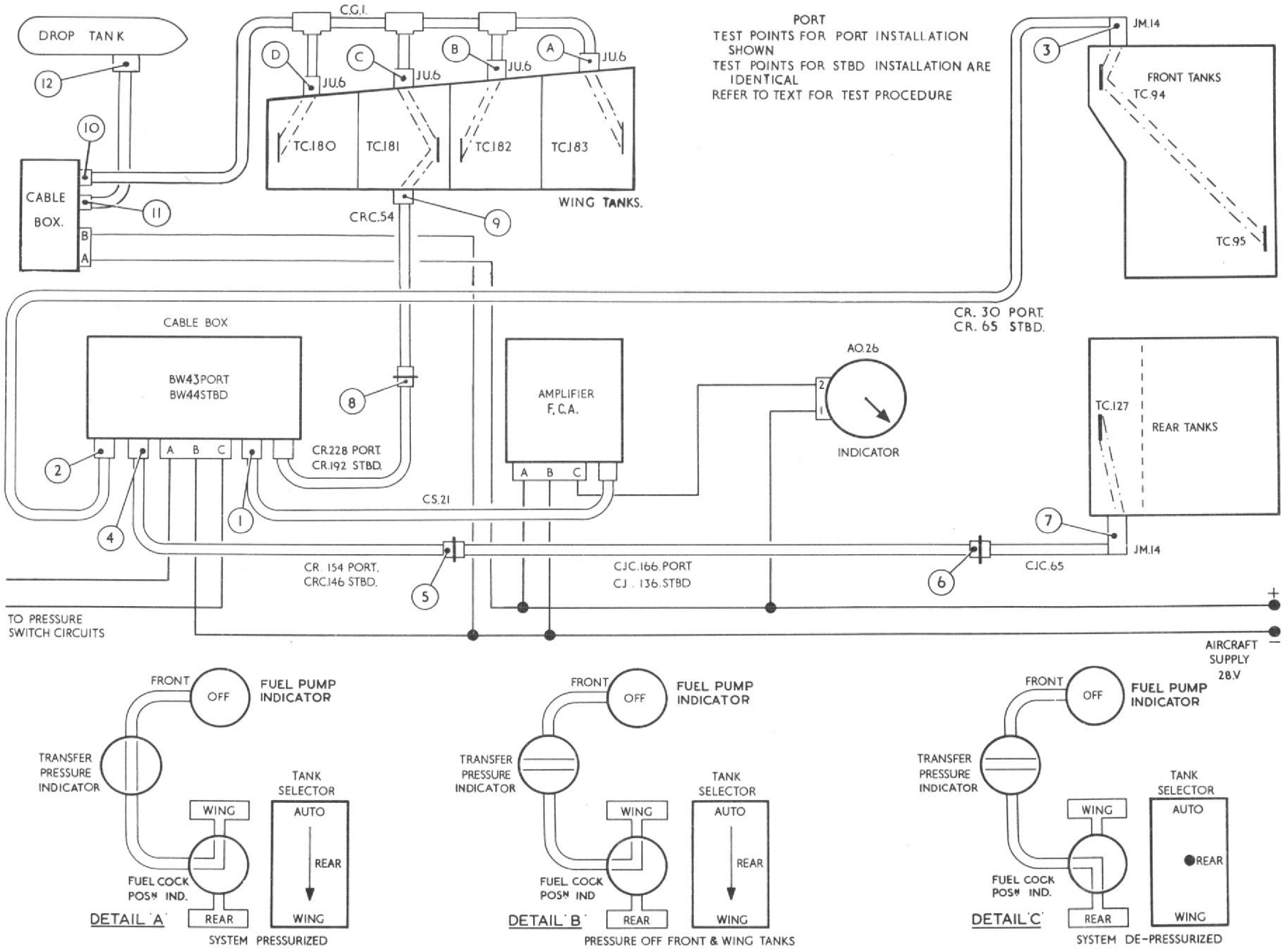

Fig.5 Fuel content gauge tank test points

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TABLE 6

Cable boxes - Summation
(both relays energized)

Code	"Tanks empty" capacitance into box at front input socket: Trimmer at min. not less than	Box input nominal value	Trimmer at max. not more than	"Tanks empty" capacitance out of box	Range out of box	Range into box
BW.43	4577 pF	4344 pF	4111 pF	1462 pF	1000 pF	2246 ± 20 pF for 2-7 mA
BW.44	4508 pF	4280 pF	4052 pF	1462 pF	1000 pF	2246 ± 20 pF for 2-7 mA

Note . . .

(C) Since fuel permittivity does not always vary exactly in relation to density, an error may exceed that quoted or the sign of an error may reverse. Should a fuel be used which differs from that defined in columns (2) and (3), the mass indication for the fuel will be in error by a factor equal to $\frac{k-1}{d} \cdot \frac{do}{ko-1}$ *i.e. the capacitance index of the fuel divided by that for the standard.*

Note . . .

(D) The correction to be made to the indicator reading to indicate true contents is equal in magnitude but opposite in sign to the error given.

Note . . .

(E) Each unit of the fuel gauge is manufactured to a desired capacitance with an associated tolerance. The probable errors due to possible combinations of the tolerances and to readability are summarised in Table 16 and the maximum errors in Table 17. Errors are expressed for summation reading with drop tanks fitted.

Checking the fuel gauge installation

30. Apart from the normal inspection for physical damage, the installation on this aircraft requires no maintenance during service other than the functional *(or tanks drained)* check. The fault location checks should be carried out, using the code QAA test set, which is described in A.P.1275T, Vol.1. The figures quoted for these checks should only be employed as a quide when using the QAA test set, the necessary standard of accuracy not being obtainable with this instrument. If a unit appears to deviate greatly from the figures quoted, it should be removed from the aircraft and checked, with the test equipment *(para.18)* or alternatively, replaced by a new unit and the fault location test repeated. A unit should not be rejected solely on the evidence of the test set. It is permissible to change a valve in an amplifier, but this must be replaced only by a Code ZAA valve supplied by Smiths Aircraft Instruments Ltd. After a valve replacement has been carried out the amplifier must pass a capacitance/indicator current test *(para.26)*, again using the equipment referred to in paragraph 18. It has already been stated that errors will arise due to variations of temperture acting on fuel and on components and to supply variation *(para.29)*. Probable errors due to these conditions, together with those possible by a combination of tolerances and readability are summarised in in Table 18 and the maximum errors in Table 19.

Functional check

(Pre Mod.953 or when gauged drop tanks are not fitted)

31. This check should be carried out at the times quoted in the aircraft's

TABLE 7

Cable boxes - front and rear tanks
(unenergized relay connected to pin A)

Code	"Tanks empty" capacitance into box at front input socket: Trimmer at min. not less than	Box input value	Trimmer at max. not more than
BW.43	1639 pF	1559 pF	1479 pF
BW.44	1640 pF	1560 pF	1480 pF

Servicing Schedule or after any major unit of the installation is changed or whenever the tanks are drained. The check ensures a correct reading on the indicators when the tanks are drained of all normally usable fuel, and acts as a guide to the correct operation of the gauge. The setting-up procedure, using the locally manufactured test switch assembly described in A.P. 1275T, Vol.1, Sect.5, is as follows:-

(1) Ensure that the aircraft's electrical supply is switched off.

(2) Disconnect the 3 pin sockets from the tank relay boxes B.W.43 *(port)* and B.W.44 *(starboard)*.

(3) Connect the test switch sockets to the tank relay boxes and the d.c. supply plug to the aircraft's battery voltage test socket.

(4) Connect a 28 ± 0.5 volt d.c. power supply to the aircraft's external supply plug and switch ON.

TABLE 8

Cable boxes - front and wing tanks
(unenergized relay connected to pin C)

Code	"Tanks empty" capacitance into box at front input socket: Trimmer at min. not less than	Box input nominal value	Trimmer at max. not more than
BW.43	3533 pF	3477 pF	3421 pF
BW.44	3526 pF	3475 pF	3424 pF

(5) Fill and then drain the complete fuel system to the residual fuel level.

(6) Maintain the aircraft's fuel system pressurized at normal working pressure.

(7) Disconnect the drop tank coaxial cable from the BT.20-16 cable box. Connect the QAA test set to the drop tank connection on the BT.20-16 cable box and set the test set capacitor to inject 1370 pF *(allowing for connecting cables)*. Then energize the relay in the BT.20-16 cable box.

(8) Operate the test switches to energize the REAR and WING tank relays of the relay boxes B.W.43 and B.W.44. Trim the summation circuits to zero using the four trimmers marked SUM on the B.W.43 and B.W.44 relay boxes.

(9) De-energize the relay in the BT.20-16 cable box and trim the drop tank matching circuit to zero in the BT.20-16 cable box.

TABLE 9

Connectors - inboard drop tanks

Code	Capacitance
59 CO	192 ± 19 pF
70 CO	75 ± 8 pF
PAL 9	15 ± 3 pF

(10) Operate the test switches to de-energize the REAR and WING tank relays of the relay boxes. Trim the REAR matching circuits to zero using the trimmers marked REAR C.O.

(11) With the REAR tank relays still de-energized as at operation (10), operate the test switch to de-energize the WING tank relays of the relay boxes. Trim the WING matching circuits to zero using the trimmers marked WING C.O.

(12) Switch OFF the power supply, disconnect the test switch assembly and reconnect the tank relay boxes B.W.43 and B.W.44 into the aircraft's circuit.

(13) This check does not guarantee the accuracy of the system throughout the range. If the system proves suspect the units should be individually tested in accordance with the Servicing Schedule.

TABLE 10

Cable box - inboard drop tanks

Code	Capacitance of box with relay unenergized at the wing tank socket: Trimmer at min.not more than	Box input nominal value	Trimmer at max.not less than	Capacitance of box with relay energized
BT.20-16	1314 pF	1370 pF	1426 pF	12 ± 3 pF

As the cable box, Code BT.20-16 is a junction box, range valves do not apply.

32. If the test switch assembly is not available, the fuel contents gauges may be set-up as follows:-

(1) Connect a 28 ± 0.5 volt power supply to the aircraft's external supply plug and switch ON.

TABLE 11

Amplifier capacitance/indicator Current

Capacitance (pF)	Indicator Current (mA)
1500	2.0 ± .03
1700	3.0 ± .05
1900	4.0 ± .05
2100	5.0 ± .05
2300	6.0 ± .05
2500	7.0 ± .05

(2) Fill and then drain the complete fuel system to the residual fuel level.

(3) Pressurize the complete fuel system to the normal working pressure. Ensure that the tank selector switches are placed in the 'AUTO' position.

(4) At the supply panel temporarily disconnect and isolate wires C.I.D. from terminal 89 and C.2.J. from terminal 88 *(port circuit)* and wires C.2.C. from terminal 90 and C.1.P. from terminal 47 *(starboard circuit)*, i.e. break the circuit through the rear and front tank low level switches.

(5) Disconnect the drop tank coaxial cable from the BT.20-16 cable box. Connect the QAA test set to the drop tank connection in the BT.20-16 cable box and set the test set capacitor to inject 1370 pF *(allowing for connecting cables)*. Then energize the relay in the BT.20-16 cable box.

(6) Using the four trimmers marked SUM in the B.W.43 and B.W.44 relay boxes, trim the circuit summation to zero.

TABLE 12

Indicators

Indication (pounds)	Indicator Code AO-62	Indication (pounds)	Indicator Code AO-62
0	2.00	1800	4.84
100	2.13	1900	4.98
200	2.28	2000	5.10
300	2.45	2100	5.22
400	2.61	2200	5.35
500	2.78	2300	5.48
600	2.91	2400	5.61
700	3.08	2500	5.73
800	3.24	2600	5.85
900	3.39	2700	5.99
1000	3.54	2800	6.12
1100	3.70	2900	6.27
1200	3.87	3000	6.44
1300	4.02	3100	6.63
1400	4.16	3200	6.78
1500	4.31	3300	6.95
1600	4.53	3400	7.11
1700	4.69		

TABLE 13

Temperature

Temp.	−40°C	−20°C	+20°C	+50°C	+70°C
Tank empty	+0.96	+0.64	0	−0.48	−0.8
1/10	+1.2	+0.8	0	−0.6	−1.0
1/3	+1.68	+1.12	0	−0.84	−1.4
2/3	+2.4	+1.6	0	−1.2	−2.0
Full	+3.12	+2.08	0	−1.56	−2.6

TABLE 14

Supply voltage

Supply voltage	24V	28V	29V
All fuel levels	− 1.5	0	+ 0.8

(7) De-energize the relay in the BT.20-16 cable box and trim the drop tank matching circuit to zero in the BT.20-16 cable box.

(8) Maintaining the system pressurized and with 'AUTO' selected, re-connect C.2.J. to terminal 88 and C.1.P. to terminal 47, i.e. remake the circuit through the rear tank low level switch.

(9) Using the two trimmers marked 'REAR CO' in the B.W.43 and B.W.44 relay boxes trim the rear tank matching circuit to zero.

TABLE 15

Fuel variations

(1) Fuel	(2) Permittivity k	(3) gm/ml d	Density Tank empty	1/10	(4) % Errors 1/3	2/3	Tank full
BRITISH							
AVTAG/DERD 2486	2.035	0.739	0	− 0.08	− 0.3	− 0.6	− 0.8
(J.P.4B or F-40)	2.180	0.825	0	+ 0.1	+ 0.4	+ 0.8	+ 1.3
AVTUR/DERD 2482	2.035	0.780	0	− 0.6	− 2.0	− 4.0	− 6.0
(J.P.1B or F-33)	2.165	0.810	0	+ 0.2	+ 0.6	+ 1.2	+ 1.8
AVCAT/DERD 2488	2.156	0.817	0	0	− 0	0	0
(J.P.5B or F-42)	2.161	0.817	0	+ 0.05	+ 0.16	+ 0.32	+ 0.5
AMERICAN							
J.P.1 (MIL-F-5616	2.093	0.8030	0	− 0.4	− 1.2	− 2.4	− 3.7
or F-33)	2.186	0.8479	0	− 0.09	− 0.3	− 0.6	− 0.9
J.P.3 (MIL-F-5624C)	1.997	0.7434	0	− 0.5	− 1.6	− 3.2	− 5.0
	2.270	0.8300	0	+ 0.8	+ 2.8	+ 5.6	+ 8.3
J.P.4 (MIL-F-5624C	2.020	0.7467	0	− 0.3	− 1.1	− 2.1	− 3.2
or F-40)	2.106	0.8251	0	− 0.5	− 1.7	− 3.4	− 5.1

(10) Re-connect C.1.D. to terminal 89 and C.2.C. to terminal 90, i.e. remake the circuit through the front tank low level switch.

(11) Using the two trimmers marked "WING CO" in the relay boxes, trim the wing matching circuits to zero.

(12) Release all pressure in the tanks.

(13) This check does not guarantee the accuracy of the system throughout the range. If the system proves suspect the units should be individually tested in accordance with the Servicing Schedule.

TABLE 16

Probable errors

Tank Condition	Error % Full Scale
Empty	± 0.30
1/10	± 0.37
1/3	± 0.79
2/3	± 1.49
Full	± 2.22

Post Mod.953, with gauged drop tanks fitted

33. This check should be carried out at the times quoted in the aircraft's Servicing Schedule or after any major unit of the installation is changed or whenever the tanks are drained. The check ensures a correct reading on the indicators when the tanks are drained of all normally usable fuel, and acts as a guide to the correct

TABLE 17

Maximum errors

Tank Condition	Error % Full Scale
Empty	± 0.30
1/10	± 0.94
1/3	± 2.42
2/3	± 4.54
Full	± 6.66

TABLE 18

Probable errors

Tank Condition	Error % Full Scale
Empty	± 1.73
1/10	± 1.92
1/3	± 2.52
2/3	± 3.60
Full	± 4.80

operation of the gauge. The setting-up procedure, using the locally manufactured test switch assembly described in A.P. 1275T, Vol.1, Sect.5, is as follows:-

(1) Ensure that the aircraft's electrical supply is switched OFF.

(2) Disconnect the 3 pin sockets from the tank relay boxes BW.43 *(port)* and BW.44 *(starboard)*.

(3) Connect the test switch sockets to the tank relay boxes and the d.c. supply plug to the aircraft's battery voltage test socket.

(4) Connect a 28 ± 0.5 volt d.c. power supply to the aircraft's external supply plug and switch ON.

(5) Fill and then drain the complete fuel system to the residual fuel level.

(6) Maintain the aircraft's fuel system pressurized at normal working pressure.

(7) Operate the test switches to energize the REAR and WING tank relays of the relay boxes BW.43 and BW.44. Trim the summation circuits to zero using the four trimmers marked SUM on the BW.43 and BW.44 relay boxes.

(8) Disconnect the Mk.4 breeze socket at the Code BT.20-16 cable box in the wing and trim the drop tank matching circuit to zero in the BT.20-16 cable box.

(9) Re-connect the Mk.4 breeze socket at the BT.20-16 cable box.

(10) Operate the test switches to de-energize the REAR and WING tank relays of the relay boxes. Trim the REAR matching circuits to zero using the trimmers marked REAR C.O.

(11) With the REAR tank relays still de-energized as at operation (10), operate the test switch to de-energize

TABLE 19

Maximum errors

Tank Condition	Error % Full Scale
Empty	± 2.60
1/10	± 3.58
1/3	± 5.79
2/3	± 8.97
Full	± 12.16

the WING tank relays of the relay boxes. Trim the WING matching circuits to zero using the trimmers marked WING C.O.

(12) Switch OFF the power supply, disconnect the test switch assembly and reconnect the tank relay boxes BW.43 and BW.44 into the aircraft's circuit.

34. If the test switch assembly is not available, the fuel contents gauges may be set-up as follows:-

(1) Connect a 28 ± 0.5 volt power supply to the aircraft's external supply plug and switch ON.

(2) Fill and then drain the complete fuel system to the residual fuel level.

(3) Pressurize the complete fuel system to the normal working pressure. Ensure that the tank selector switches are placed in the 'AUTO' position.

(4) At the supply panel temporarily disconnect and isolate wires C.1.D. from terminal 89 and C.2.J. from terminal 88 *(port circuit)* and wires C.2.C. from terminal 90 and C.1.P. from terminal 47 *(starboard circuit)*, i.e. break the circuit through the rear and front tank low level switches.

(5) Using the four trimmers marked SUM in the BW.43 and BW.44 relay boxes, trim the circuit summation to zero.

(6) Disconnect the Mk.4 breeze socket at the Code BT.20-16 cable box in the wing and trim the drop tank matching circuit to zero in the BT.20-16 cable box.

(7) Re-connect the Mk.4 breeze socket at the BT.20-16 cable box.

(8) Maintaining the system pressurized and with 'AUTO' selected, reconnect C.2.J. to terminal 88 and C.1.P. to terminal 47, i.e. remake the circuit through the rear tank low level switch.

(9) Using the two trimmers marked 'REAR CO' in the BW.43 and BW.44 relay boxes trim the rear tank matching circuit to zero.

TABLE 20

Test Points *(Port System)*

Test point	A Test capacitance (pF)	B Test capacitance (pF)	Adapters and cables used	Approximate reading on Aircraft's indicator	Test set meter
1	1462 ± 3	1304 ± 8	CC1, CE1	Zero contents	2 mA
2	692 ± 28	542 ± 31	CE1	" "	"
3	638 ± 25	480 ± 30	CC1, CE1	" "	"
4	883 ± 64	733 ± 67	CE1	" "	"
5	606 ± 59	448 ± 64	CC1, CE1	" "	"
6	329 ± 31	171 ± 36	CC1, CE1	" "	"
7	220 ± 20	–	CC1, *	" "	"
8	2374 ± 137	2216 ± 142	CC1, CE1	" "	"
9	2277 ± 134	2119 ± 139	CC1, CE1	" "	"
10	1382 ± 59	1224 ± 64	CC1, CE1	" "	"
11	1370 ± 56	1220 ± 59	CC1	" "	"
12	1305 ± 53	1143 ± 57	CE1, CGA 75	" "	"

* Use a cable of known capacitance, less than 125 ± 3 pF basic Code CS.

TABLE 21

Test points *(Starboard system)*

Test point	A Test capacitance (pF)	B Test capacitance (pF)	A Adapters and cables used	Approximate reading on Aircraft's indicator	Test set meter
1	1462 ± 3	1304 ± 8	CC1, CE1	Zero contents	2 mA
2	755 ± 28	605 ± 31	CE1	" "	"
3	638 ± 25	480 ± 30	CC1, CE1	" "	"
4	819 ± 59	669 ± 62	CE1	" "	"
5	556 ± 54	398 ± 59	CC1, CE1	" "	"
6	329 ± 31	171 ± 36	CC1, CE1	" "	"
7	220 ± 20	—	CC1, *	" "	"
8	2374 ± 137	2216 ± 142	CC1, CE1	" "	"
9	2277 ± 134	2119 ± 139	CC1, CE1	" "	"
10	1382 ± 59	1224 ± 64	CC1, CE1	" "	"
11	1370 ± 56	1220 ± 59	CE1	" "	"
12	1305 ± 53	1143 ± 57	CE1, CGA 75	" "	"

* Use a cable of known capacitance less than 125 ± 3 pF, basic code CS.

(10) Reconnect C.1.D. to terminal 89 and C.2.C. to terminal 90, i.e. remake the circuit through the front tank low level switch.

(11) Using the two trimmers marked 'WING CO' in the relay boxes, trim the wing matching circuits to zero.

(12) Release all pressure in the tanks.

(13) This check does not guarantee the accuracy of the system throughout the range. If the system proves suspect the units should be individually tested in accordance with the Servicing Schedule.

Insulation resistance check

35. This check should be carried out periodically with at least the same frequency as an insulation resistance check is made on the remainder of the aircraft's electrical system. Using a 250-volt insulation resistance tester, the individual units should conform to the tolerances quoted in paragraph 18. It is important that insulation resistance checks should not be carried out on amplifiers, cable boxes and indicators, and it is preferable that the tanks are completely drained of fuel before the checks are commenced.

WARNING

A 250-volt insulation tester only should be used, as the application of voltages above 300 may cause a tank explosion if there is a distorted or otherwise damaged tank unit present.

Fault location checks

General

36. Apart from failure in the 28-volt d.c. supply, a fault in the installation will only affect one indicator, therefore, in the majority of instances it will only

TABLE 22

Test points
(Wing system)

Point at which test capacitance is connected	Value of tank unit, plus internal wiring measured at tank terminal
A	190 ± 15 pF
B	152 ± 15 pF
C	207 ± 20 pF
D	110 ± 15 pF

be necessary to carry out a check on one side of the system. The method of testing each side of the system is identical, but the test values are a little different due to certain cable dissimilarities. These values are given in Tables 20 and 21.

Check on amplifier and indicator

37. Connect the QAA test set between an amplifier and its power supply as described in A.P.1275A, Vol.1. Move the test set's selector switch to position 1 and then to position 2, thereby checking the power supply and current into the amplifier by noting the test set meter reading. This procedure is explained in greater detail in A.P.1275A, Vol.1. If an unsatisfactory result is obtained, check back to the source of the power supply.

38. To test the circuit between an amplifier and indicator, tum the test set's selector switch to position 3. As the output of the F.C.A. amplifier varies between approximately 2 and 7 mA over the range of 'tanks empty' to 'tanks full' the test set meter reading should be between these two limits, depending on the amount of fuel on board. If a satisfactory result is not obtained, the fault could be either with the amplifier and associated tank circuit or with the indicator and its circuit. To check which of these two is at fault, move the selector switch to position 4. This cuts out the circuit to the indicator and if a satisfactory result is still not obtained, the fault must be in the amplifier or in the tank circuit. If a satisfactory reading is obtained, the fault lies in the indicator circuit.

39. Disconnect the tank circuit coaxial cable from the amplifier and substitute the coaxial cable supplied with the test set; connect the other end of the cable to either of the coaxial sockets on the test set. This arrangement is shown in A.P.1275A, Vol.1. The test set's cable has a capacitance of 150 pF, therefore if the variable capacitor on the test set is adjusted to 1350 pF a capacitance of 1500 pF will be fed into the amplifier. If the selector switch is now placed at position 3 or 4 the test set meter should read approximately 2 mA. This procedure should be repeated for each of the settings given in Table 11, and the amplifier checked for approximate accordance with the values given.

Check on tank circuits

40. Figure 5 of this group shows that each test point is numbered starting at the BW-Series cable box output and working to the tanks. These numbers will be found in Table 20 and 21, together with the capacitance that must be connected at each point to give an indication of approximately 2 mA on the test set meter and a reading of zero contents on the indicator. When testing beyond points 3, 7, 10 and 12 it is essential that the tanks are drained of all usable fuel, and the system pressurized.

41. If the amplifier has proved serviceable, reconnect, the aircraft's coaxial cable to the amplifier and disconnect it at point 1 of the associated system. The test set's coaxial cable must now be connected to the aircraft's cable, employing the Pye-Waymouth adapter supplied with the test set.

42. The variable capacitor should now be set to 1500 pF, less the capacitance of the aircraft's CS.21 cables *(port and starboard)*, test set cable and adapter; the resultant value to be fed into the system is the figure given in the table. The indicator should now read approximately zero contents and the test set meter about 2 mA. This process is repeated at each of the remaining connection points throughout the system, the variable capacitor value being set to the figures given in the appropriate table as each unit is connected back into the installation until a complete check has been carried out.

43. The capacitance values given have the total tolerance at each particular test point quoted alongside. The desired meter reading of 2 mA, should therefore, be obtainable with the variable capacitor setting within these limits, provided that

the system trimmers are correctly adjusted. On no account should the cable box trimmer settings be altered; these settings should only be adjusted during a functional check.

44. The method of checking the units installed in the port and starboard wing tanks is a little different to that described in the preceding paragraphs and is described below.

45. Disconnect the coaxial harness CGB1 at points A, B, C, D and No.11 *(fig.5)* and connect the QAA test set to the amplifier as described in A.P.1275A, Vol.1. Using a suitable coaxial cable assembly and a Pye-Waymouth adapter, join the spare coaxial socket to any point of the harness. Set the variable capacitor to give a milliammeter reading of 5 mA and note the variable capacitor reading. Disconnect the harness, leaving the coaxial cable and adapter connected to the test set and re-adjust the variable capacitor to give a reading of 5 mA. The capacitance of the CGB1 harness is obtained by subtracting the first variable capacitor reading from the second and should be within the limits quoted in paragraph 27, plus ten per cent allowance for test set inaccuracies. This method is described in greater detail in A.P.1275A, Vol.1.

46. Assuming that the harness is serviceable, leave it disconnected; also disconnect the coaxial cable CRC54 from the JM14 tank terminal *(point 10)*. Employing the method detailed for the CGB1 harness, check each tank at points A, B, C and D which should be within the values given in Table 22.

47. The values quoted in column A of Tables 20 and 21 are the true capacitances to be connected at each point, whilst those in column B are the true capacitances less the actual test set variable capacitor settings, and the 'A' values are the theoretical values. Both are given to enable an operator to make allowances accordingly should a different method of connection be used.

Additional equipment required for checking wing tank system

48. The equipment issued with the standard QAA Mod.02 test set is insufficient when checking aircraft and/or components fitted with Pye coaxial plugs and sockets. On this aircraft the wing and drop tanks are so equipped. To meet these requirements a CGA75 adapter *(capacitance 12 ± 1 pF)* for testing at point 12 *(point and starboard)* only, and a CGA74 adapter *(capacitance 12 ± 1 pF)* for connecting to the drop tank terminal to enable the drop tank to be measured, are also required.

REMOVAL AND ASSEMBLY

General

49. The removal of the instrument panels and cabin shelves carrying the fuel content gauges, selector switches, pressure warning lamp, drop tanks empty and transfer pressure indicators, is fully described in Group 1B. Illustrations showing the location of all the components will be found in Group 1C. Once access has been obtained, the removal of the remaining items of equipment should present no difficulties.

Assembly of fuel cock actuators

50. To ensure correct assembly of the actuators to the transfer fuel cocks, proceed as follows:-

(1) Check that the cocks are selected to the correct position i.e. wing tanks to front tanks as follows:-

(a) Check on PORT cock that the red mark in the spindle slot lines up with the OPEN position marked on the mounting flange.

(b) Check on STARBOARD cock that the red mark in the spindle slot lines up with the SHUT position marked on the mounting flange.

(2) Check that the actuator visual indicators are correctly set for wings to front tanks selection. The PORT actuator should indicate OPEN and the STARBOARD actuator should indicate SHUT.

Note . . .

This can be checked by coupling the actuators to the aircraft's wiring, and with

an external supply connected, selecting wings to front tanks by use of the tank selector switch in the cabin.

(3) When the above conditions have been obtained, fit the actuators to the cock mounting flanges with joint washers between the faces and secure with the existing nuts and washers. Wire lock with 22 s.w.g. stainless steel wire to Spec.D.T.D. 189 or 161.