GROUP 2.A

FUEL CONTENT GAUGES, COCK CONTROL AND FUEL PRESSURE WARNING

(Completely revised)

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Introduction

1. This group contains a description, including the method of operation, of the fuel contents, cock control and fuel pressure warning circuits installed in this aircraft, together with the necessary servicing information required 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 contents, cock control and fuel pressure warning equipment employed in this aircraft is listed in Table 1, together with the appropriate Air Publications to which reference should be made for a detailed description and the necessary servicing required to maintain them in an efficient condition.

TABLE 1

Equipment type and Air Publication reference

Equipment Type	Air Publication
Content gauges, Type AO-26, Mod.01 Gauge amplifiers, Type FAB or FAB/18 Relay boxes, Type BW.13 and 14 Tank units, Type TC.94, 95, 127, 180, 181, 182 and 183	A.P.1275A, Vol.1, Sect.18
Pressure switches, Type TP.1200 or 5252/1 Low level switches, Type C.3504100/38 Forward tank float switches, Flight Refuelling Type D.3504147 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, Rotax Type D.5406	A.P.4343C, Vol.1, Book 1, Sect. 1
Transfer pressure failure indicators, Dowty Mk.7 Drop tank empty indicators, Type B.2 Engine fuel pressure warning lamp, Type A Fuel low level warning lamps, Type B Fuel cock position indicators, Type CZ.74109/2	A.P.4343E, Vol.1, Book 4, Sect.18
Relays A.1, B.1, M.1 and L.1, Type Q No.1 Relays T.I, U.1, V.1 and W.1, Type SM.5	A.P.4343C, Vol.1, Book 2, Sect. 3
Cock control relays, Type S No.3 Fuel cock actuators, Type CZ.54709/5/F	A.P.4343D, Vol.1, Book 3, Sect.16

DESCRIPTION

Fuel content gauges and cock control (Code FC)

3. This is a 28-volt electronic installation. The two Smiths-Waymouth gauges, one for the port and another for the starboard tanks, 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 drop tanks, thus :-

(a) All tanks *(summation)*

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

(c) Front and wing tanks *(should pressure fail in the rear tank and when fuel cock actuator is at "wings").*

(d) Front tank only *(in the event of transfer pressure failure or by operation of the front tank low level switch).*

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 capacitor gauge units fitted within each tank, via two relay boxes and amplifier units mounted in the radio bay. These tank relay boxes are controlled by four relays, located adjacent to the supply panel, which in

turn are controlled by four pressure switches positioned, one in each of the rear and wing tank fuel outlet lines, at frame 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 operated from the relays controlling the fuel gauge relay boxes and the fuel cock position indicators are controlled by cock control relays located on the supply panel. These latter relays also control the operation of two fuel cock actuators, mounted between frames 26 and 27. The cock control relays are controlled by the tank selector switches, positioned on the cabin starboard shelf and by the low level float switches mounted in the rear fuel tanks.

6. Routeing and theoretical diagrams of the circuits are given in fig.1 and 2 of this group, while the fuel system as a whole is covered in Sect.4, Chap.2 of this volume. For a detailed description of the gauges and the operation of the system, reference should be made to the Air Publications listed in Table 1.

Operation

Power OFF condition

7. As the port and starboard fuel contents gauge and cock control systems are separately fused and provided with independent control equipment, it is only necessary to follow the operation of the port system to fully understand both installations. The theoretical diagram shows the state of the circuit 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, while the pressure switches and the float switch will be open. The fuel cock actuator will be holding the fuel cock in the position which allows fuel to flow from the rear tank to the forward tank, and the fuel cock position indicator will show this state. The transfer pressure indicator will indicate no flow and the fuel gauges will not be registering.

Power On, engine not running

8. When the battery master switch is closed, prior to starting the engine, the amplifier and gauge will commence operation. The gauge will now indicate the contents of the front tank only, since the capacitor unit in this tank is always connected to the amplifier, and the system is not yet pressurized. Dummy capacitances, located in the tank relay box and matching the "tank empty" values of the rear and wing tank units are also in circuit. If the tank selector switch is in the 'REAR' or 'AUTO' position the control cock relay will remain de-energized, causing the fuel cock and fuel cock indicator to remain in the rear tank to forward tank position. If, however, the tank selector switch is placed in the 'WING' position, the cock control relay will be energized, causing the fuel cock actuator to move the fuel cock, thus enabling fuel to be transferred, when pressurized, from the wing tank to the forward tank. The fuel cock position indicator will also be energized to indicate the changed position of the fuel cock.

Engine running - "AUTO" selected

9. When the engine is started with the fuel tank selector switch at "AUTO", 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' tanks including 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, B.1, which in turn control relays in the tank relay boxes. The supply to the rear tank relays is via relay J *(4 - 4a)*, the fuel cock actuator rear tank limit switch, relay J *(6a - 6)* and relay A.1 *(5 - 6)*. The wing tank relays are supplied via the 5 amp circuit fuse, relay T.1 *(3 - 2) (permanently made when Auto is selected)*, relay V.1 *(2 - 1)* and relay B.1 *(5 - 6)*. Front, rear and wing tank capacitance units are therefore connected to the amplifier and the gauge will show the total contents of all three tanks.

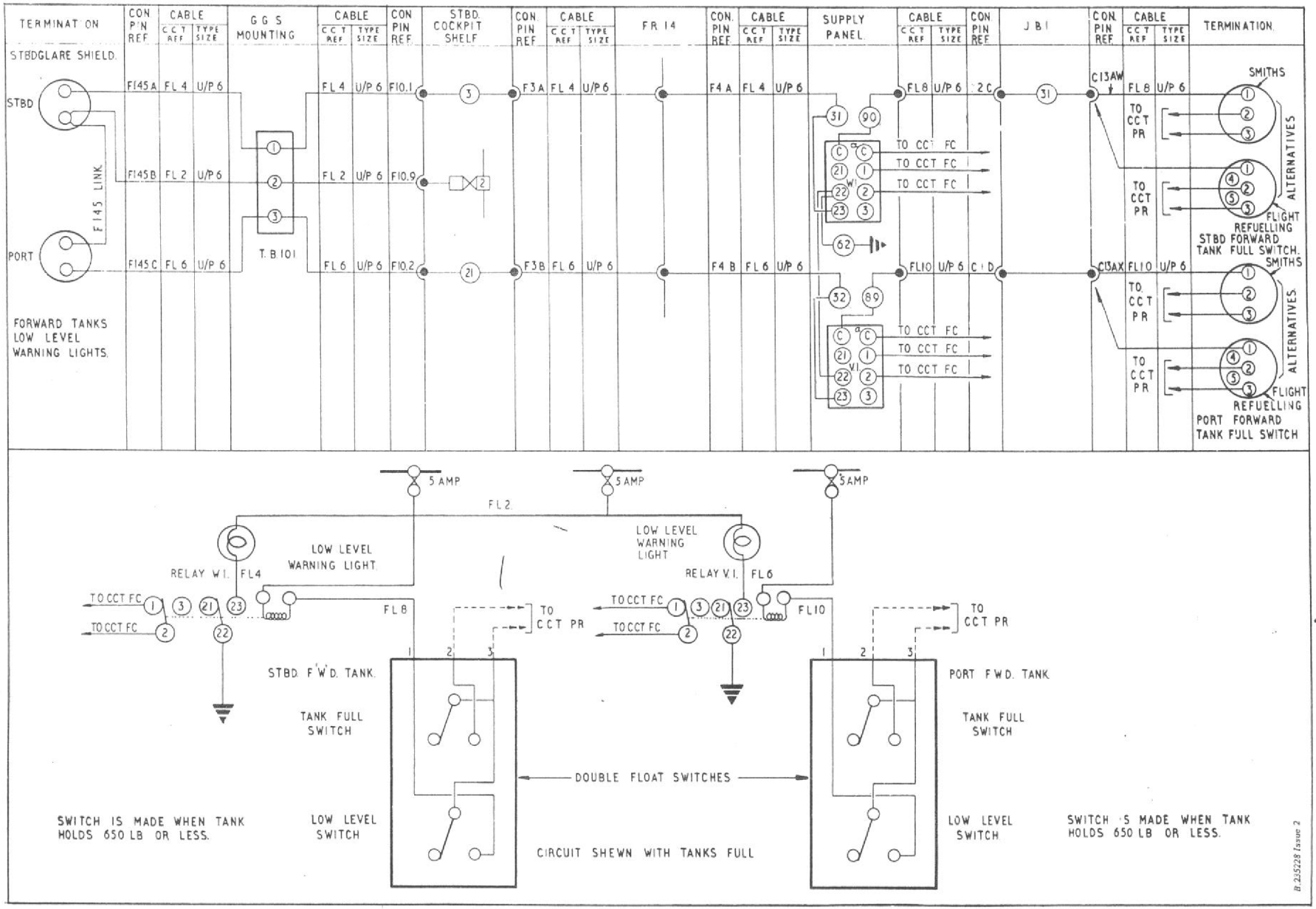

Fig.3 Fuel low level warning

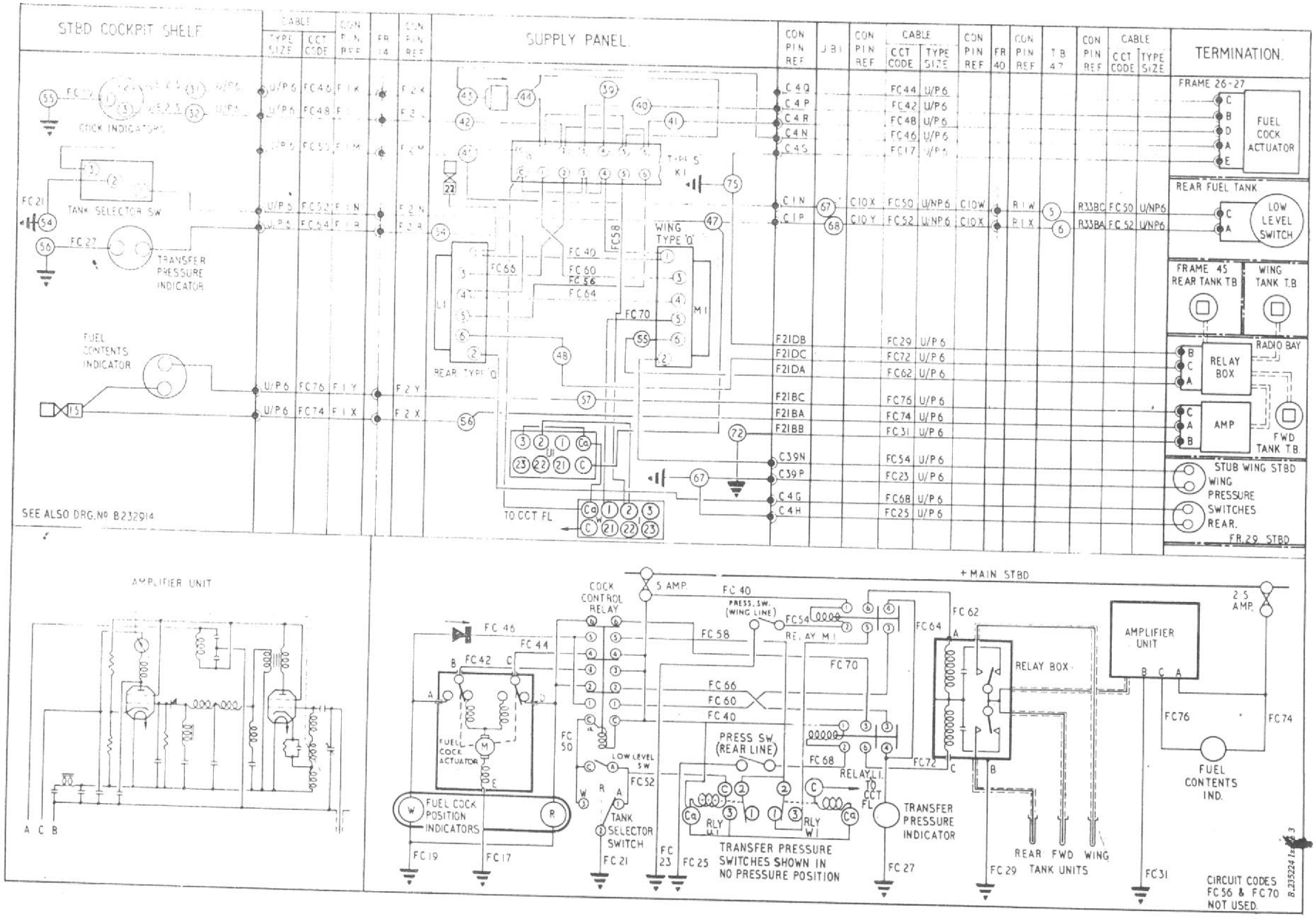

Fig. 2 Fuel content gauge and cock control (starboard)

RESTRICTED

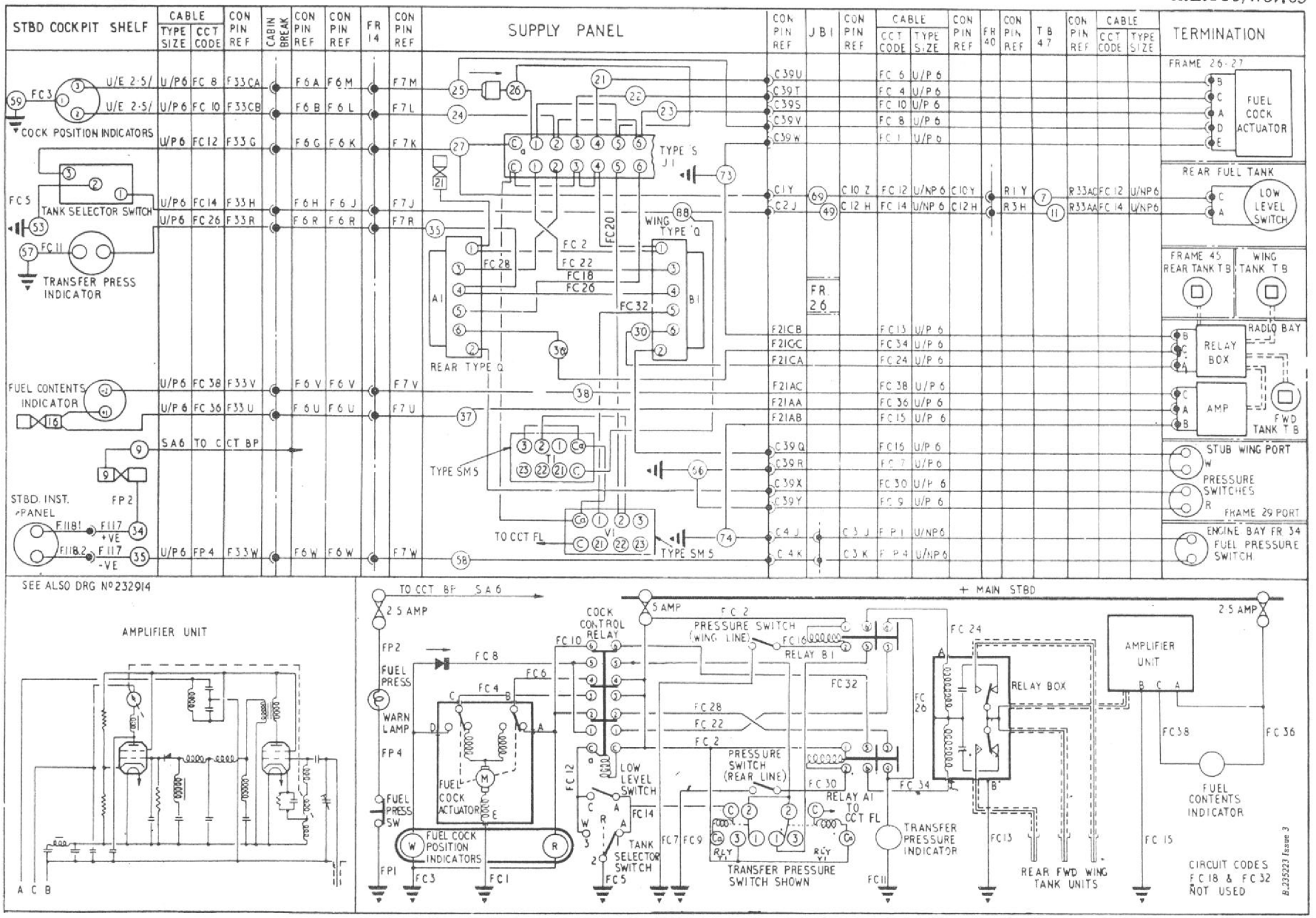

Fig. 1 Fuel content gauge, pressure and cock control (part)

Automatic fuel cock operation

10. The low level switch closes as the rear tank empties and completes the circuit of the cock control relay coil via the "AUTO" position of the tank selector switch. Contacts 3-3a of this relay then 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 this actuator is operating the contacts 4-4a and 6a-6 of the cock control relay break the power supply to the rear tank relay in the tank relay box. Any unusable residual fuel in the rear tank is, therefore, not indicated. When the actuator has completed its travel and its limit switch makes contacts C and D, a second positive is connected to relay V.1, terminal 2 via relay J *(3 - 3a)*, the fuel cock actuator wing tanks limit switch, and relay J *(5a - 5)*. If the fuel cock actuator fails to complete its full travel, the fuel cock position indicator will not change over, nor will the supply to relay V.1, via relay J, be made. The wing tank contents, however, will still be shown on the gauge by virtue of the original supply from the circuit fuse. This condition will remain until the fuel level in the front tank has dropped sufficiently to operate the low level switch, which energises relay V.1. and breaks the circuit to the wing tank relay. Thereafter, only the fuel contained in the front tank, i.e. the usable fuel, will be gauged.

'REAR' or 'WING' selected

11. When the engine is started with the tank selector switch at 'REAR' the fuel gauge will show only a summation of the contents of the front and rear tanks as the supply to the wing tank relay is broken at relay T.1 which is de-energized. 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 change-over to the wing tank supply. Observation of the falling indication of the gauges and operation of the fuel low level warning lamps, will give warning of the necessity to select 'WING' on the switch. When this is done the cock control relay coil will be energized, via the 'WING' position of the selector switch, independent of the rear tank fuel low level switch. The fuel cock actuator will then operate as described in para.10, connecting the wing tanks to the front tank, and the total contents of the front and wing tanks will be registered on the gauge.

Fuel transfer indication

12. 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, whether tank selection is at AUTO or by manual control, to give indication of continued fuel transfer pressure.

Fuel pressure warning (Code FP)

13. The operation of the fuel pressure warning circuit is such that when the engine pump delivery pressure falls below 3-3½ lb/sq in, the engine fuel pressure switch contacts close and make the supply to energize the indicator lamp, mounted on the starboard instrument panel which will show to give warning of this condition. The circuit is shown in fig.1.

Fuel low level warning (Code FL)

14. A pair of warning lamps, mounted on a small bracket located on the port glare shield adjacent to the R.P. selector panel in the cabin, are provided to indicate when the fuel in the port and starboard forward tanks falls to 650 lb. These lamps are operated by the contacts *(23 - 22)* of relay V.1. which is energised by the lower switch of the double fuel level float switch unit installed in each front tank The upper switch of this unit is employed in the pressure refuelling circuit as described in Group C.3, Chap.1. A routeing and theoretical diagram of the 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.

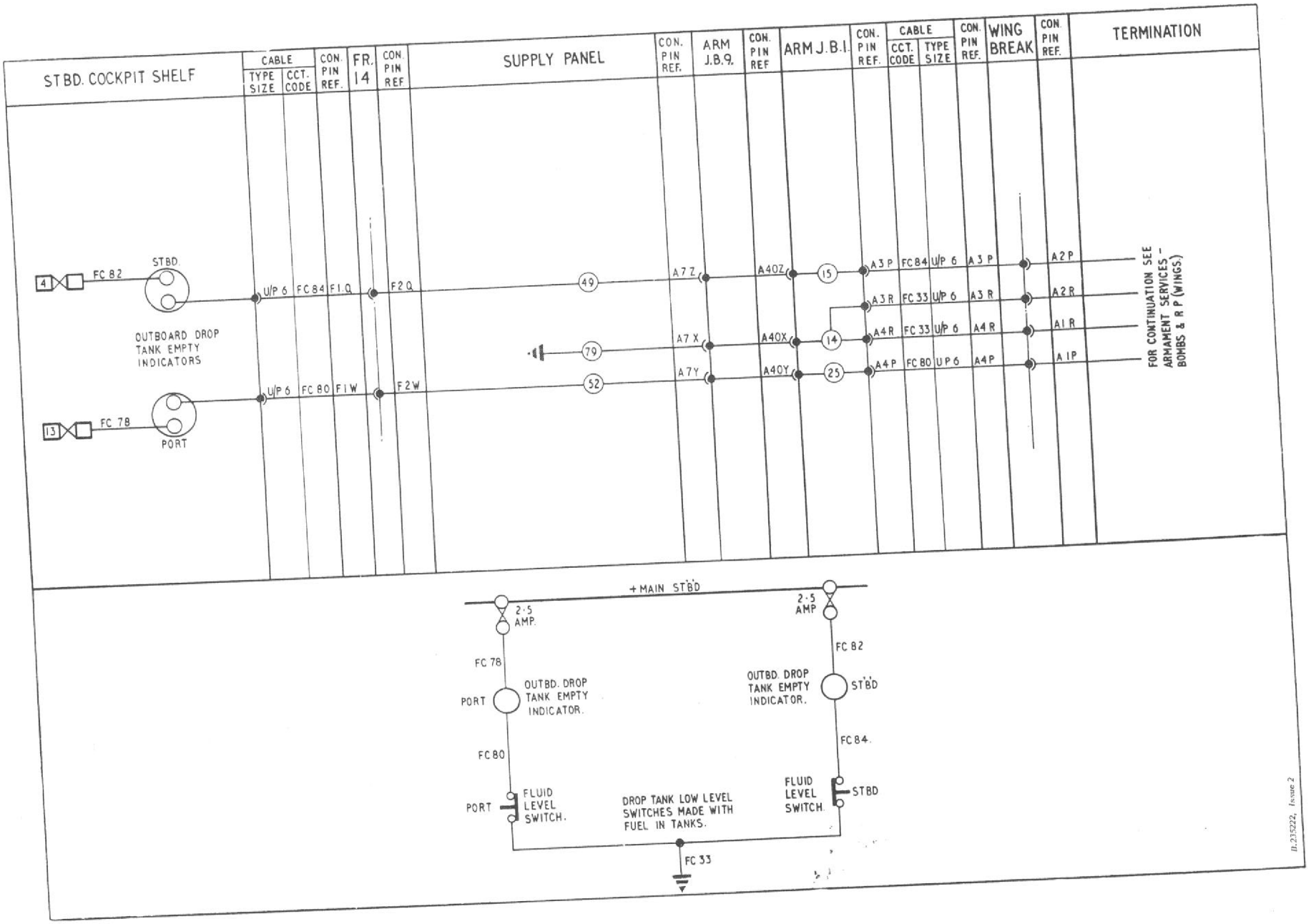

Fig. 4 Outboard drop tanks empty indicators

16. Since the drop fuel tanks are ungauged and feed into the wing tanks, it should be appreciated that the fuel content gauges *(para.3)* will show front and wing tanks full until such time as the drop tanks are empty.

Operation

17. The operation of the outboard drop tanks empty indicator circuit will be obvious once reference has been made to the circuit diagram *(fig.4)* of this group. Reference should also be made to the Air Publications listed in Table 1 for a full description of the indicators and float switches.

SERVICING

General

18. 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 and T, Vol.1. Before servicing or removing any of the electrically-operated instruments the aircraft must be rendered electrically safe, as described in Sect.5, Chap.1, Group A.1 of this volume.

Fuel content gauges

Data and tolerances on units

19. These figures are given in order that the units may be checked individually. The following equipment should be used for carrying out the tests and must be of at least 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 15 mA, 0 to 30 mA
Accuracy to BS.89 precision grade

(3) Voltmeter -
Range 0 to 40 volts.
Accuracy to BS.89 first grade

(4) FAB/18 amplifier -
Tested using the above instruments for conformation to the limits given in para.26.

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

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

Tank units

20. The initial capacitance quoted in Table 2 is measured with the tank unit moist, but thoroughly drained of all fuel. Measurements must be carried out with the unit well clear of all 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 lead attached to the tank unit should be rolled up into a coil ¾ 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

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

21. The capacitance of the tank terminals

is as follows. The terminals should have an insulation resistance of at least 20 megohms.

Code JM14 Capacitance 23 ± 3 pF

Code JU6 Capacitance 23 ± 3 pF

Complete tank with tank terminal

22. 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 above 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.

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

Coaxial cables

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

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

See note after Table 2

Cable boxes, Code BW.13 and BW.14

24. 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 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.

25. As each cable box contains a coil 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.

Amplifiers, Code FAB/18

26. The relationship between the indicator current and capacitance with a power

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.146	146	262 ± 5
CRC.54	54	97 ± 3
CS.21	21	38 ± 3

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.13	2985 pF	2821 pF	2657 pF	712 pF	500 pF	1047 pF
BW.14	2914 pF	2755 pF	2596 pF	712 pF	500 pF	1047 pF

supply of 28 volts is given in Table 9. 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 referred to in para. 19.

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 nominal value	Trimmer at max. not more than
BW.13	1623 pF	1543 pF	1463 pF
BW.14	1622 pF	1542 pF	1462 pF

Power supply -

Nominal voltage 28 volts.

Current at 28 volts 0.7 amps. (approx.)

Capacitance -

Initial (or tanks empty) 750 pF

Tanks full 1250 pF

Range 500 pF

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.13	2026 pF	1970 pF	1914 pF
BW.14	2019 pF	1968 pF	1917 pF

Coaxial harness, Code CG.1

27. The capacitance of the coaxial harness is 136 ± 5 pF and it should have an insulation resistance of at least 20 megohms.

Indicators

28. Early aircraft are fitted with AO-26 indicators, while later aircraft have AO-26 Mod.01 indicators installed. It is essential that both port and starboard indicators should be of the same code; if they differ, the pilot will have a false indication of his fuel balance state. An insulation resistance test should not be carried out on the indicators. These may be considered serviceable if they conform to the figures given in Table 10.

TABLE 9

Amplifier capacitance/indicator current

Capacitance (pF)	Indicator current (mA)
750	2.0 ± .03
823	3.0 ± .05
908	4.0 ± .05
1005	5.0 ± .05
1120	6.0 ± .05
1250	7.0 ± .05

TABLE 10

Indicators

Indication (pounds x 100)	Indicator Code AO-26 Mod.01 current (mA)	Indicator Code AO-26 current (mA)
0	2.00	2.00
1	2.38	2.38
2	2.81	2.82
3	3.25	3.25
4	3.66	3.64
5	4.03	4.00
6	4.33	4.30
7	4.66	4.62
8	4.94	4.90
9	5.25	5.19
10	5.59	5.51
11	5.91	5.80
12	6.20	6.06
13	6.43	6.33
14	6.73	6.56
15.10(F)	7.00	6.82

Accuracy of the fuel gauge installation

29. It will be realised from the nature of the system that its accuracy depends, amongst other things, on the supply voltage being maintained at the required figure and the physical properties of the fuel conforming to specification. The calibration

TABLE 11

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

of this gauge is based on a kerosine 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

30. The following tables 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 the total indication, with the exception of fuel temperature errors, which are expressed as a percentage of indicated fuel contents per degree Centigrade.

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 figures given in Table 13 will enable an operator to calculate errors when using fuels differing in permittivity and density to those for which the gauge is calibrated (para.29). It should be borne in mind that the errors given in column (4) of Table 13 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 quoted in columns (2) and (3). The errors given have been calculated from the "highest" and "lowest" values obtained by laboratory measurement of fuel samples.

TABLE 12

Supply voltage

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

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 employed which differs to that defined on columns (2) and (3), the mass indication

for that fuel will be in error by a factor equal to $\frac{k-1}{d} \cdot \frac{do}{ko-1}$; *that is to say, 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 by 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. It is, therefore, possible, although unlikely, for all these to be either high or low in tolerance. For this reason Table 15 quoting the maximum system errors is given.

TABLE 13
Fuel variations

(1) Fuel	(2) Permittivity k	(3) Density gm/ml. Tank empty d		(4) % Errors 1/10	1/3	2/3	Tank full
			BRITISH				
AVTAG/DERD2486	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/DERD2482	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
AVÇAT/DERD2488	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

TABLE 14
Temperature variations acting on the fuel

Condition	% Error
Temperatures above +20 deg.C	−0.028/°C
Temperatures below +20 deg.C	+0.028/°C
For 50 deg.C fall in temperature	+1.40
For 50 deg.C rise in temperature	−1.40

Setting-up fuel content gauges

31. Before commencing to set-up the fuel gauges, ensure that the power supply to the amplifier is switched on for at least 15 minutes by placing the battery master

TABLE 15
System error (includes 0.3 per cent readability error)

Tanks empty	± 0.3
1/10	± 0.9
1/3	± 2.3
2/3	± 4.3
Full	± 6.5

switch to the ON position or by connecting an external supply to the aircraft's electrical system, before carrying out any adjustments. 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.13 *(port)* and B.W.14 *(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 B.W.13 and B.W.14. Trim the summation circuits to zero using the four trimmers marked SUM on the B.W.13 and B.W.14 relay boxes.

(8) 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.

(9) With the REAR tank relays still de-energized as at operation (8), 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.

(10) Switch OFF the power supply, disconnect the test switch assembly and reconnect the tank relay boxes B.W.13 and B.W.14 into the aircraft's circuit.

32.. If the test switch assembly is unavailable, the fuel contents gauges may be set-up as follows:-

(1) Connect a 28± 0.5 volt d.c. 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.

TABLE 16

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	712 ± 3	554 ± 8	CE1, CC1	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	1278 ± 80	1128 ± 59	CE1	" "	"
9	867 ± 75	709 ± 80	CC1, CE1	" "	"
10	770 ± 72	612 ± 77	CC1, CE1	" "	"

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

(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 aircraft's 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.I.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 B.W.13 and B.W.14 relay boxes, trim the circuit summation to zero.

(6) Maintain the fuel system pressurized and AUTO selected, reconnect wire C.2.J to terminal 88 and C.I.P. to terminal 47 i.e. remake the circuit through the rear tank low level switch.

(7) Using the two trimmers marked REAR C.O. in the relay boxes, trim the rear tank matching circuits to zero.

(8) Reconnect wires C.I.D. to terminal 89 and C.2.C to terminal 90 i.e. remake the circuit through the front tank low level switches.

(9) Using the two trimmers marked WING C.O. in the relay boxes, trim the wing matching circuits to zero.

(10) Release all pressure in the tanks and switch OFF the power supply.

TABLE 17

Test points (Starboard 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	712 ± 3	554 ± 8	CE1, CC1	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	389 ± 59	CC1, CE1	"	"
6	329 ± 31	171 ± 36	CC1, CE1	"	"
7	220 ± 20	62 ± 25	CC1, *	"	"
8	1213 ± 80	1063 ± 83	CE1	"	"
9	867 ± 75	709 ± 80	CC1, CE1	"	"
10	796 ± 70	638 ± 82	CC1, CE1	"	"

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

Checking the fuel gauge installation

33. 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 guide when using the QAA test set, the necessary standard of accuracy not being obtainable with this instrument. If, however, a unit appears to deviate greatly from the figures quoted, it should be removed from the aircraft and checked, using the accurate test equipment referred to in para.19, or alternatively, replaced by a new unit and the fault location test repeated. On no account should a unit be rejected solely on the evidence of the test set.

34. 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 *(paragraph 26)*, again using the accurate equipment referred to previously.

Functional check

35. 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. The check ensures a correct reading on the indicators when the tanks are drained of all normally usable fuel, and thus acts as a guide to the correct operation of the gauge. Each side of the system must be checked separately and therefore the following procedure must be carried out on each in turn.

36. Before commencing this test, the system must be pressurized to the normal working pressure, the tanks must also have been recently filled and then drained of all normally usable fuel. It is important to note that 15 minutes should be allowed to elapse to enable the tank units to completely drain, otherwise the tank units will have a higher capacitance than that quoted. In addition, the power supply to the amplifier must be switched on at least 15 minutes before the check is carried out.

37. If these conditions obtain, the indicator should read zero contents. If not, the trimmers marked SUM in the cable box must be revolved until the indicator gives a satisfactory reading.

38. The front and wing tanks should now be depressurized and the tank selector switch set to WING. The indicator should still show zero contents, but if not, the trimmers marked WING C/O in the cable box should be used to obtain the desired reading.

39. Release all the pressure from the system by setting the tank selector switch to REAR. The indicator should still show zero contents, but if not the trimmers marked REAR C/O in the cable box should be used to obtain the desired reading. It must be realised that this check in no way quarantees the accuracy of the system throughout the range and that if this is suspect the units should be individually tested with the equipment listed in para. 19.

Insulation resistance check

40. An insulation resistance check should be carried out periodically with at least the same frequency as this 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 laid down in para. 19 to 28. It is important to note that insulation resistance checks should not be carried out on amplifiers, cable boxes and indicators for the reasons stated previously, and that it is preferable that the tanks are completely drained of all 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*

41. Apart from failure in the 28-volt supply, a fault in the installation will only affect one indicator and therefore in the great majority of cases it will only be necessary to carry out a check on the one side of the system. The method of testing each side is identical, but the test values are naturally a little different owing to certain cable dissimilarities. These necessitate the two tables 16 and 17 found in this group.

Check on amplifier and indicator

42. The first part of a fault location check is carried out by connecting the test set between an amplifier and its power supply as described in A.P.1275T, Vol.1. Move the test set's selector switch first

to position 1 and then to position 2, thereby checking the power supply and current respectively into the amplifier by noting the test set meter reading; this procedure is explained in greater detail in the above Air Publication. If an unsatisfactory result is obtained, check back to the source of the power supply.

43. To test the circuit between an amplifier and indicator, turn the test set's selector switch to position 3. As the output of the FAB/18 amplifier varies between approximately 2 and 7 mA over the range of "tanks empty" to "tanks full", it follows that the test set meter reading should lie between these two limits, depending on the amount of fuel on board. If a satisfactory reading is not obtained, the fault could lie 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 lie in the amplifier or in the tank circuit. If a satisfactory reading is obtained, the fault lies in the indicator circuit. The foregoing procedure is explained at greater length in A.P.1275T, Vol.1 and a table that summarises it appears in that publication as well as on the lid of the test set itself.

44. Now disconnect the tank circuit coaxial cable from the amplifier and substitute the coaxial cable supplied with the test set, connecting the other end of the cable to either of the test set's two coaxial sockets. This arrangement is also shown in A.P.1275T, Vol.1. As the test set's cable has a capacitance of 150 pF, if the variable capacitor on the test set is adjusted to 600 pF, a capacitance of 750 pF will be fed into the amplifier. Thus, if the selector switch is placed at position 3 or 4 the test set meter should read about 2 mA. This procedure should be repeated for each of the settings given in Table 9 and the amplifier checked for approximate accordance with the values given.

Check on tank circuits

45. It will be seen in fig.5 that every connection or test point is numbered, starting at the cable box and working to the tanks. These numbers will be found in Tables 16 and 17, 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 therefore a reading of zero contents on the indicator.

46. When testing at and beyond points 3, 7 and 10 it is essential that the tank be drained of all normally usable fuel and the system pressurized. 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 double socket clipped to the inside of the test set's lid.

47. The variable capacitor should now be set to 750 pF, less the capacitance of the aircraft's CS.21 cables *(port and starboard)*, test set cable and the socket; the resultant value is the figure given in the table. The indicator should now read approximately zero contents and the test set's meter about 2 mA. This process is repeated at each of the remaining 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 made.

48. The capacitance values given have the total tolerance at each particular 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's 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.

49. The method of checking the units installed in the port and starboard wing

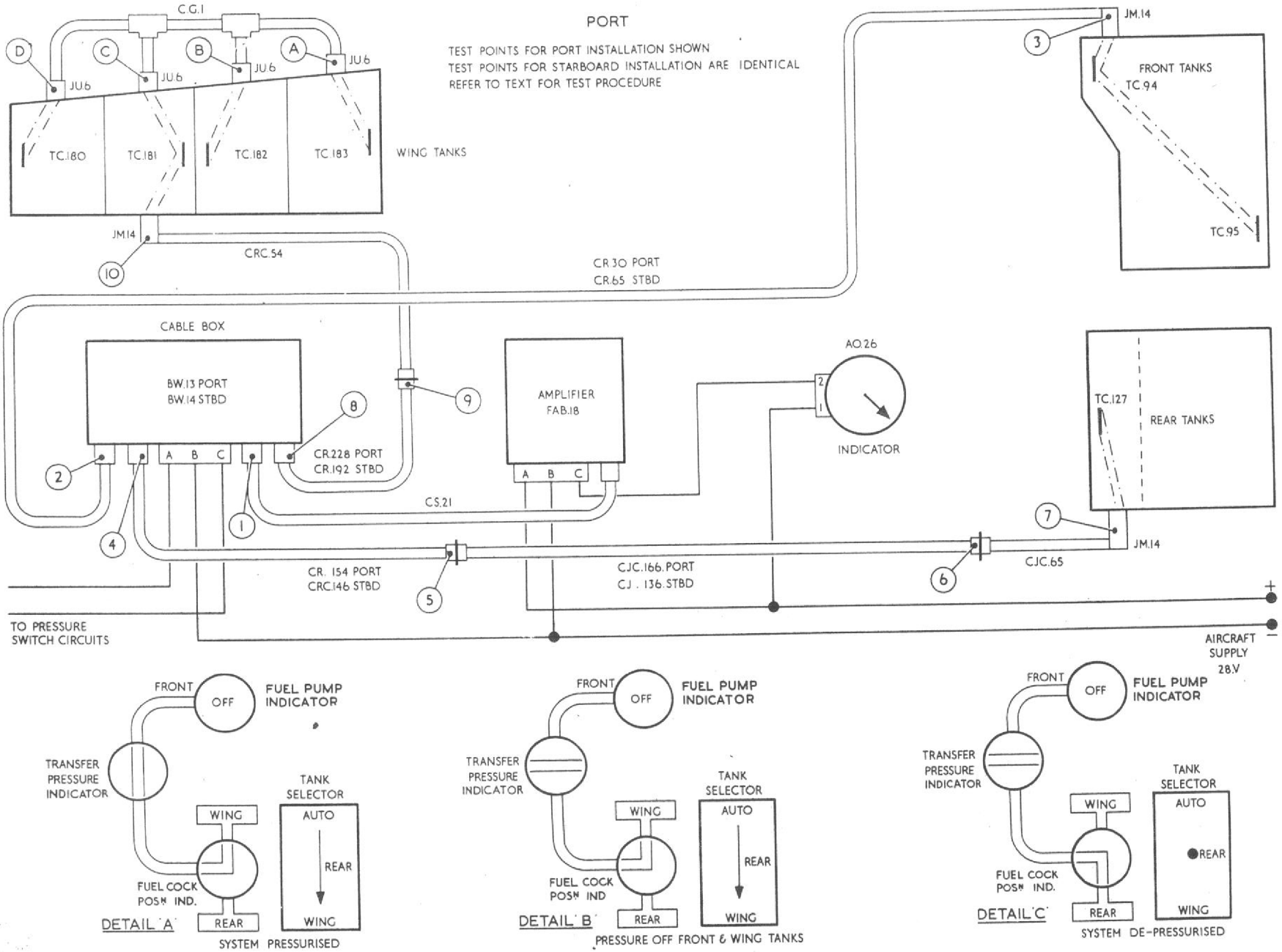

Fig.5 Fuel content gauge tank test points

tanks is a little different to that described in the preceding paragraphs, and is therefore described below.

50. Disconnect the coaxial harness CG1 at points A, B, C and D *(fig.5)* and connect the QAA test set to the amplifier as described in A.P.1275T, Vol.1. Using a suitable length of coaxial cable and a Pye Waymouth adapter, join the spare coaxial socket to any point of the harness. The variable capacitor should now be set to give a milliammeter reading of, say, 5 mA, and the harness disconnected, leaving the coaxial cable and adapter all connected to the test set socket. Having noted the variable capacitor reading, it should be re-adjusted until the same milliammeter reading is again recorded. The capacitance of the C.G.1 harness is obtained by subtracting the first variable capacitor reading from the second, and should be within the limits quoted in para.27, plus ten per cent allowance for test set inaccuracies. This method is described in greater detail in A.P.1275T, Vol.1.

51. Assuming that the harness is serviceable, leave it disconnected and also disconnect the coaxial cable CRC.54 from the JM.14 tank terminal. Employing the method detailed for the CG1 harness, now check each tank at points, A, B, C and D for accordance with the capacitance values given in Table 18.

52. The values quoted in column A of Tables 16 and 17 are the true capacitances to be connected at each point, whilst those in column B are the true capacitances less the capacitance of the connecting cables and/or sockets. In other words, the values in column B are the actual test set variable capacitor settings, and the values in column A are the theoretical values. Both are given so that an operator may make allowances accordingly should he use a different method of connection.

TABLE 18

Test points (wing system)

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

Additional equipment required for checking wing tank system

53. 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 particular aircraft, the wing tank system is so equipped. To meet these requirements, the following additional items with their capacitance values, are given below and may be obtained through the usual channels:-

(1) Pye Waymouth adapter, Code CC1, capacitance 8 ± 2 pF.

REMOVAL AND ASSEMBLY

General

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

Assembly of fuel cock actuators

55. 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.