Cancelled now AP1201-0206-1

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LEADING PARTICULARS

Test equipment, Ultra, Type Q2A8	**Ref. No. 5G/3694**
Speed measurement range	10% *to* 110% *for percentage type tacho-generator systems* (*equivalent to* 420 *to* 4620 *tacho r.p.m.*)
Speed measurement accuracy ...	... ... ±0·1%
External power supply	28*V d.c.* (*not more than* 20% *superimposed ripple*)
Internal power supply	*Battery, Mallory, Type SKB*544. *Ref. No.* 5*J*/3465
Overall dimensions—	
*Control unit QC2A*80	17 *in.* × 13 *in.* × 13 *in.*
*Motor unit QM2A*80	16 *in.* × 10 *in.* × 9 *in.*
Weights (*excluding test cables*)—	
*Control unit QC2A*80	*lb.*
*Motor unit QM2A*80	*lb.*

Introduction

1. Test equipment, Type Q2A8, is a speed source designed to facilitate bench and aircraft testing of the speed control systems of gas turbine engines. The equipment comprises two portable units, the control unit, Type QC2A80 and the motor unit, Type QM2A80, together with interconnecting cables and adaptors.

2. The equipment provides for the simulation and accurate measurement of the output signals from compressor driven tachogenerators. In addition the equipment can monitor the outputs of a wide range of speed control amplifiers of the type used to control solenoid operated fuel valves, and provision is made for bench and aircraft testing of other types of control systems.

DESCRIPTION

3. Test equipment, Type Q2A8, consists of the following items:—

(1) Control unit, Type QC2A80 (fig. 1). This unit houses the circuits which control the frequency of the simulated speed signal, together with the speed measurement device, the output monitoring circuits and the datum selection circuits.

(2) Motor unit, Type QM2A80 (fig. 2). This unit contains the motor system, which is driven by the speed signals from the control unit. The motors drive a tachogenerator of the appropriate type, the output of which is fed to the speed control system under test.

(3) Test cable, QY2A81, which is a 35 ft. 7-core cable used to connect the control unit to the motor unit.

(4) Test cable, QY2A82, which is a 20 ft., 2-core cable used to connect the control unit to the 28V d.c. supply.

(5) Test cable, QY2A83, which is a 75 ft., 3-core cable used to connect either the motor unit or the control unit to the aircraft engine speed control installation.

4. Test cable, QY2A83 may be connected to a variety of different aircraft installations by means of adaptors designed to suit the individual installation. The type numbers of these adaptors are QA2A8.1, QA2A8.2 etc., the final digit referring to a particular installation. A list of those adaptors suitable for use on Service installations is given below:—

QA2A8.1	Victor Mk. II—H.P. compressor input signal.
QA2A8.2	Victor Mk. II—L.P. compressor input signal.
QA2A8.3	Victor Mk. II—L.P. compressor pick-up signal.
QA2A8.4	Britannia—compressor input signal.
QA2A8.5	VC10—H.P. and L.P. compressor input signals.

5. In order to facilitate testing of a wide range of aircraft installations, several types of tachogenerator may be fitted to the motor unit. In order to cater for the differing connectors fitted to these tachogenerators, a range of jumper cables is available, these cables being connected between the tachogenerator and the motor unit junction box. The type

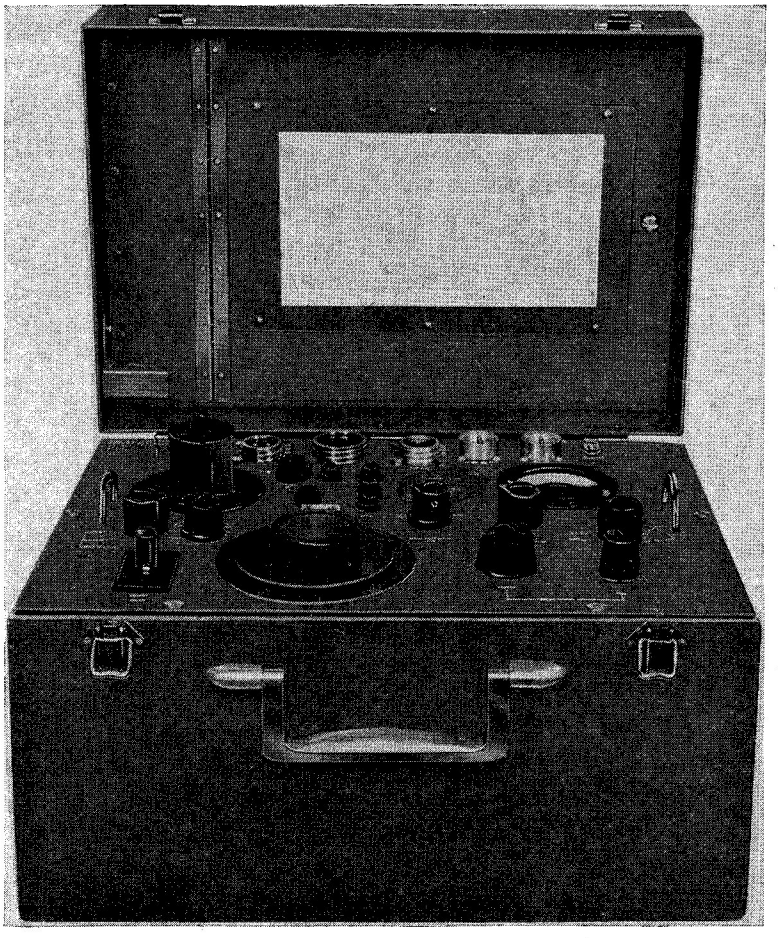

Fig. 1. Test equipment, ultra, Type Q2A8—control unit QC2A80

numbers of these jumper cables are QJ2A8.1, QJ2A8.2 etc., the final digit referring to a particular tachogenerator. A list of those jumper cables suitable for use when testing Service installations is given below:—

QJ2A8.1	Britannia—Sangamo Weston, Type S168 generator.
QJ2A8.3	Victor Mk. II—Elliot Type 305.75 Mk. II or Kelvin & Hughes Type KGA0801 tachogenerators.
QJ2A8.4	VC10—Kelvin & Hughes, Type KGA0704 tachogenerator.

In addition to the above listed jumper cables, two tachogenerator mounting plates are available and these cover the range of tachogenerators in use by the Services.

Control unit, Type QC2A80

6. The control unit, (fig. 1), is housed in a portable light alloy case, having a detachable lid. The test cables and adaptors are contained in the lid, behind a hinged flap. All the controls, indicators, and connectors are located on the top panel of the unit (fig. 3). Access to the battery compartment and test panel is gained via a hinged flap on the right-hand side of the case (fig. 5).

Controls and indicators

7. The following meters, controls and indicators are fitted:—

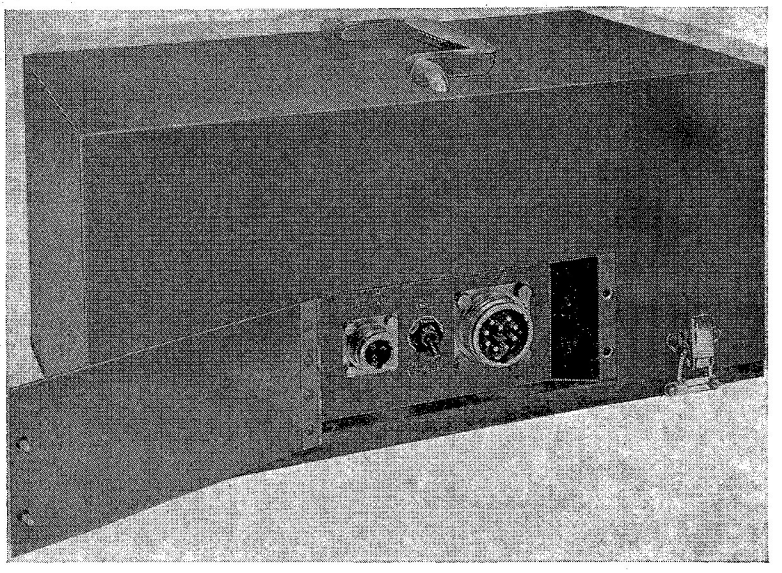

Fig. 2. Test Equipment, Ultra, Type Q2A8—motor unit QM2A80

(1) The meter, M1, has the following ranges, selected by the SELECT METER TEST switch:—

(a) O-25V d.c., having a green zone between 17V and 25V, used to indicate the condition of the internal battery (BATT.).

(b) 0-500 mA d.c., used to measure the output current of an engine speed control amplifier (D.C.SOL.).

(c) 0-50 mA d.c., used to measure the output current of a ram air turbine scoop amplifier (SCOOP).

(d) 0-300 mV d.c., used to measure the output current of an air-bleed valve control amplifier (BLEED VALVE).

(e) 0-50V a.c., used to measure the output voltage of each phase of the aircraft tachogenerator (TACHO. GEN. VOLTS).

(2) The galvanometer is a high-sensitivity, centre zero, suspension instrument, incorporating mechanical zeroing and clamping devices. The galvanometer is used to detect null conditions in the speed measurement bridge.

Caution . . .

The clamping device must be in the CLAMP position when the galvanometer is not in use.

(3) The SPEED SIGNAL, COARSE control is a single turn potentiometer. The associated FINE control is a ten-turn, helical potentiometer enabling sensitive adjustments to be made. These two potentiometers control the output frequency of the motor control oscillator and hence the speed of the motor system in the motor unit.

(4) The SPEED SCALE is a ten-turn control calibrated in % r.p.m. over the range 10% to 110%, corresponding to a tachogenerator speed range of 420 r.p.m. to 4620 r.p.m. The outer dial is calibrated in 10% increments, the inner dial is calibrated in 1% increments, subdivided into 0·1% steps. The speed scale is used in conjunction with the galvanometer, to measure either the simulated speed signal or the aircraft tachogenerator signal.

Note . . .

An indication of 100% *on the speed scale corresponds to a tachogenerator speed of* 4200 *r.p.m., giving an output frequency of* 70 *c/s. The relationship between % r.p.m. and actual r.p.m. is linear, so other % readings may be converted as shown in the following example:—*

Speed scale indication $=75\%$

$\therefore$ tachogenerator speed $= \frac{75 \times 4200}{100}$

$= 3150$ r.p.m.

The Britannia aircraft engine speed indication system is different from that described above, but a conversion chart in the lid of the control unit, Type QC2A80, facilitates speed measurements on this aircraft.

(5) The 28V D.C. SUPPLY switch is a two-position, ON/OFF switch controlling the d.c. supply to the control unit and to the d.c. motor in the motor unit.

(6) The SELECT METER TEST switch is a six-way, four-pole switch which feeds one of seven test signals to the meter M1 for monitoring purposes.

Switch position			Meter indication.
BATT			Condition of internal battery.
D.C. SOL.			Output current of speed control amplifiers.
SCOOP			Output current of scoop amplifiers.
BLEED VALVE			Output current of bleed valve control amplifiers.
TACHO. GEN. VOLTS	∅1	Phase A-B	Output voltages of aircraft tachogenerators.
	∅2	Phase B-C	
	∅3	Phase A-C	

Note . . .

The output voltage of a single-phase tachogenerator is measured with the switch in the ∅1 position.

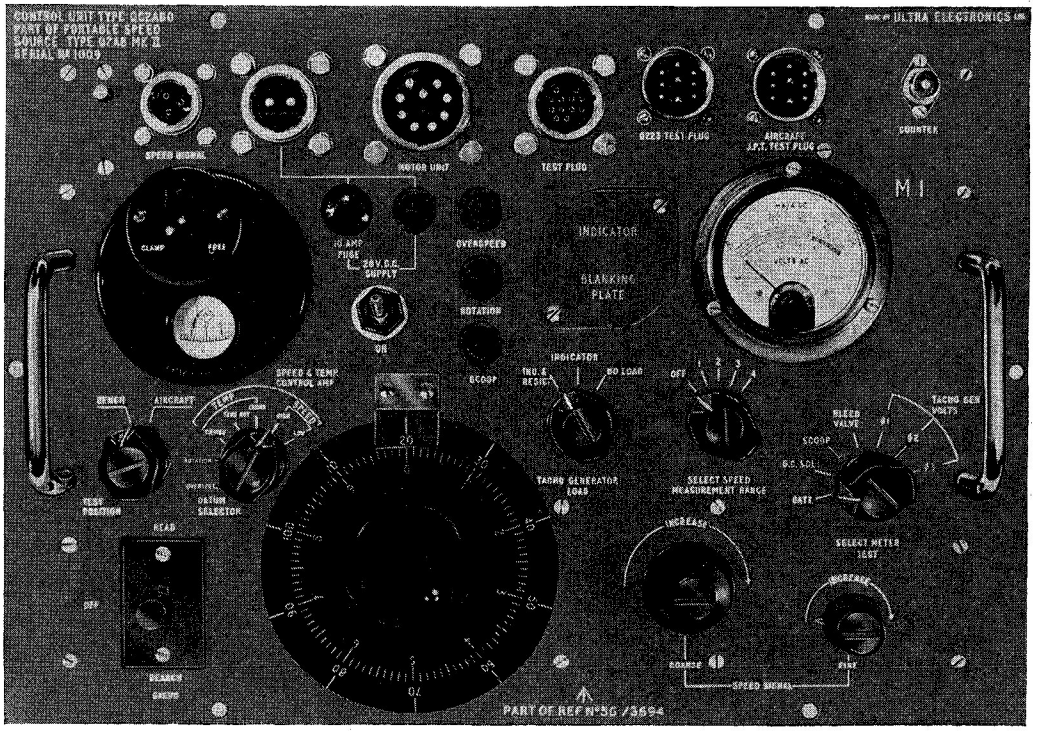

Fig. 3. Control unit, Type QC2A80—front panel

(7) The SELECT SPEED MEASUREMENT RANGE switch is a five-way, four-pole switch which selects the range of the speed measurement scale.

Switch position	Range selected
OFF	Internal battery disconnected.
1	10% to 110% on percentage type systems.
2	Spare. Ranges fitted to suit individual
3	Spare. installations. e.g. 200 to 700 c/s
4	Spare. (4000 to 14000 c.r.p.m.) for Britannia aircraft.

Note . . .

A microswitch, actuated by closing the control unit lid, disconnects the battery in the event of the SELECT SPEED MEASUREMENT RANGE switch being left in positions 1, 2, 3 *or* 4.

(8) The TACHO GENERATOR LOAD switch is a three-way, four-pole switch used to select the loading applied to percentage type tachogenerators.

Switch position	Tachogenerator load
IND & RESIST	Tacho-indicator (when fitted) and 100Ω, delta connected resistive load.
INDICATOR	Tacho-indicator only.
NO LOAD	No internal loading on tachogenerator output.

(9) The DATUM SELECTOR switch is a three-pole, seven-way switch which selects the appropriate speed of temperature datum of the amplifier under test.

Speed datums		Temperature datums	
Overspeed	bench tests only	Cruise	bench tests only
Rotation		Take off	
High	bench and a/c tests	Climb	
Low			

(10) The TEST POSITION switch is a two-way, four-pole switch. In the AIRCRAFT position, and with the SELECT METER TEST switch set to D.C. SOL., the meter M1 monitors the current flowing in the aircraft fuel valve solenoid, via test cable QY2212 connected to the AIRCRAFT J.P.T. TEST PLUG. Cable QY2212 forms part of test equipment, Ultra, Type QE2230, and is not supplied with test equipment, Type Q2A8. In the BENCH position, the dummy solenoid in the control unit is brought into circuit to facilitate bench testing of speed and temperature control amplifiers and rotation and overspeed indicators, via the TEST PLUG.

(11) The GALVO switch is a two-position, centre OFF switch labelled READ and SEARCH and is used to connect the galvonometer into the speed measuring bridge circuit. In the SEARCH position the switch lever is spring biased to OFF; in the READ position the lever is not so biased and the galvonometer is thus maintained in circuit whilst final bridge balance is obtained.

(12) The following indicator lamps are fitted:—

Lamp	Function
28V D.C. SUPPLY	Indicates the presence and correct polarity of the 28V d.c. supply to the control unit.
OVERSPEED	Indicates the operation of an overspeed warning system.
ROTATION	Indicates the operation of a rotation indicator unit.
SCOOP	Indicates the operation of a ram air turbine scoop amplifier.

(13) A 10A fuse link is connected in series with the 28V d.c. supply. The link is Belling-Lee, Type L693 (Ref. No. 011-9925).

(14) The co-axial socket labelled COUNTER facilitates the connection of an external frequency measuring instrument to enable the speed measuring bridge to be calibrated.

Plugs and sockets

8. The following plugs and sockets are fitted:—

(1) 28V D.C. SUPPLY—PL1—a two-pole, quick release plug used to connect the 28V d.c. supply to the control unit.

(2) QT223 TEST PLUG—PL5—a nine-pole Breeze plug used to connect the control unit to the test set, Type QT223, when it is required to check, simultaneously, the temperature and speed channels of a control amplifier.

(3) AIRCRAFT J.P.T. TEST PLUG—PL6—a nine-pole Breeze plug used to connect the control unit to the jet-pipe temperature test plug in the aircraft. This plug enables the output current of speed and temperature control amplifiers to be monitored without disturbing the control system wiring, and enables LOW datum to be selected during engine running tests.

(4) SPEED SIGNAL—SKT1—a three-pole, quick release socket used to connect the control unit to the aircraft installation either to inject a speed signal or to measure the signal from the aircraft tachogenerator.

(5) MOTOR UNIT—SKT3—a nine-pole, quick release socket used to connect the motor unit to the control unit. This socket carries the 28V d.c. supply to the d.c. motor, the speed control signals to the synchronous motor and the tachogenerator output signals.

(6) TEST PLUG—SKT4—a twelve-pole, quick release socket used to connect the control unit to the amplifier under bench test conditions

(7) An internal cable terminating in a three-pole socket—SKT7—is used to connect a tacho-indicator to the tachogenerator in the motor unit, or to the aircraft tachogenerator. Provision is made for mounting the indicator in the front panel of the control unit, the mounting hole being normally covered by a blanking plate (see fig. 3).

Motor Unit, type QM2A80

9. The motor unit, (fig. 4), consists of a light alloy baseplate on which are mounted the d.c. motor, the synchronous motor and the tachogenerator. A small junction box carries the plug and socket used to connect the motor unit to the control unit and to the installation under test. The bracket also carries three toggle switches and the plug which connects the tachogenerator jumper cable to the junction box.

10. The light alloy cover, (fig. 2), is held in place by toggle fasteners and has a hinged flap which gives access to the connectors. The motor unit should not be used without the cover in place.

11. The motor unit will drive a variety of engine tachogenerators whose operating speeds fall within the range 1500 r.p.m. to 5000 r.p.m. and which do not require a driving torque in excess of 6 oz. in. at 4200 r.p.m. The unit is supplied with two sets of mounting plates and couplings to suit the tachogenerators to be fitted.

Caution . . .

Care should be taken to avoid running the motor unit at non-synchronous speeds.

12. To change a tachogenerator, proceed as follows:—

(1) Remove the motor unit cover.

(2) Remove the jumper cable QJ2A8. (fig. 4) connecting the tachogenerator to the junction box.

(3) Slacken the two socket-head screws securing the drive coupling to the d.c. motor.

(4) Remove the $\frac{3}{8}$ in. BSF bolt securing the tachogenerator bracket to the baseplate and draw the bracket away from the d.c. motor.

(5) Remove the bracket and tachogenerator from the baseplate.

(6) If necessary, remove the tachogenerator from its bracket by unscrewing the mounting bolts and remove the drive coupling by slackening the two socket-head screws.

(7) Fit the new tachogenerator to its

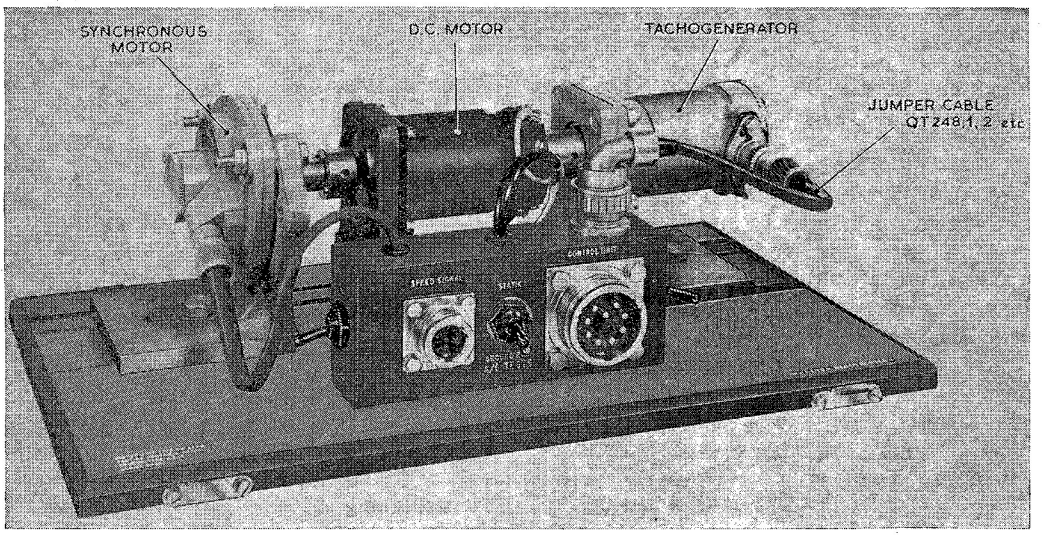

Fig. 4. Motor unit, Type QM2A80—cover removed.

bracket and secure the appropriate drive coupling to the tachogenerator shaft.

(8) Ensure that the baseplate and bracket are clean, then place the bracket on the baseplate and slide the bracket along the baseplate until the drive coupling engages the d.c. motor shaft.

(9) Check that the bracket is mounted squarely on the baseplate and that the tachogenerator and d.c. motor shafts are in alignment.

(10) Replace and tighten the $\frac{3}{8}$ in. BSF bolt.

(11) Tighten the two socket-head screws securing the drive coupling to the d.c. motor shaft.

(12) Ensure that the motors and tachogenerator turn freely.

(13) Connect the tachogenerator to the junction box using the appropriate jumper cable, QJ2A8.

Switches and connectors

13. (1) The A/C TESTS switch feeds the tachogenerator signal to the aircraft installation (STATIC) or feeds the aircraft tachogenerator signal to the control unit (GROUND RUN).

(2) The TORQUE switch selects HIGH or LOW torque according to the type of tachogenerator fitted in the motor unit.

(3) The CW-OFF-ACW switch selects the desired rotation of the d.c. motor according to the direction of rotation of the tachogenerator in the system under test.

Caution . . .

Care must be taken to set this switch to the correct position. Damage to the aircraft engine speed indicators will result if the tachogenerator is run in the wrong direction.

(4) The SPEED SIGNAL socket—SKT2—is a three-pole, quick release socket used to connect the motor unit to the aircraft installation either to inject a speed signal or to pick up the speed signal from the aircraft.

(5) The CONTROL UNIT plug—PL2 is a nine-pole, quick release plug used to connect the motor unit to the control unit (SKT3).

PRINCIPLES OF OPERATION

14. The test facilities afforded by the test equipment, Type Q2A8, are summarised below:—

(1) Amplifier speed datum test to establish the datum speed at which the required amplifier output current is obtained.

(2) Gain, standing current, response and override or muting checks of speed control amplifiers installed in an aircraft.

(3) Aircraft engine speed indicator checks.

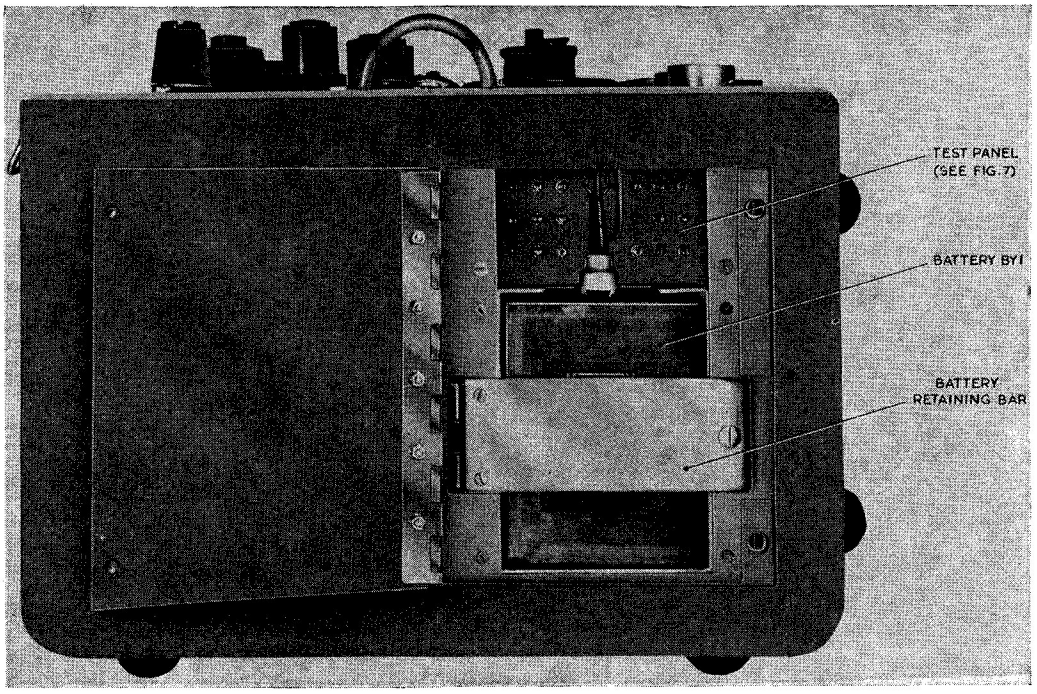

Fig. 5. Battery and test panel

(4) Operation and datum settings of L.P. compressor rotation and overspeed indicators.

(5) Operation and datum settings of ram air turbine scoop amplifier systems.

(6) Operation of the datum lift circuit in the B.A.P.3 throttle control system (See A.P.4343K, Vol. 1, Sect. 4, Chap. 1).

(7) Setting up the compressor speed governor circuit in the B.A.P.3 throttle control system (See A.P.4343K, Vol. 1, Sect. 5, Chap. 1).

(8) Operation and datum settings of bleed valve control amplifier systems.

15. If necessary, test equipment, Type Q2A8, can be connected into the aircraft installation in conjunction with test equipment, Type QE2230. Both speed and temperature channels of an engine control system may then be checked simultaneously.

Speed signal source

16. As mentioned in para. 1, the test equipment is, basically, a speed signal generating and measuring instrument. The speed signal is derived from a tachogenerator similar to that used in the aircraft installation under test. The tachogenerator is driven by a d.c. motor/a.c. synchronous motor combination. The d.c. motor provides approximately 60% of the drive power; the synchronous motor gives an accurate control of speed and stability and provides the remainder of the drive power.

17. An oscillator, located in the control unit, provides an a.c. output the frequency of which is controlled by the SPEED SIGNAL COARSE and FINE controls. This signal is fed to the a.c. motor which follows, in synchronism, the signal frequency. The tachogenerator is thus driven at the selected speed and gives a stable output which can be fed into the system under test to simulate the signal from the engine driven tachogenerator. The torque applied to the tachogenerator is approximately 6 oz. in. at 4200 r.p.m. and the speed range is 1500 to 5000 r.p.m.

Speeed measurement

18. The speed signal to be measured may be either that developed by the motor unit or, during ground running tests, that developed by the engine driven tachogenerator.

The speed signal is fed to a transistorised version of the Maxwell bridge circuit powered by the internal battery. The output of the bridge is compared with a d.c. signal controlled by the speed measurement scale. Null conditions are detected by the galvanometer and the speed scale reading, at null, is equivalent to the tachogenerator speed.

Test facilities

19. Mention is made in para. 14 of the test facilities available. A brief description of the methods of achieving these facilities is given in the following paragraphs.

Amplifier speed datum tests

20. A speed signal, derived from the motor unit, is fed to the tacho signal input of the amplifier under test. The signal is injected at the tachogenerator end of the aircraft cable. The aircraft tachogenerator should, therefore, be disconnected during these tests. The speed signal is adjusted until the amplifier output current, measured by the meter on the control unit, corresponds to the datum operating current specified for the amplifier.

21. The speed signal is then applied to the Maxwell bridge circuit and galvanometer balance is obtained using the speed scale. The datum speed can then be read from the speed scale.

Amplifier gain and standing current

22. Amplifier gain is measured simply by measuring the amplifier output current change for a change of speed signal. Gain is then expressed in terms of mA/r.p.m. Standing current is obtained merely by reducing the speed signal below the datum level and measuring the output current.

Amplifier response and override operation

23. A suitable speed signal is injected into the amplifier on the bench. An external step d.c. signal of known magnitude is then fed into an intermediate stage of the amplifier. The change of output current, caused by the application of the step input, is monitored using an oscilloscope. Override operation is checked by injecting a suitable speed signal into the amplifier. When the override control is selected the amplifier output should drop to zero.

Engine speed indicator checks

24. A speed signal, or a range of speed signals, is fed into the aircraft engine speed indicator channel. The reading of the engine speed indicator, on the flight deck, is then compared with the reading of the speed scale on the control unit.

Rotation and overspeed indicator checks

25. A speed signal is fed into the h.p. compressor speed channel of the aircraft installation. The speed signal is adjusted until the OVERSPEED lamp, in the aircraft, lights. The speed signal is measured, using the speed scale and compared with the specified datum speed for overspeed operation. The speed signal for checking the rotation indicator on the bench is obtained by turning the motor unit tachogenerator by hand.

Ram air turbine scoop amplifier

26. The speed signal required to achieve scoop operation is fed into the h.p. compressor speed channel of the aircraft installation. The speed signal is then measured, using the speed scale, and compared with the specified datum speed for scoop operation.

Datum lift circuit checks (B.A.P.3 Throttle control)

27. A simulated temperature signal, equivalent to the acceleration datum is applied to the C.J.C. unit in the B.A.P.3 system and the output of the temperature amplifier is monitored using a suitable meter. The speed signal is fed into the aircraft installation via the engine tachogenerator lead. As the test speed signal is increased from 10,000 c.r.p.m. to 12,000 c.r.p.m., to simulate the conditions of acceleration, the output of the temperature amplifier should fall to zero.

28. Operation of the datum lift suppression circuit may be checked by increasing the temperature signal to a value slightly above datum and applying a speed signal between 6000 c.r.p.m. and 8000 c.r.p.m. There should be no output from the temperature amplifier over this range of speed.

Setting up the compressor speed governor (B.A.P.3 Throttle control)

29. A speed signal is applied to the aircraft installation via the engine tachogenerator lead. The pilot's speed governor trim control is set to its central position and the datum selector unit is switched on. The appropriate datum level (HIGH or LOW) is selected and the governor test points on the transmitter unit are monitored, using an a.c. voltmeter. The speed signal is set, using the speed scale, to the required datum value and the appropriate reset potentiometer in the datum selector unit is adjusted for minimum deflection on the a.c. voltmeter.

Bleed valve control system checks

30. A speed signal is injected into the engine tachogenerator circuit and operation of the bleed valve control relay, in the amplifier, is monitored by the meter on the test set. The datum speed at which this relay is operated is measured, using the speed scale, and compared with the specified datum speed.

Note . . .

Before the bleed valve amplifier can be tested, the connections on the aircraft altitude muting switch must be simulated by selecting LOW datum on the control unit. This test requires the use of a special cable. The cable can be made locally and details are given in the Air Publications dealing with specific amplifiers (A.P.4343E, Vol. 1, Book 2, Sect. 9).

Detailed test procedures

31. The foregoing paragraphs are intended merely as a guide to the test facilities available. Detailed test procedures will be found in the Air Publications dealing with specific items of aircraft equipment.

CIRCUIT DESCRIPTION

32. Circuit diagrams of the motor and control units are given in fig. 6 and 8.

Note . . .

Component references on some early models printed on, or adjacent to, the components of the control unit may not correspond with those used in the circuit diagrams and the following text. But these may be found by comparison with fig. 7.

Motor unit speed control

33. The control signal for the synchronous motor in the motor unit is derived from a multivibrator and power amplifier in the control unit (fig. 8). The control signal circuit is powered from the 28V d.c. supply which is fed to the unit at PL1. The supply is fed, via the ON/OFF switch, S1, diodes MR1 and MR2 and inductor L1 to the indicating lamp ILP1 and thence to the multivibrator and amplifier. The purpose of the diodes is to prevent damage to the amplifier due to inadvertent wrong connection of the supply. If the supply is connected in the wrong polarity, the indicating lamp will not light when S1 is set to ON. L1 and C1 provide smoothing to enable the control unit to be run from a rectified a.c. supply.

34. Transistors VT3 and VT4 form an emitter coupled multivibrator in which the timing elements, RV1, RV2, R6, C5 and C6, are in the emitter circuit. The emitters of VT3 and VT4 are fed from the constant current sources VT1 and VT2, and the emitter currents are balanced by RV3, thus giving a control of the mark : space ratio. The multivibrator is free running, each transistor conducting during alternate half cycles, so that C5 and C6 charge and discharge through each constant current source in turn. The period of oscillation depends on the values of C5 and C6 and on the resistance of the collector load of VT3. RV1 and RV2, therefore, control the frequency of oscillation and are the SPEED SIGNAL COARSE and FINE controls respectively.

35. The output of the multivibrator is taken from the collector of VT4, via the coupling transformer T1. Diode MR3 ensures a rapid decay of voltage across T1 primary and prevents damage to the multivibrator transistors due to current surges. VT5 and VT6 form a push-pull amplifier driven by the split phase output from the two secondary windings of T1, the quiescent operating level of the amplifier being set by R8 and R9. The collector loads of VT5 and VT6 are the two halves of T2 primary. The secondary of T2 is connected to the bases of the output transistors. Each half of the push-pull output stage consists of two transistors connected in parallel and the collector loads are the two halves of the primary of T3. Diodes MR4 and MR5 provide protection from voltage surges appearing in the output stage due to the inductive loading. The parallel connection of the output transistors, VT7 to VT10, serves to increase the power rating of the output stage.

Caution . . .

Due to the high power dissipation of the output stage a 28V d.c. fan is fitted inside the control unit. When the 28V D.C. SUPPLY switch is set to ON, ensure that the fan motor is turning.

Potentiometer RV4 sets the amplitude of the output from T3 secondary and is ganged to RV1 to ensure that the output amplitude is increased as the frequency increases. This is

done because the a.c. synchronous motor has a low impedance at low frequencies and excessive currents would flow in the output stage if no series resistance was included. The output from the slider of RV4 and one end of T3 secondary, is fed via poles F and G of SKT3 to the synchronous motor.

Speed measuring circuit

36. The speed signal, either from the motor unit or from the engine driven tachogenerator, is fed to the primary of T4. Secondary windings 1 and 2 feed this signal to the bases of transistors VT11 and VT12 forming part of the Maxwell bridge frequency discriminator. Secondary winding 3 feeds the speed signal to the co-axial socket on the front panel of the control unit to enable the measuring circuit to be calibrated using an external frequency measuring instrument.

37. Transistors VT11 and VT12 are switched on and off alternately by the positive and negative half-cycles of the speed signal. Capacitors C2A and C2B are thus charged and discharged once in every cycle of the signal. The charging current produces a positive pulse across R21 and the discharge current produces a positive pulse across R20. The mean voltage at the junction of VT12 collector and R20 is, therefore, dependent on the number of charging and discharging pulses per unit of time, i.e., on the speed signal frequency.

38. This voltage is compared with a reference potential derived from the battery BY1 (22·5V). This potential is controlled by the resistor chain R22 to R25, RV5 and RV7, the two remaining arms of the Maxwell bridge, and is fed to one side of the galvanometer, the potential due to the speed signal being fed to the other side of the galvanometer. When the reference voltage at the slider of RV6 is equal to the mean potential due to the speed signal, no current will flow through the galvanometer. It follows that the setting of RV6 (SPEED SCALE), at null, is a measure of the speed signal frequency. Switch S5 selects the 10 to 110% (7 to 77 c/s) speed range and disconnects the battery when the speed measuring circuit is not in use.

Meter test switch

39. This is switch S6 on the circuit diagram, (fig. 8). Its function is to connect meter M1, via the appropriate multipliers or shunts, to the outputs of the systems under test. In addition the internal battery voltage and the tachogenerator output voltages can be measured. The functions of the switch are listed below.

Switch position	Function
1 (BATT)	Meter M1 is connected, via the 25V multiplier, to battery BY1 to monitor the condition of the battery.
2 (D.C. SOL.)	Used when bench testing speed control systems which operate by energising a fuel valve solenoid. The output of the control amplifier is fed into the control unit at PL6. R28 and L3 form a load which is equivalent to the solenoid of the fuel valve. Solenoid current is monitored by connecting meter M1 across a 0·5Ω resistor in the amplifier. When carrying out aircraft tests, meter M1 is switched by the TEST POSITION switch (S4) across poles A and B of plug PL5 and thence to the 0·5Ω resistor in the amplifier.
3 (SCOOP)	The output of a ram air turbine scoop amplifier is fed into the control unit at SKT4. Relay RL1 is energised by the output current and the relay contacts close, thus connecting the 28V d.c. supply to the indicating lamp ILP4. In addition, the output current is fed, via the 50 mA shunt and wafers A and B of S6, to meter M1.

Switch position	Function
4 (BLEED VALVE)	The output of an air-bleed valve control amplifier is fed into the control unit at SKT4 and is passed, via the 300mV multiplier and wafers A and B of S6, to meter M1.
5, 6 and 7 ($\varnothing_1$, $\varnothing_2$, $\varnothing_3$)	Wafers C and D of S6 select each of the three phases of the tachogenerator signal and pass them, via the 50V multiplier, to the bridge rectifier MR6. The d.c. output of the rectifier is then fed, via wafers A and B of S6, to meter M1. When single-phase tachogenerators are used, only position 5 of S6 is selected.

Datum selector switch

40. In some engine control systems, a number of datum levels is provided, these being selected by the pilot or flight engineer to suit the conditions prevailing. An exception to this method of selection is in rotation and overspeed indicators, in which the changeover from rotation indication to overspeed warning is achieved automatically at the end of the engine starting cycle. Switch S3 (DATUM SELECTOR) selects the appropriate datum during bench testing as described below.

Switch position	Function
1 (OVERSPEED)	Isolates the changeover relays in the rotation and overspeed unit thus operating the unit in the overspeed mode. The overspeed datum is preset by the frequency discriminator within the unit and operation of the unit is indicated by the OVERSPEED indicator lamp ILP2.
2 (ROTATION)	Wafer B of switch S3 feeds a +28V d.c. signal to the changeover relays in the rotation and overspeed unit. This bypasses the discriminator and ring demodulator and connects the output to the ROTATION indicator lamp ILP3.
3 (CRUISE) 4 (TAKE OFF) 5 (CLIMB)	These three positions of switch S3 select each temperature datum of three-datum amplifiers. The appropriate datum is selected by relays in the speed and temperature control amplifier, these relays being energised by the −28V d.c. supply selected by wafer C of switch S3. The supply is fed out of the test set on poles D and F of SKT4 and the +ve side of the supply is connected to pole E of SKT4.
6 (HIGH) 7 (LOW)	These two positions of S3 select the high and low speed datums of two-datum amplifiers during bench or aircraft testing. The low datum is selected by making a short circuit inside the amplifier. The action of this short circuit is to connect a preset signal to r.p.m. stage 1 in the amplifier, thus depressing the datum point. The short circuit is made by wafer A of S3.

Tachogenerator load circuit

41. The tachogenerator signal, from either the aircraft installation (SKT1) or the motor unit (SKT3) is fed to switch S2. Using switch S2, the tachogenerator signal can be connected either to an internal tacho-indicator, if fitted, or to the tacho-indicator plus a resistive load, or to the resistive load alone if no

internal tachogenerator is fitted, or left open circuit. The tacho-indicator is connected via SKT7 and is located in a mounting hole on the front panel of the control unit. The action of switch S2 is as follows:—

Switch position	Function
1 (IND. & RESIST)	The tachogenerator signal is fed from wafers A and B of S2 to wafers C and D and also to poles A and B of SKT7. From wafers C and D of S2 the signal is fed to the delta connected resistive load R15, R16 and R17 and thence to pole C of SKT7.
2 (INDICATOR)	The tachogenerator signal is fed from wafers A and B of S2 to poles A and B of SKT7.
3 (NO LOAD)	In this position of S2, the tachogenerator signal is not connected to any internal load other than the permanently connected high impedance input of the primary winding of the Maxwell bridge transformer T4 and the meter test switch S6.

Motor unit

42. The circuit diagram of the motor unit is illustrated in fig. 6. The type of tachogenerator used will depend on the installation under test. The tachogenerator is connected to PL1 on the junction box, via jumper lead QJ2A8 .1, .3 or .4 (para. 5).

43. The main driving torque is provided by the series wound, d.c. motor, which is fed with a 28V d.c. supply via poles H and J of PL2. Resistor R1 can be switched in series with the supply by switch S2. Certain tachogenerators, for example the Sangamo Weston, Type S168, require a low driving torque in order to maintain synchronism at low speeds; R1 and S2 afford a convenient means of reducing the driving torque. Switch S3 connects the 28V d.c. supply to field windings in the appropriate polarity, depending on the direction of rotation required. The centre position of S3 disconnects the d.c. supply.

44. A stable speed control of the drive, over the range 30% to 110%, is provided by the synchronous motor following, in synchronism, the adjustable frequency output of the speed control circuit in the control unit (para. 33).

Caution . . .

When using the motor unit, care should be taken to avoid running the drive at non-synchronous speeds.

45. When switch S1 is in the STATIC position, the output of the tachogenerator is fed to the aircraft installation, via SKT2, and to the control unit, via PL2. When switch S1 is in the GROUND RUN position, the output of the aircraft tachogenerator is fed, via SKT2 and PL2 to the control unit and the motor tachogenerator is isolated.

SERVICING

46. To check the serviceability of the test set the following tests may be carried out:—

Motor unit speed control circuit

47. The following equipment is required:—

(a) Multimeter, Type 12889.

(b) An oscilloscope capable of displaying a square wave signal of 200 to 1000 c/s at 100V r.m.s.

(c) An electronic counter to measure frequencies in the range 200 to 1000 c/s to an accuracy of $\pm 5\%$. An attenuator may be required, since the signal to be measured has an amplitude of 100V r.m.s.

(d) A 28V +1V d.c. power supply capable of supplying a current of up to 7A.

(1) Release the fasteners securing the hinged flap on the right-hand side of the control unit and open the flap to expose the test panel (fig. 5).

(2) Link test points 14 and 15 and ensure that no other test points are connected.

(3) Connect the Multimeter, on the 250V a.c. range, together with the oscilloscope and counter, between test points 13 and 14. Ensure that the earth connections of the oscilloscope and the counter are connected to the same point.

(4) Check that the 28V D.C. SUPPLY switch is set to OFF and that the SPEED SIGNAL COARSE and FINE controls are fully counterclockwise.

(5) Connect the control unit 28V D.C. SUPPLY plug to the 28V d.c. supply.

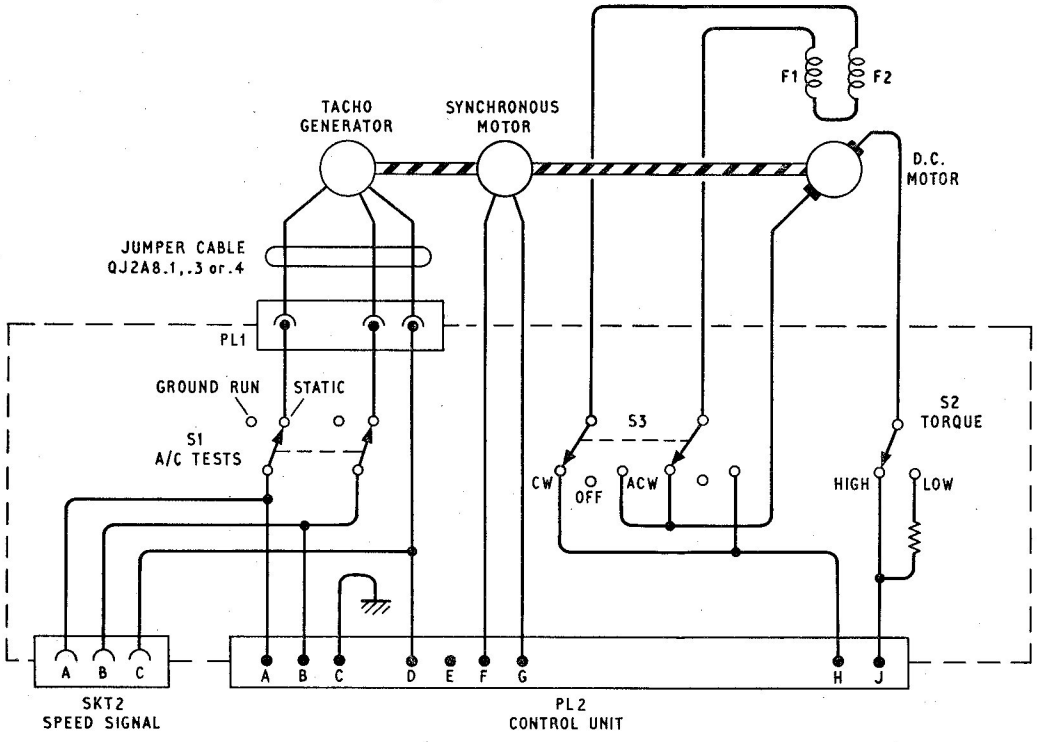

Fig. 6. Motor unit, Type QM2A80—circuit

(6) Set the 28V D.C. SUPPLY switch to ON and check that the supply lamp is lit.

(7) The reading on the Multimeter should be not less than 98V.

(8) The output waveform should be square, symmetrical and should show no signs of overshoot or ringing.

(9) The frequency of the output signal should be 200 to 380 c/s.

(10) Turn the SPEED SIGNAL COARSE and FINE controls slowly clockwise, observing the waveform displayed on the oscilloscope. The waveform should maintain its shape throughout the range of the controls.

(11) When the controls are set fully clockwise, the frequency displayed on the counter should be 960 to 1200 c/s and the Multimeter reading should be not less than 98V.

Note . . .

If the unit fails to meet the requirements of the above test, refer to the fault finding procedure detailed in para. 51.

(12) Remove the link between test points 14 and 15.

Calibration of speed measuring scale

48. The following equipment is required:—

(a) An electronic counter capable of measuring pulse intervals in the range 10 to 50m sec. to an accuracy of ±0·05%.

(b) A 28V ±1V d.c. power supply capable of supplying a current of up to 7A.

(1) Assemble the appropriate tachogenerator to the motor unit baseplate (see para. 12).

(2) Connect the motor unit to the control unit using test cable QY2A81.

(3) Ensure that the 28V D.C. SUPPLY switch is set to OFF and connect the control unit to the 28V d.c.

(4) Connect the electronic counter to the co-axial socket labelled COUNTER.

(5) Set the SPEED SIGNAL COARSE control fully counterclockwise and the FINE control in its mid position (five complete turns from either end stop).

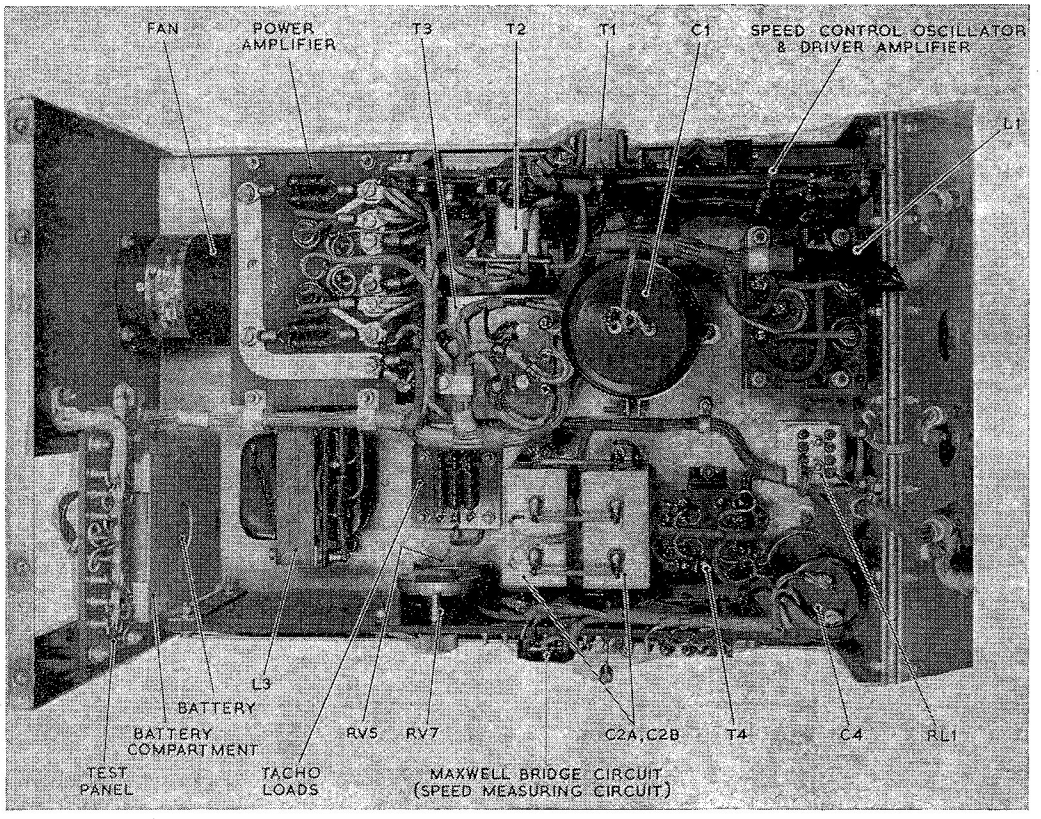

Fig. 7. Control unit, Type QC2A80—component location

(6) Set the speed datum scale to an arbitrary position.

(7) Set the TEST POSITION switch to AIRCRAFT.

(8) Set the TACHO LOAD switch to NO LOAD.

(9) Set the SELECT SPEED MEASUREMENT RANGE switch to position 1 and carry out the battery check detailed in para. 49.

(10) Set the SELECT METER TEST switch to ∅1.

(11) At the motor unit, set the TORQUE switch to HIGH or LOW depending on the tachogenerator fitted. Set the CW-OFF-ACW according to the direction of rotation specified for the tachogenerator Set the A/C TESTS switch to STATIC.

(12) Set the 28V D.C. SUPPLY switch to ON, check that the supply lamp is lit and that the motor unit is running.

(13) Slowly increase the setting of the SPEED SIGNAL COARSE control until the reading on meter M1 begins to increase. The motor speed is now synchronous with the control unit oscillator output.

(14) Using the COARSE and FINE controls, set the speed signal pulse interval to the required value (see table 1).

(15) Set the galvanometer clamp to its FREE position and, if necessary, zero the pointer using the adjusting knob.

(16) Depress the GALVO key momentarily to the SEARCH position and observe the deflection of the galvanometer needle. Adjust the setting of the speed datum scale to reduce the deflection to zero, depressing the key switch at frequent intervals to observe the effect on the galvanometer deflection.

(17) When the galvanometer deflection is within eight divisions of zero, set the GALVO key in the READ position.

(18) Make final adjustments to the speed datum scale to obtain zero deflection of the galvanometer needle.

(19) Read the speed setting on the speed datum scale, set the GALVO key to its mid position and set the galvanometer clamp to CLAMP.

(20) Read the pulse interval time on the electronic counter and compare it with the equivalent speed datum scale setting listed in table 1.

Note . . .

The relationship between pulse interval and speed datum scale setting is linear; intermediate readings may be converted by interpolation.

(21) Compare the speed datum setting obtained in para. 19 with that obtained in para. 20. The two readings must agree within $\pm 0{\cdot}1\%$.

(22) Other points on the datum scale may be checked by repeating sub-para. (14) to (21).

Note . . .

If the above test indicates that the speed datum scale is incorrectly calibrated, carry out the fault finding procedure detailed in para. 52. Should the fault finding procedure fail to reveal the fault, the speed datum scale should be recalibrated as described below.

(23) Remove the control unit chassis by releasing the six quick release fasteners on the front panel and lifting the chassis out of the case.

(24) Connect the equipment and set up the controls as described in sub-para. (1) to (13).

(25) Set the speed datum scale to 40% and adjust the SPEED SIGNAL COARSE and FINE controls until the pulse interval, measured by the electronic counter, is 35·714m sec.

(26) Set the galvanometer clamp to FREE and depress the GALVO key switch momentarily to the SEARCH position and observe the effect on the galvanometer needle. If the speed scale is correctly calibrated, there should be no deflection. If, however, there is a deflection, it should be removed by adjusting RV7.

(27) Depress the GALVO key switch at frequent intervals while adjusting RV7 and, when a null has been obtained, lock RV7.

(28) Set the SPEED SIGNAL COARSE and FINE controls until the pulse interval, measured by the electronic counter, is 12·987m sec. Set the speed datum scale to 110%.

(29) Depress the GALVO key switch momentarily to the SEARCH position and observe the effect on the galvanometer needle. Any deflection should be removed by adjusting RV5 and, when a null has been obtained, lock RV5.

(30) The settings of RV5 and RV7 are interdependent and the procedures detailed in sub-para. (25) to (29) should be repeated until balance can be obtained at both settings of the speed datum scale.

(31) As a final check, repeat the procedures detailed in sub-para. (14) to (21) for speed scale settings of 60% and 80%.

(32) Disconnect the test equipment and set the galvanometer clamp to the CLAMP position. Set the SELECT SPEED MEASUREMENT RANGE switch to OFF.

(33) Replace the control unit chassis in the case and tighten the six fasteners.

TABLE 1

Speed scale settings and corresponding speed signal pulse intervals

Speed scale (setting (%)	Pulse interval (m sec.)	Speed scale (setting (%)	Pulse interval (m sec.)
30	47·619	71	20·121
31	46·083	72	19·841
32	44·643	73	19·569
33	43·290	74	19·305
34	42·017	75	19·048
35	40·816	76	18·797
36	39·683	77	18·553
37	38·610	78	18·315
38	37·594	79	18·083
39	36·630	80	17·857
40	35·714	81	17·637
41	34·843	82	17·422
42	34·014	83	17·212
43	33·223	84	17·007
44	32·468	85	16·807
45	31·746	86	16·611
46	31·056	87	16·420
47	30·395	88	16·234
48	29·762	89	16·051
49	29·155	90	15·873
50	28·571	91	15·699
51	28·011	92	15·528
52	27·473	93	15·361
53	26·954	94	15·198
54	26·455	95	15·038
55	25·974	96	14·881
56	25·510	97	14·728
57	25·063	98	14·577
58	24·631	99	14·430
59	24·213	100	14·286
60	23·810	101	14·144
61	23·419	102	14·006
62	23·041	103	13·870
63	22·676	104	13·736
64	22·321	105	13·605
65	21·978	106	13·477
66	21·645	107	13·351
67	21·322	108	13·228
68	21·008	109	13·106
69	20·704	110	12·987
70	20·408		

Battery check

49. (1) Set the SELECT METER TEST switch to the BATT. position.

(2) Set the SELECT SPEED MEASUREMENT RANGE switch to position 1.

(3) The needle on meter M1 should be in the green zone on the meter scale. If the battery is found to be faulty, proceed as follows:—

(4) Release the fasteners securing the hinged flap on the right-hand side of the control unit case and open the flap (fig. 5).

(5) Release the fastener securing the battery retaining bar and pivot the bar away from the battery.

(6) Withdraw the battery from its compartment and disconnect it.

(7) Connect the new battery (Mallory, Type SKB544, Ref. No. 5J/3465) and insert it into the compartment.

(8) Secure the fastener on the battery bar and close the hinged flap.

(9) Repeat the tests detailed in sub-para. (1) to (3). Set the SELECT SPEED MEASUREMENT RANGE switch to OFF.

FAULT FINDING

Control unit

50. A test panel is located behind the hinged flap on the right-hand side of the control unit (fig. 5). Simple fault finding checks may be carried out using a Multimeter and an oscilloscope such as a Cossor Type 1058. Reference to these checks and to the circuit diagram, (fig. 8), will locate the fault to a component or a group of components. Further testing may be done by removing the control unit from its case and performing a point to point wiring check, again referring to the circuit diagram. Fig. 7 illustrates the layout of the main components within the control unit case.

51. Loss of output from the power amplifier.

(1) Check the continuity of test cable, QY2A81 and the jumper lead between the junction box in the motor unit and the tachogenerator.

(2) Set the 28V D.C. SUPPLY switch to OFF and set the SPEED SIGNAL COARSE and FINE controls fully counterclockwise.

(3) Connect the 28V D.C. SUPPLY plug, on the control unit, to the 28V d.c. supply.

(4) Open the hinged flap to expose the test panel.

(5) Link test points 14 and 15.

(6) Set the 28V D.C. SUPPLY switch to ON and carry out the tests indicated in table 2.

TABLE 2

Power supply and oscillator output checks

Operation	Indication	Probable fault	Action
Set 28V D.C. SUPPLY switch to ON	28V D.C. SUPPLY lamp lights	1. Lamp o/c 2. Fuse o/c 3. Incorrect polarity of supply	1. Renew lamp 1. Renew fuse 3. Reverse connections to cable QY2A82
With Multimeter on 100V d.c. range, measure between TP1 (+ve) and TP4	24V to 30V	External supply voltage incorrect	Set voltage to correct value. DO NOT EXCEED 30V.
With Multimeter on 100V d.c. range, measure the difference between the external supply voltage and the voltage between TP1 (+ve) and TP4	Not greater than 4V	Component failure	Refer to circuit diagram and check components connected to supply
With Multimeter on 100V d.c. range, measure between poles J (+ve) and H of MOTOR UNIT socket	24V to 30V	Wiring fault	Refer to circuit diagram and check continuity of wiring

TABLE 2 cont'd

Operation	Indication	Probable fault	Action
With Multimeter on 250V a.c. range, measure between TP13 and TP14	Not less than 95V	Component failure	Refer to circuit diagram and carry out checks detailed in table 3
With oscilloscope monitor waveform between TP13 and TP14	Waveform to be square, symmetrical with no overshoot or ringing		
With Multimeter on 250V a.c. range, measure between poles G and F of the MOTOR UNIT socket	Not less than 95V	Wiring fault	Refer to circuit diagram and check continuity of wiring

Note ... *TP=test point*

TABLE 3

Internal voltages of oscillator circuit

Test No.	Test point	Instrument and range	Indication
1	TP7 to TP8	Oscilloscope	Amplitude 1·3V to 1·7V p.p., square wave with overshoot
2	TP6 to TP7	Oscilloscope	Amplitude 0·65V to 0·85V p.p., square wave with overshoot 0·2V to 0·3V
3	TP6 to TP7	Multimeter on 2·5V a.c. range	
4	TP6 to TP8	As Test No. 2 above	
5	TP6 to TP8	As Test No. 3 above	
6	TP1 to TP6	Multimeter on 25V d.c. range (TP1 +ve)	10·5V to 13V
7	TP17 to TP18	Oscilloscope	Amplitude 14V to 18V p.p., square wave with overshoot
8	TP17 to TP18	Multimeter on 10V a.c. range	8V to 10V
9	TP1 to TP17	Oscilloscope	Amplitude 7V to 9V p.p., square wave with overshoot 4V
10	TP1 to TP17	Multimeter on 10V a.c range	to 5V
11	TP1 to TP17	Multimeter on 2·5V d.c. range (TP1 +ve)	0·7V to 0·9V
12	TP1 to TP18	As Test No. 9 above	
13	TP1 to TP18	As Test No. 10 above	
14	TP1 to TP18	As Test No. 11 above	
15	TP1 to TP5	Multimeter on 25V d.c. range (TP1 +ve)	11V to 13V
16	TP1 to TP3	Multimeter on 25V d.c. range (TP1 +ve)	1·1V to 1·4V
17	TP1 to TP2	As Test No. 16 above	

Speed measurement bridge fault

52. If the calibration check (para. 48 (1) to (22)) indicates that the instrument is faulty, the following procedure should be carried out.

(1) Carry out the battery check detailed in para. 49.

(2) Set the SELECT SPEED MEASUREMENT range switch to position 1.

(3) Open the battery compartment flap (fig. 5).

(4) Connect the output of an 1.f. oscillator, such as an Advance, Type J2, to the panel socket labelled COUNTER.

(5) Set the oscillator output to 6V r.m.s., 70 c/s.

(6) Connect an oscilloscope, such as a Cossor, Type 1058, between test points 10 and 12 and monitor the waveform.

(7) The waveform should be of the form illustrated on the circuit diagram, fig. 8.

(8) Further testing may be done, using a Multimeter, with reference to the circuit diagram, fig. 8.

Caution . . .

Remove the battery connections before carrying out continuity checks on this circuit.

(9) Remove the link between test points 14 and 15 and set the SELECT SPEED MEASUREMENT RANGE switch to OFF.

Motor unit

53. Reference to the circuit diagram, fig. 6, will show that a point-to-point wiring check will suffice to locate any fault which may arise on this unit.

54. Care should be taken to ensure that the motor unit is kept free from dust and grease. The two drive couplings should be checked for tightness and should be examined to ensure that no torsional play is present.

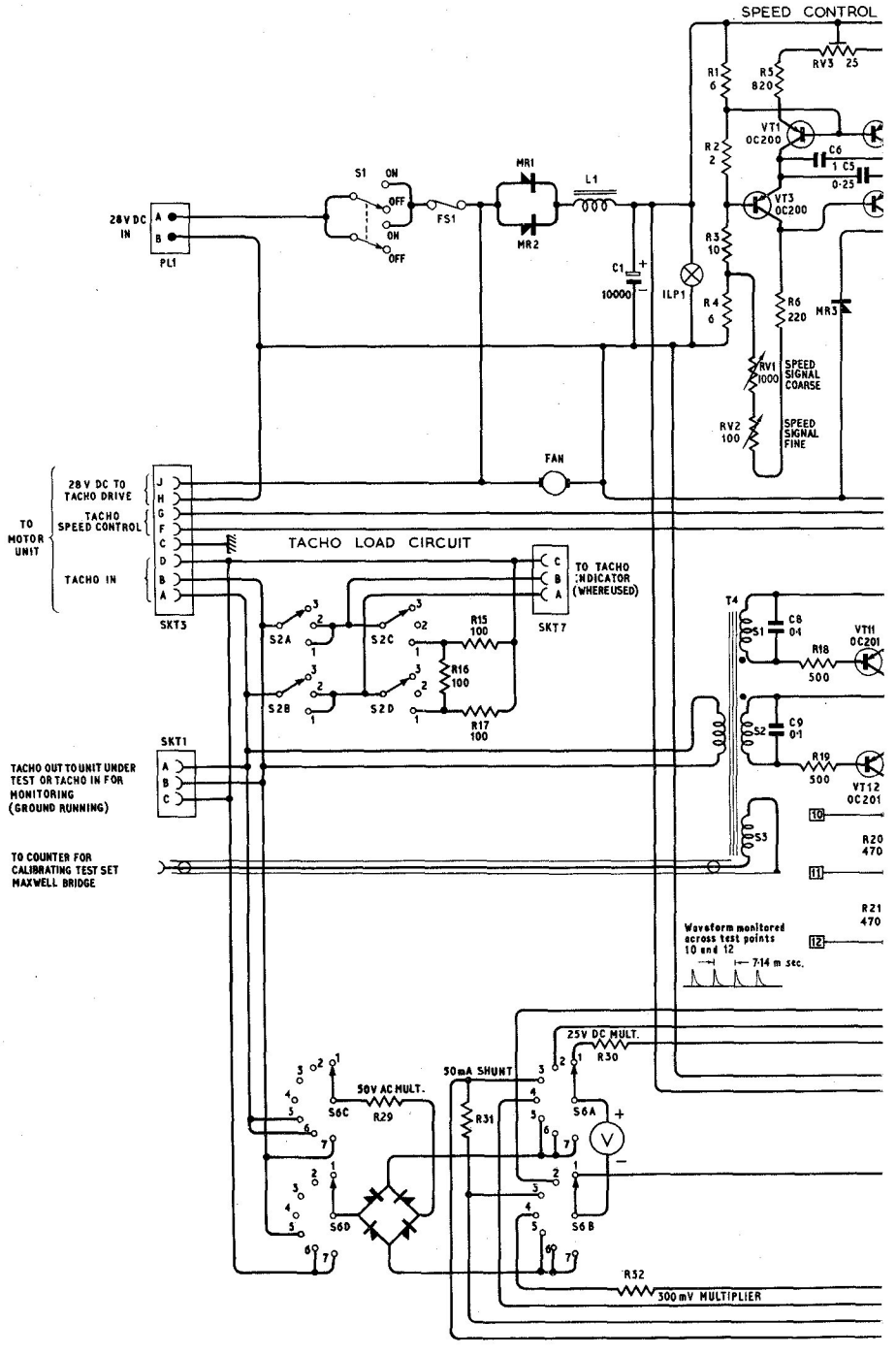

Fig.8

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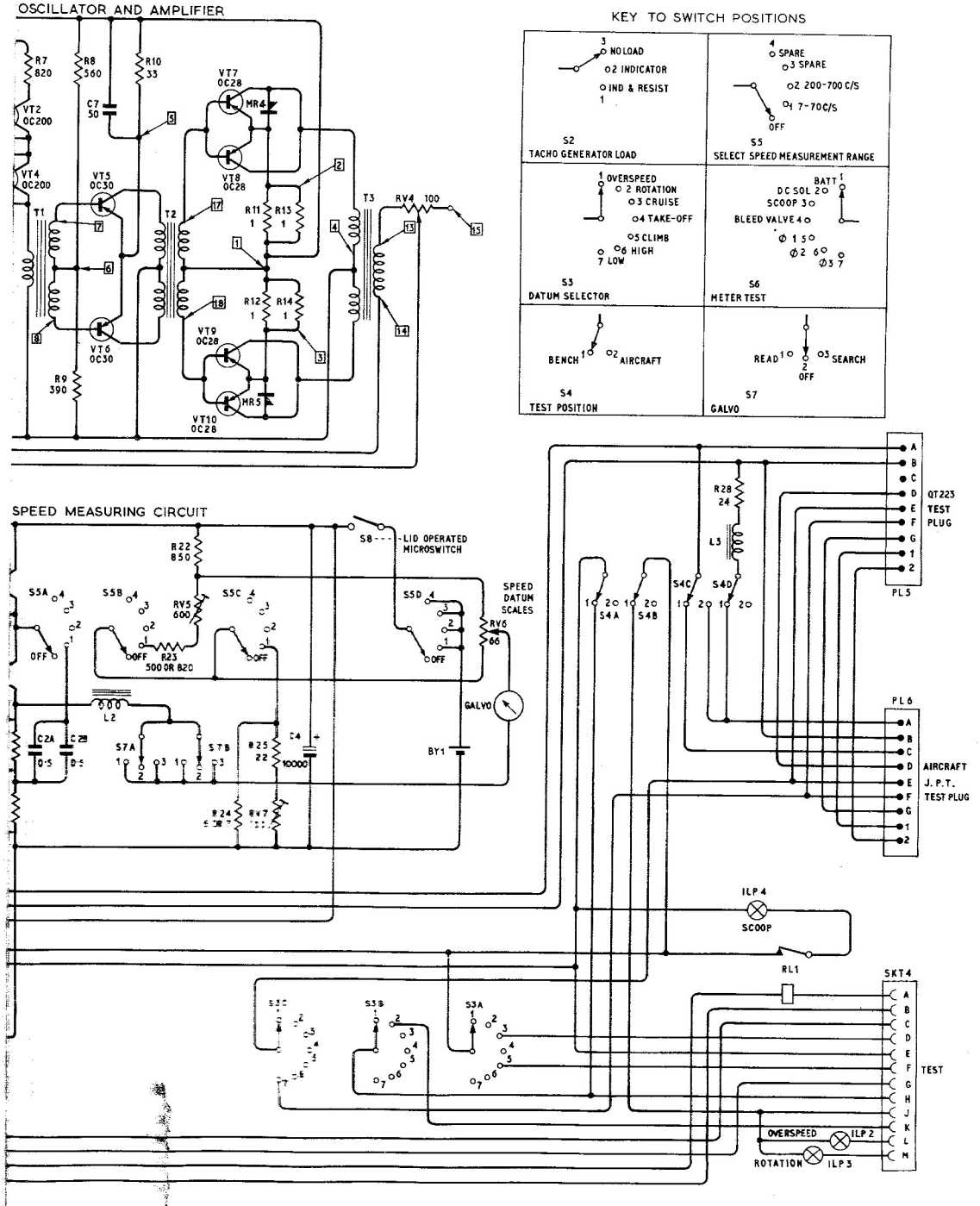
Control



unit, Type QC2A80-circuit

Fig. 8

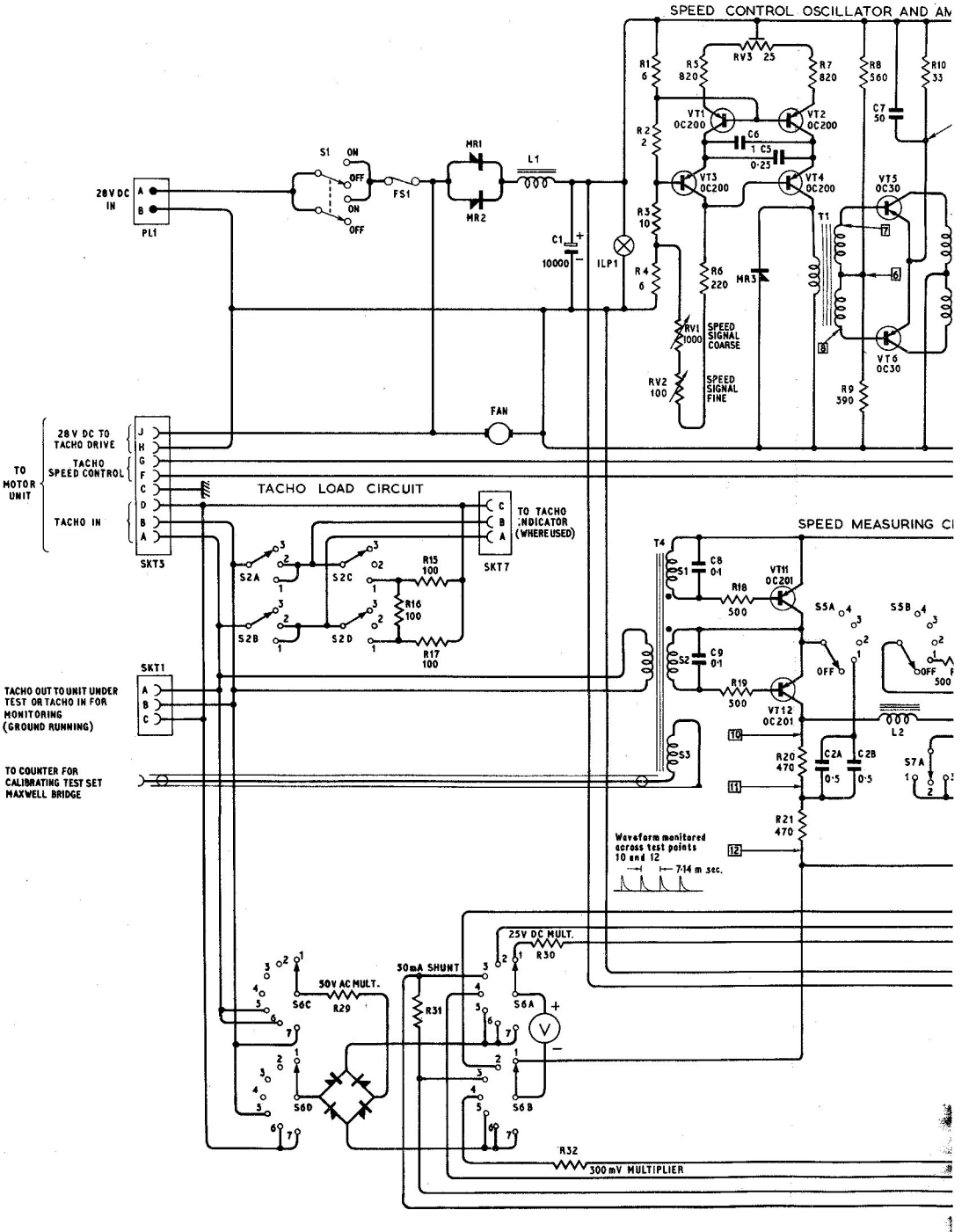


Fig.8

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Control unit, Type Q(

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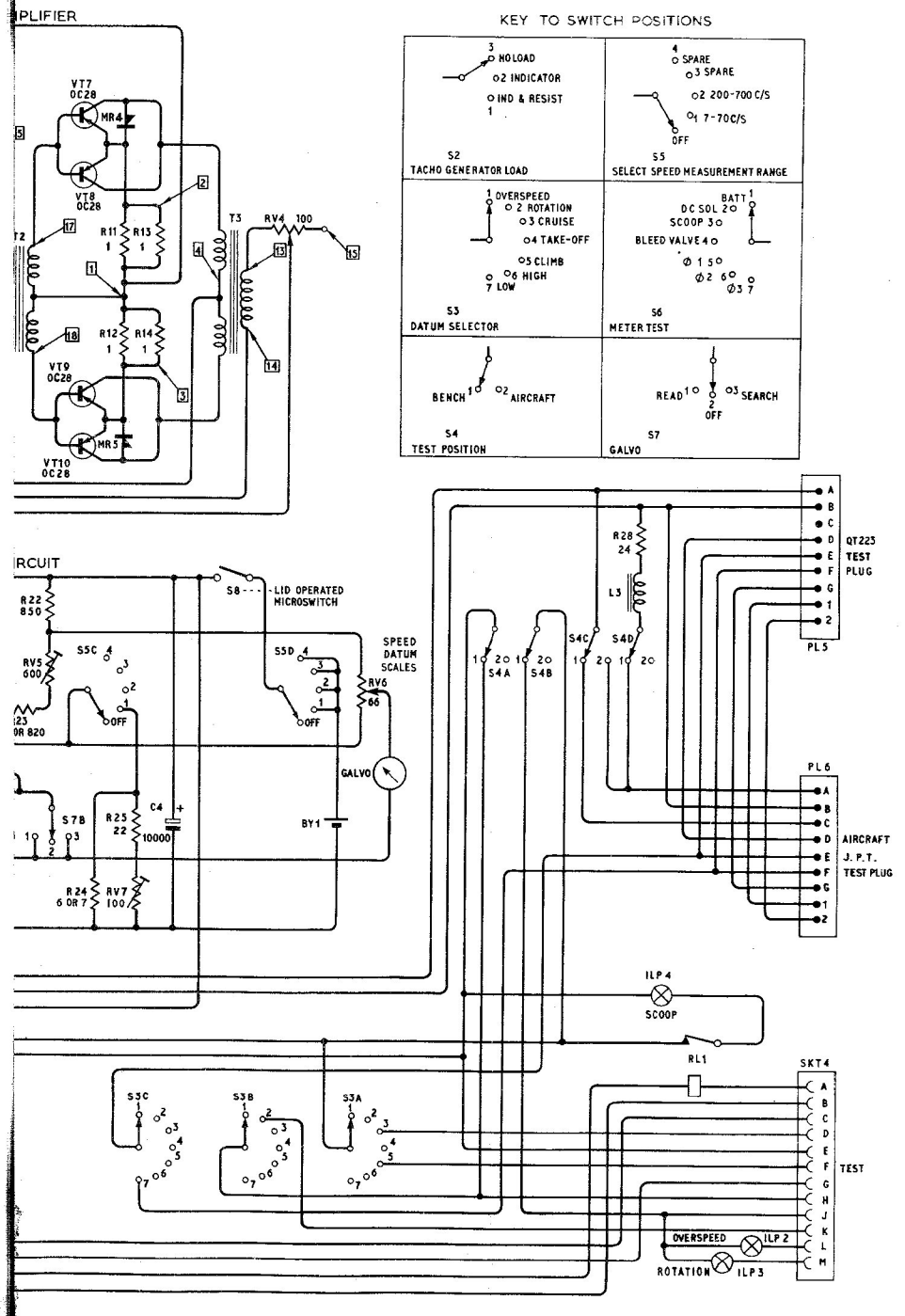

C2A80-circuit
TED

Fig. 8