Cancelled now AP 113F-0503-1

AMPLIFIER UNIT, ULTRA, TYPE A401/3

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LEADING PARTICULARS

Amplifier unit, Ultra, Type A401/3 **Ref. No. 5CZ/6137**

Power supply	*115V, 400 c/s single phase*
Overall dimensions	$15\frac{1}{8}$ *in.* × 8 *in.* × $5\frac{1}{8}$ *in.*
Weight	21 *lb.*

Introduction

1. Amplifier unit, Ultra, Type A401/3 (*fig. 1.*) forms part of the Throttle Control System, Ultra, Type B.A.P. 3, described in A.P.4343K, Vol. 1, Sect. 1, Chap. 1. The amplifier unit comprises the following parts of the system :—

(1) Stabilised supply
(2) Datum reference voltage
(3) Shaping network
(4) Datum lift amplifier
(5) Temperature amplifier with rate feedback
(6) Rectifier
(7) Phase discriminator
(8) Rate limiter
(9) Positioner amplifier

2. The amplifier unit also contains a temperature safety circuit which, in the event of an open circuit or short circuit in the C.J.C. or temperature input circuit, interrupts the normal throttle motor circuit and causes the warning lamp to light.

3. The discriminator, limiter and positioner amplifier form part of the basic position control system.

4. The stabilised supply, datum reference voltage, temperature amplifier and rectifier form part of a temperature control system which applies an additional input to the positioner amplifier and serves to modify the final position of the engine throttle lever according to the engine jet-pipe temperature.

5. The shaping network and datum lift amplifier accept a signal from the engine-driven tacho-generator, and under certain conditions of engine acceleration, serve to raise the datum of the temperature control system.

DESCRIPTION

6. The component parts of the amplifier unit are mounted on a light alloy chassis casting. On the front of the chassis are the four, fixed plugs which connect the amplifier unit into the B.A.P.3 system. On the top of the chassis, at the front, is a row of terminal pins which serve as test points when the unit is installed in the aircraft. Fig. 2 shows the amplifier unit with the top cover removed, and identifies the temperature safety relay and the seven, sealed canisters mounted on the top of the chassis. The canister connections, associated potentiometers and test

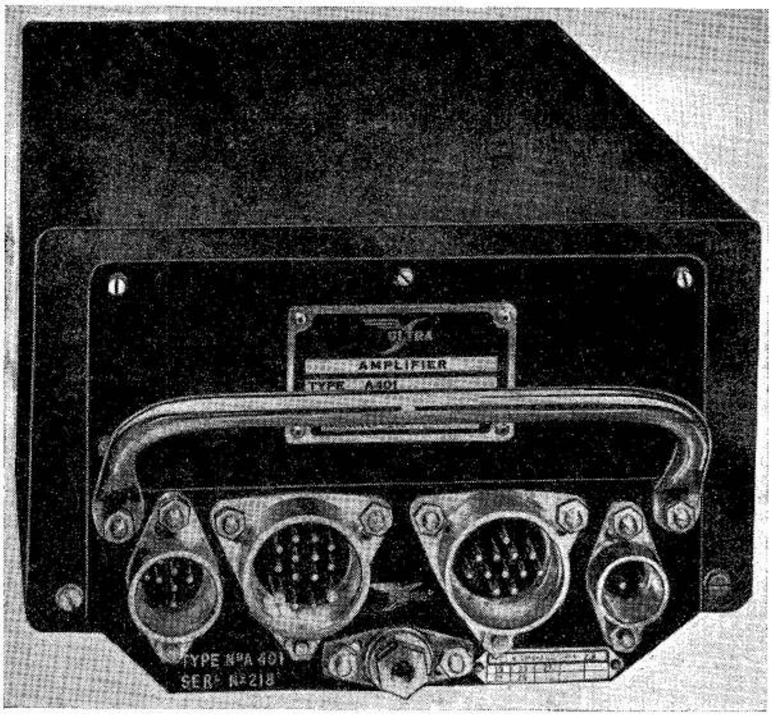

Fig. 1 Amplifier unit, Ultra, Type A401/3

points are located on the underside of the chassis. Fig. 3 shows the underside of the chassis with the cover plate removed, and identifies the above items.

7. The plugs of the amplifier unit are connected into the B.A.P.3 system as follows:—

Plug		
A1 (5 - pin)	to	C.J.C. unit
A2 (14-pin)	to	transmitter unit
A3 (12-pin)	to	throttle motor
A4 (2 - pin)	to	115V, 400 c/s single-phase power supply

In the circuit of the amplifier unit (*fig.* 5), each external connection is prefixed with the plug number (e.g. 3.L, 4B, 1.C etc.).

PRINCIPLES OF OPERATION

8. The principles of operation of the complete B.A.P.3 system are described in A.P.4343K, Vol. 1, Sect. 1, Chap. 1.

CIRCUIT DESCRIPTION

9. The power unit supplies all the a.c. circuits in the B.A.P.3 system. A 115V, 400 c/s supply is fed, via amplifier plug A4, to seals A and B of the power unit. As shown in fig. 5, the power unit houses two transformers. The transformer having nine secondary windings supplies the following circuits in the amplifier unit :—

Seal No.	Circuits
A/1, B/1, C/1	Positioner 1 amplifier
F/1, G/1, H/1	The a.c. output from F/1, H/1 is rectified by half-wave rectifier MR53, and the resultant d.c. is smoothed by C24. Resistor R45 (in the can) and RV7 form a voltage divider network across G/1 (+ve) and H/1. A d.c. voltage is taken from the slider of RV7 and G/1 for the rate limiter circuit in the phase discriminator (positioner 1 can).
O, N P, Q	Phase discriminator
L,M	Stabilised reference source
U, V, W	Datum lift amplifier
R, S, T	Temperature safety amplifier
R, T	Temperature safety input circuit
S, T	Temperature safety balance circuit

10. The transformer having four secondary windings supplies the following circuits :—

Seal No.	External connections	Circuits
G, H	A.2.L	Positioner 2 amplifier and throttle motor in series
J, K	A.2.C, A.2.D	Transmitter unit : synchro rotor, positioner safety amplifier, 1st stage governor amplifier, positioner safety balance circuit intermittent supply safety circuit.
D, E	A.2.G, A.2.H	Transmitter unit : 2nd stage governor amplifier, control phase of governor trim potentiometer motor.
D, F	A.2.F, A.2.G	Transmitter unit : reference phase of governor trim potentiometer motor, governor trim potentiometer, positioner safety input circuit.

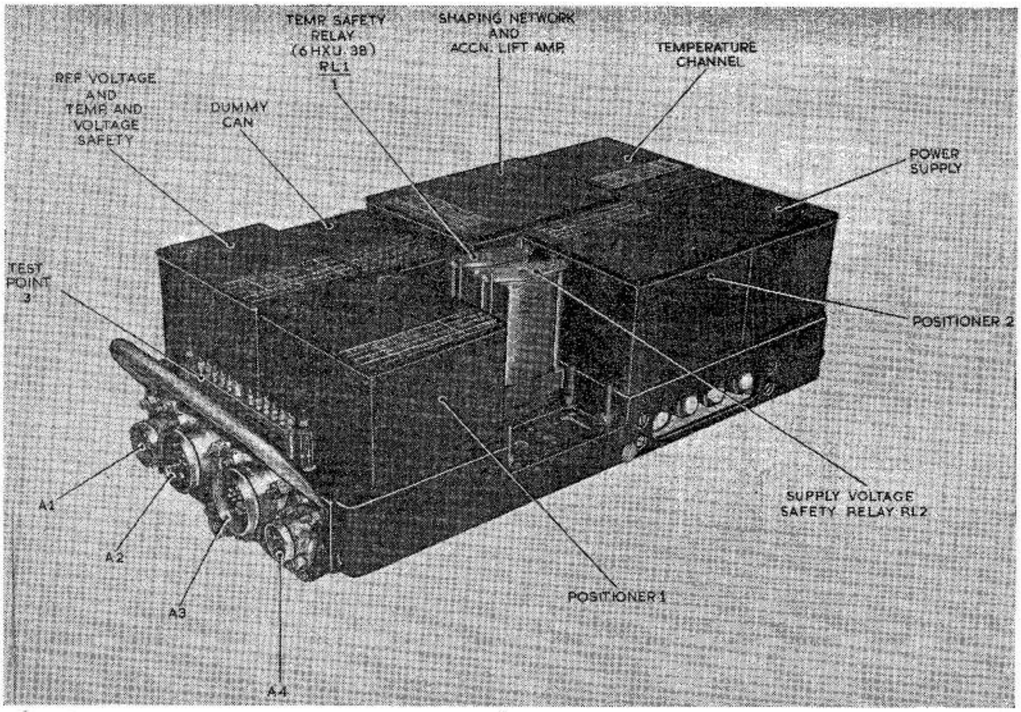

Fig. 2 Amplifier unit, Ultra, Type A401/3—top cover removed

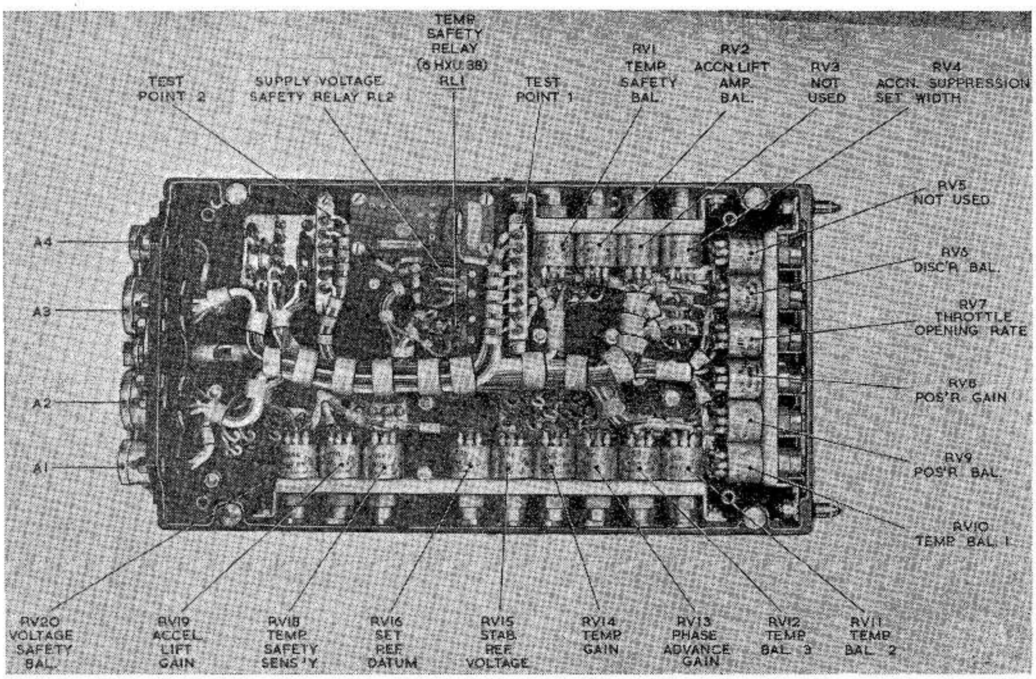

Fig. 3 Amplifier unit, Ultra, Type A401/3—underside,cover removed

11. The amplifier unit serves to interconnect the main units of the system. Direct links exist between the following plug connections in the amplifier unit :—

Link	Circuit
A2A-A3E A2B-A3G A2D-A3F	Transmit synchro stator (transmitter unit) to reset synchro stator (motor unit)
A3L-A.2.1 A3M-A.2.2	Tacho-generator signal to governor datum selector (via transmitter unit)

Positioner channel

12. The operation of the positioner system is described in A.P.4343K, Vol. 1, Sect. 1, Chap. 1. The positioner channel in the amplifier unit consists of the phase discriminator, limiter and positioner 1 amplifier (in positioner 1 can), and positioner 2 amplifier.

13. The a.c. error signal, from the reset synchro rotor in the throttle motor, is applied to the phase discriminator via plug poles A3J and A3H. The magnitude of the signal represents the degree of displacement of the reset rotor with respect to the transmit rotor. The phasing of the signal represents the sense of the displacement, and hence a close-throttle or open-throttle signal. The phase discriminator rectifies the error signal and, at the same time, preserves the sense of the displacement, thus the output of the discriminator is a d.c. signal which reverses in polarity when the phase of the error signal reverses.

14. The phase discriminator circuit comprises an error signal transformer, two bridge rectifiers MR47, MR48, and two mixing resistors R42, R43, balanced by potentiometer RV6. The bridge rectifiers are connected back-to-back, so that with equal a.c. voltages applied to each, the potential difference between the ends of the resistor chain comprising R42, RV6 and R43, is zero. Each secondary winding of the error signal transformer is connected in series with an a.c. reference voltage obtained from the power unit (seals O-N and P-Q). The reference voltages are anti-phase.

15. An error signal input to the discriminator will add to the reference voltage in one half of the circuit and subtract from the reference voltage in the other half according to the phase of the error signal. The d.c. output from one rectifier bridge will exceed that from the other, and thus the circuit will be unbalanced in a sense which corresponds with the phasing of the input.

Governor trim

16. An additional a.c. signal is applied to the discriminator from the r.p.m. governor channel in the transmitter. When the engine speed exceeds that selected at the datum selector unit, the governor channel output drives a motor which is geared to an a.c. potentiometer through a slipping clutch. The potentiometer output, the phasing of which represents a close-throttle signal, is applied to the discriminator via plug poles A2E and A2F.

Rate limiter

17. For transit rotor displacements of up to 8° in the opening throttle sense, the rotational speed of the throttle motor shaft is proportional to displacement. For displacements greater than 8°, the rotational speed is limited to 20° per second. This limiting is achieved by connecting a biased diode, MR51, across the phase discriminator output to shunt the output above a given level. The bias supply to the diode is taken from the amplifier power unit, via rectifier MR53, giving a negative reference voltage at the wiper of RV7. For transmit rotor displacements in the opening direction of less than 8°, the discriminator output is less than the bias on the diode. The diode does not conduct, and the discriminator output to the positioner 1 stage is proportional to the displacement.

18. For transmit rotor displacements of greater than 8°, however, RV7 is preset so that the limiting diode conducts. R45 shunts the discriminator output, thereby limiting the maximum signal in the winding and hence limiting the maximum throttle opening rate to 20° per second. The limiting is not effective in the closing throttle sense and a rate of 90° per second can be achieved on rapid shutdown.

Feedback stabilisation

19. A small d.c. generator in the throttle motor is driven by the normal motor, and develops an output voltage proportional to the motor speed. The output from the generator is connected in series opposition to the error signal (as rate feedback), and thus provides damping. Further stabilisation is provided by the network C22 and R41, which, in addition to providing a signal input proportional to the resulant of the error and feedback voltages (via R41), also provides a signal proportional to the rate of change of voltage (via C22).

20. The effect of this damping or stabilisation is to prevent overshoot of the throttle, and to bring the throttle quickly into correspondence with the pilot's lever. When the pilot moves the throttle lever to a new position the error signal, sensed by the reset synchro, is fed into the amplifier. The output from the amplifier develops a torque in the normal motor, causing the system to accelerate and as the throttle begins to move the error signal reduces. At the same time as the motor speed is increasing the feedback voltage is also increasing, and as the error becomes smaller a point is reached where the feedback voltage is greater than the error voltage, and the input to the amplifier reversed. Thus a decelerating torque is applied to the motor bringing the system to rest with negligible overshoot.

Position amplifier

21. The position amplifier is a two-stage, magnetic amplifier, with four inputs and an a.c. output, driving the three-phase, normal throttle motor. The first amplifier stage (positioner 1) consists of a d.c., push-pull transductor with auto-self-excitation and series mixing. The output from each transductor half is applied as a negative bias to the other transductor half. The resultant cross-bias circuit gives the stage positive feedback. The stage is balanced by means of RV9, which adjusts the relative values of mixing resistors R39 and R40. The potential difference developed across RV9 is applied across the second feedback winding to enhance the degree of control. The resultant of the basic positioning signal, governor trim signal and rate feedback signal is applied to the first input winding via C22, R41. A temperature trim signal is applied to the second input winding via diode MR52. The diode ensures that only close-throttle signals are applied to the positioner channel. The polarity of the d.c. output from the positioner 1 stage depends on the sense of the total input to the input windings (open or close-throttle). The gain of the positioner channel is adjusted by means of RV8, which is in series with the input winding of the output stage.

22. The output stage of the positioner amplifier is a self-biasing push-pull amplifier stage. When an opening signal is received from the positioner stage 1, a d.c. voltage will appear across the input winding to the positioner output stage. Current will therefore flow through one half (say X winding) of the control winding, in such a direction as to increase the flux in core X, while the same current flowing in the Y winding will tend to decrease the flux in the Y core, since the two sections of the control windings are reverse wound. As the magnetising current increases round the X core, so the permeability of the core, and therefore the inductance of the a.c. winding, decreases. Thus as the inductive reactance of the a.c. winding falls and voltage across the X coil is consequently reduced, the voltage at A3A is greater than the voltage at A3B. Current therefore flows from A3A to A3B, via capacitors C19 and C20 with a consequent phase lead, causing the throttle motor to turn in the opening direction. Similarly for a closing signal, the inductance of the Y coil decreases and the voltage at A3B is greater than at A3A.

23. The self-biasing of the output stage is effected as follows. The bias winding in each transductor half, in series with a resistor, is connected across rectifiers MR45 or MR46. Consider the circuit action in the X transductor half during one full cycle of the a.c. supply. The forward impedance of the rectifiers is very small compared with that of the transductor a.c. windings.

(1) When canister seal E is positive with respect to G, there is a negligible current flow (reverse current in one half of MR46) in the a.c. winding adjacent to R70. The potential at the junction of the a.c. winding and R70 is nearly equal to the applied voltage. At the same time, the other half of MR46 conducts fully, and current flows in the a.c. winding remote from R70. Owing to the impedance of this winding there is a voltage drop across it, and the potential at the junction with the bias winding is low. The bias winding in series with R70 is connected across the ends of the a.c. windings. As the junction with R70 is positive with respect to the junction with the bias winding, bias current will flow.

(2) When seal G is positive with respect to E, one half of MR46 conducts fully and current flows in the a.c. winding adjacent to R70. Owing to the impedance of this winding, the voltage developed across it, and hence the potential at the junction with R70 is high. At the same time there is a negligible current flow (reverse current in the other half of MR46) in the a.c. winding remote from R70, and the potential at the junction with the bias winding is low. As in (1) above, the junction with R70 is still positive with respect to the junction with the bias winding. A unidirectional current will therefore flow in the bias winding throughout the full cycle of the supply.

24. The normal throttle motor circuit is completed via the contacts of the temperature safety relay (amplifier unit) and of the positioner safety relay (transmitter unit). This arrangement ensures that if a fault occurs in the normal throttle control system the motor is immobilised, thus preventing movement of the throttle.

Temperature channel

25. The final position of the throttle can be offset from the null point of the reset synchro by the additional trimming signals applied to the positioner channel. The governor channel in the transmitter applies a close-throttle signal to the discriminator when the engine exceeds a given speed. The temperature channel applies a close-throttle signal to the positioner 1 amplifier when the jet-pipe exceeds a given temperature.

26. The jet-pipe temperature signal, derived from a thermocouple system, is compared with a stable reference voltage which represents the datum temperature. When the thermocouple signal exceeds this datum, an error signal is produced which, after amplification in the temperature amplifier, applies a close-throttle signal to the positioner channel.

Stabilised supply bridge

27. The stabilised supply and the reference voltage network are located in the reference and voltage safety canister, and the C.J.C. unit. An a.c. supply is fed via rectifier MR1 and resistors R7, R7a to the stabilised supply bridge. This uses the reverse voltage characteristic of a Zener diode to supply a stable current to the C.J.C. unit and reference voltage network.

28. The Zener diode has the property that, above a given reverse voltage (Zener voltage), it operates on a substantially straight part of its characteristic, the slope of which represents a very small dynamic resistance. Thus, variations in reverse current produce proportionately very small variations in the voltage developed across the diode. In the stabilised supply bridge, RV15 is adjusted to a value equivalent to the dynamic resistance of the diode MR2. The stabilised output is taken from across the bridge, so that any variation in the voltage developed across the diode is counteracted by the voltage developed across RV15. Thus the bridge network produces a highly stable supply voltage for the reference voltage network.

29. In series with R9 in the bridge output is a copper resistor which compensates for changes in the bridge resulting from ambient temperature variations. Variable resistor RV16 controls the current in the voltage divider chain R9, RV16 and R5, and thus determines the voltage applied to the reference voltage network.

Reference voltage network

30. The basic reference voltage network consists of R4, R52 (amplifier unit) R3, R2 and R1 (C.J.C. unit). The reference voltage, which determines the temperature datum, is developed across R1. The thermocouple signal is compared with the reference voltage, and the error signal produced across A1A and A1B is applied to input winding of the temperature amplifier.

Cold junction compensation

31. The thermocouple signal which is compared with the reference voltage, represents the temperature difference between the thermocouple hot junction (engine jet-pipe) and the C.J.C. unit. As the cold junction senses ambient temperature, a temperature rise at the C.J.C. unit would reduce the thermocouple signal for a constant jet-pipe temperature. Cold junction compensation (of the order of 85%, for optimum working of the throttle control system) is effected by reducing the reference voltage across R1 in proportion to the ambient temperature rise. Resistor R3 is copper-wound so that, as the cold junction temperature rises, the increased resistance of the reference voltage network reduces the current in R1.

Temperature amplifier

32. The error signal which results from the comparison of the thermocouple signal with the reference voltage is fed to the temperature amplifier via canister seals A and B. The network comprising R51 (in shaper canister) and RV3, is in parellel with the input winding. Negligible shunting of the error signal occurs, because R51 is large compared with the winding resistance. The temperature amplifier consists of a three-stage magnetic amplifier, the d.c. output of which is applied via diode MR52 to the positioner 1 amplifier. The use of the diode ensures that only over-temperature (close-throttle) signals are applied to the positioner amplifier.

33. Each amplifier stage consists of a d.c., push-pull transductor with auto-self-excitation and series mixing. The output from each transductor half is applied as a negative bias to the other transductor half. The resultant cross-bias circuit produces a positive feedback effect in the stage. The stages are balanced by means of RV10, RV11 and RV12 which adjust the relative values of their respective mixing resistors (R23 and R25, R30 and R32, R34 and R36). In each stage, the potential difference developed across the balance potentiometer is applied across a feedback winding. The resistor R37 (in dummy canister) increases the load impedance of the first stage to the optiumum working level.

34. The output of the first stage, developed across the mixing resistors R23 and R25, is applied as negative feedback, via resistors R27 and R68. Positive transient feedback is applied to a second winding via R22 and C17. The output of the second stage, developed across the mixing resistors R30 and R32, is applied as negative feedback via resistor R26. Positive transient feedback is applied to a second winding via RV13, R29 and C18. By varying the degree of transient feedback in the second stage, RV13 adjusts the response time of the temperature amplifier. The output of the third stage developed across the mixing resistors R34, R36, is applied as negative feedback via variable resistor RV14. The use of negative feedback in the temperature amplifier stabilises the output against variations of operating conditions. The gain of the temperature amplifier is adjusted by varying the negative feedback in the third stage, using RV14.

Temperature datum, steady state and acceleration

35. At any constant compressor speed the temperature datum is constant. This characteristic is also applicable during accelerations when the compressor speed is below 9500 r.p.m. During accelerations when the compressor speed is above 9500 r.p.m. however, the temperature datum is lifted to an acceleration level. This is achieved by the acceleration datum lift circuit in the shaping network canister.

36. The temperature datum is lifted by increasing the current flow in the reference voltage network, and hence increasing the voltage developed across the reference resistor R1, located in the C.J.C. unit. This increase is effected by switching RV19 and thermister Th4 in parallel with R4 and R52. The variable resistor serves to determine the amount of the datum lift. The thermister serves to offset the temperature coefficient of the copper C.J.C. resistor, which would over-compensate with the increased current in the reference voltage network.

37. The switching-in of RV19 and Th4 is effected by means of the rectifier bridge MR26, 27, 28 and 29, which forms the output load of the datum lift amplifier. When the amplifier output causes the bridge to conduct, an additional current path including RV19 and Th4 is connected across R4 and R52 in the reference voltage network.

Datum lift amplifier

38. The datum lift amplifier consists of a d.c., push-pull transductor with auto-self-excitation and series mixing. The cross-bias circuit produces a positive feedback effect in the stage. The mixing resistor circuit is asymmetrical (R18 is 470Ω, R19 is 47Ω), so that with no input, the output of the stage prevents the rectifier bridge from conducting. To adjust the unbalance of the output, and hence the bias applied to the rectifier bridge, variable resistor RV2 is connected in parallel with R18.

Datum lift and shaping circuits

39. The datum lift circuit provides the input to the datum lift amplifier which causes the rectifier bridge (MR26, 27, 28 and 29) to conduct. The shaping circuit serves to suppress the datum lift circuit within a given range of engine speed. Both circuits derive their input from the tacho-generator, via plug poles A3L and A3M and a common transformer. The tacho-generator provides an a.c. signal, the frequency of which varies directly with engine speed. The signal voltage also varies with the engine speed, so that an increase in speed results in an increase in voltage.

40. The datum lift signal is derived from the engine tacho-generator, via the transformer and bridge rectifier MR19, 20, 21 and 22. When the engine is running at constant speed the d.c. output from the bridge rectifier is blocked by capacitor C32. When the engine speed is varying i.e. during accelerations or decelerations, the d.c. output from the bridge will vary. During accelerations, a derivative signal (i.e. signal proportional to the acceleration, since C32 and R16 form a differentiating circuit) will flow in the datum lift amplifier control winding, causing the output of the amplifier to reverse, which lifts the bias on the bridge network in the temperature datum circuit. During decelerations, the signal to the control winding of the datum lift amplifier is suppressed by series rectifier MR23.

41. The output from the engine tacho-generator is also fed to the shaping network (*fig.* 4.). This network consists of three filter circuits: a high pass, low pass and linear response circuit. The output from the linear circuit is substracted from the sum of the outputs of the high pass and low pass filters. Positive signals are suppressed by rectifier MR18. At compressor speeds below 9500 r.p.m. the output of the shaping network is a negative going dip, which is applied to the input winding of the datum lift amplifier to suppress the output from the datum lift circuit. During accelerations at compressor speeds below 9500 r.p.m., the datum lift circuit will not lift the bias from the bridge network (MR26, 27, 28 and 29) and the temperature datum will remain as for the steady state condition. VR4 controls the width of the negative going dip (i.e. the speed range during which the datum lift is suppressed.

Temperature safety circuit

42. The normal throttle motor circuit is completed by contacts RL1A of the temperature safety relay via plug poles A2M and A3C (Plug pole A3C is also common to one lead of the feedback generator, but the circuits operate independently). The purpose of the temperature safety relay is to ensure that, in the event of an open circuit or short circuit in the reference voltage network or temperature input circuit, the motor is immobilised to prevent the throttle from closing. The relay is operated by the output of the temperature safety amplifier. This amplifier accepts two opposing inputs, one which is determined by the impedance of the reference voltage network and temperature input circuits, the other is adjusted to a level which produces zero amplifier output. Any change of impedance in the reference voltage network or temperature input circuit will result in the application of an error signal to the temperature safety amplifier. An amplifier output of either polarity operates the relay, which then open-circuits the throttle motor supply.

43. The impedance of the temperature and reference circuits is monitored by injecting an a.c. voltage across them, sensing the resultant current in a transformer primary winding, rectifying the transformer output by means of MR4 and applying it to one input winding of the temperature safety amplifier. The a.c. voltage from seals R and T of the power unit is applied across one end of the temperature channel input winding (plug pole A1B), and the junction between R4 and R52. The capacitor C2 prevents the d.c. reference current from flowing in the a.c. injection circuit. Capacitor C1 serves to decouple the temperature channel input winding and C29 serves to decouple the reference voltage resistor.

44. The balance input to the temperature safety amplifier is derived from a voltage divider network R71 and RV1 fed from seals S and T of the power unit. The a.c. is rectified by rectifier MR3, and the resultant d.c. is smoothed by means of C28. The balance input is adjusted by means of RV1 to produce zero output from the temperature safety amplifier. The resistor R71 is connected, via plug poles A2J and A2K, to contacts RL2A of the intermittent supply safety relay, located in the transmitter. Closure of these contacts unbalances the inputs to the temperature safety amplifier by increasing the voltage across RV1, and causes the temperature safety relay to operate.

45. The amplifier consists of a d.c., push-pull transductor with series mixing and a cross-bias circuit. There is no static zero balance adjustment. Dynamic balancing is effected by the adjustment of RV1, so that the balance input nullifies the impedance monitoring input and also the inherent unbalance in the transductor.

46. The output of the temperature safety amplifier is applied to relay RL1/1. The relay is of the side-stable, polarised type, necessitating the use of both energising coils in conjunction with rectifiers MR9 and MR10, to enable operation with amplifier outputs of either polarity. The sensitivity of the relay is adjusted by means of RV18 to avoid spurious operation. When the relay is de-energised, contacts RL1A complete the throttle motor circuit. When the relay is energised, the throttle motor circuit is interrupted and a short-circuit is placed across the temperature safety input transformer. The temperature safety relay is thus self-latching, and remains energised until the master control is switched to OFF.

Supply voltage safety relay

47. An additional safety circuit is provided across the rectified supply to the reference voltage network. This comprises a bridge which monitors the voltage of the rectified supply. One arm of the bridge comprises diodes MR5 and MR6, and has therefore a non-linear resistance characteristic. The bridge is adjusted by means of RV20 so that it is balanced at the nominal supply voltage. Deviations from the nominal unbalance the bridge. In series with the bridge output are diodes MR7 and MR8, which also represent a non-linear resistance. These, in conjunction with R60, determine the sensitivity of RL2/1, hence the supply voltage tolerance. Relay contacts RL2A cause the temperature safety circuit to operate by short-circuiting the temperature safety input transformer.

48. Modification B181 removes the voltage safety relay from the amplifier and renders the safety circuit inoperative. Modification B185 removes the supply to the voltage safety bridge.

SERVICING

49. The procedure for bench testing the amplifier, using test set, Type QT4066, and ancillary equipment, is given in Appendix A.

Aircraft tests

50. Since it is not practicable to make accurate shaft angle measurements on the throttle motor and transmitter, when these are installed in an aircraft, comprehensive performance tests can only be done with the amplifier on a bench, using the bench test rig (see Appendix A).

51. Aircraft tests are performed with the test equipment, Ultra, Type QE406. A description of this equipment, together with detailed test instructions, will be found in A.P. 4343K, Vol. 1, Sect. 10, Chap. 3. Although the amplifier forms only a part of the B.A.P.3 system, the complete range of aircraft tests listed in Table 3 of the above mentioned A.P. should be carried out after installation of the amplifier.

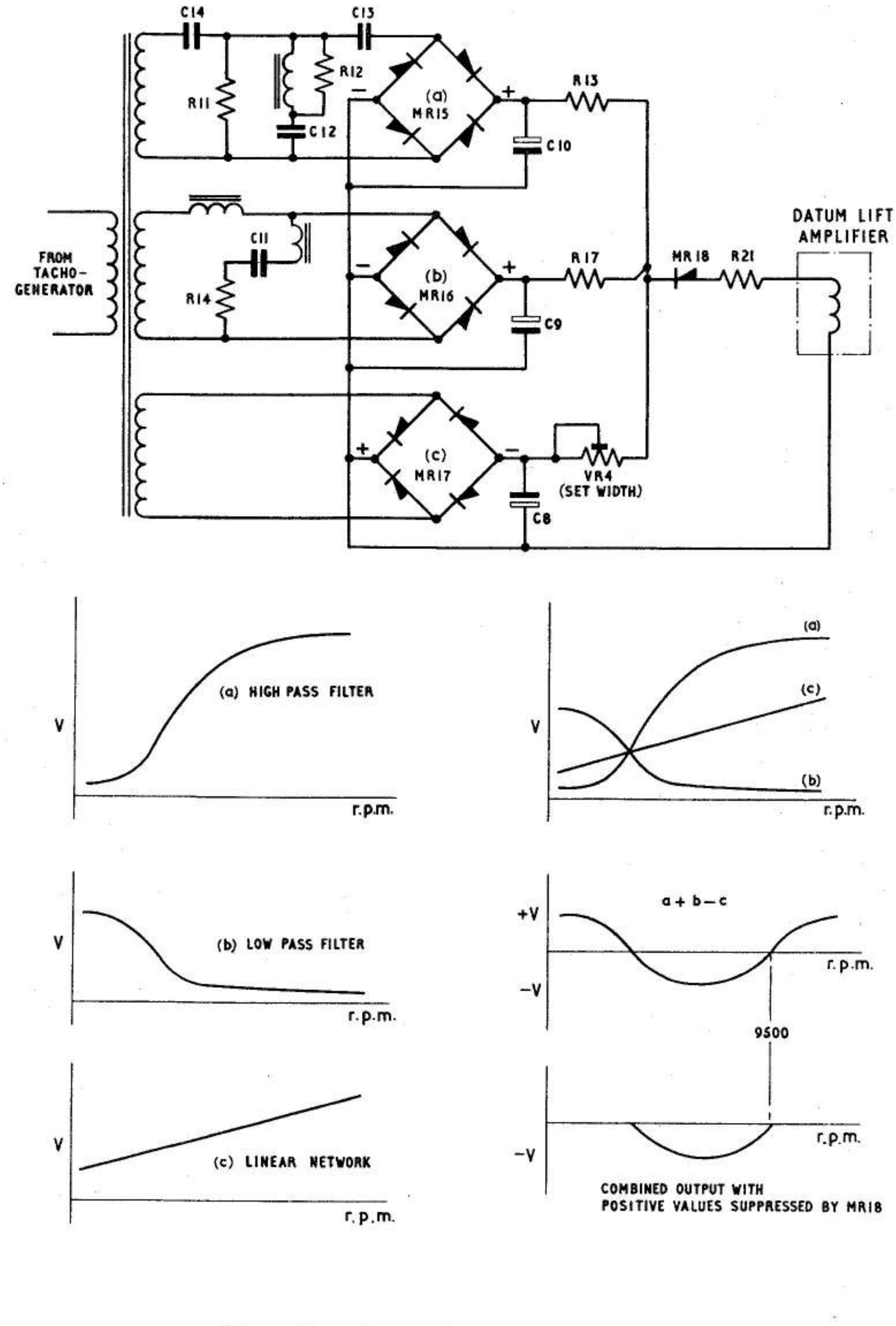

Fig.4 Shaping network

RESTRICTED

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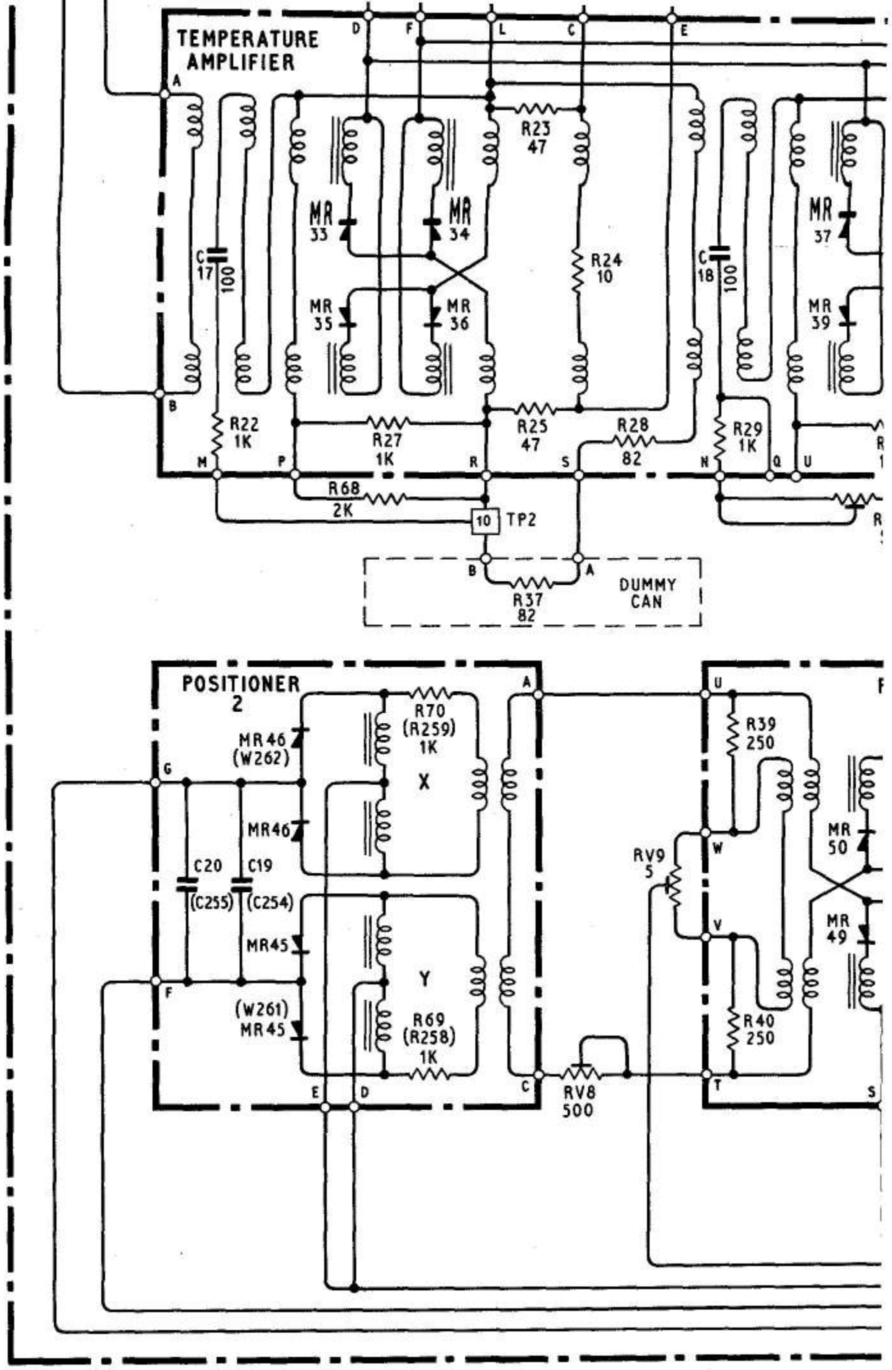
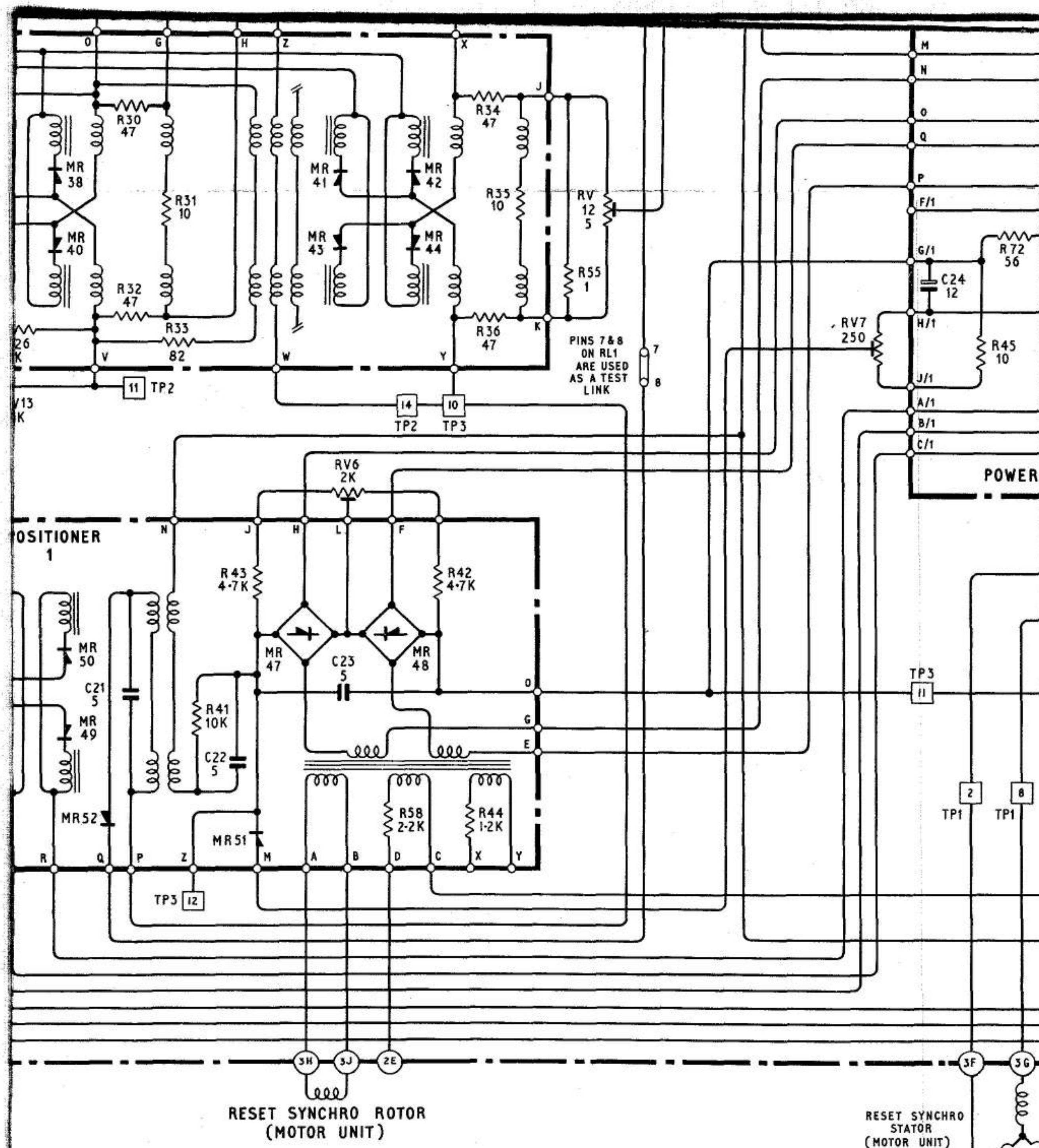


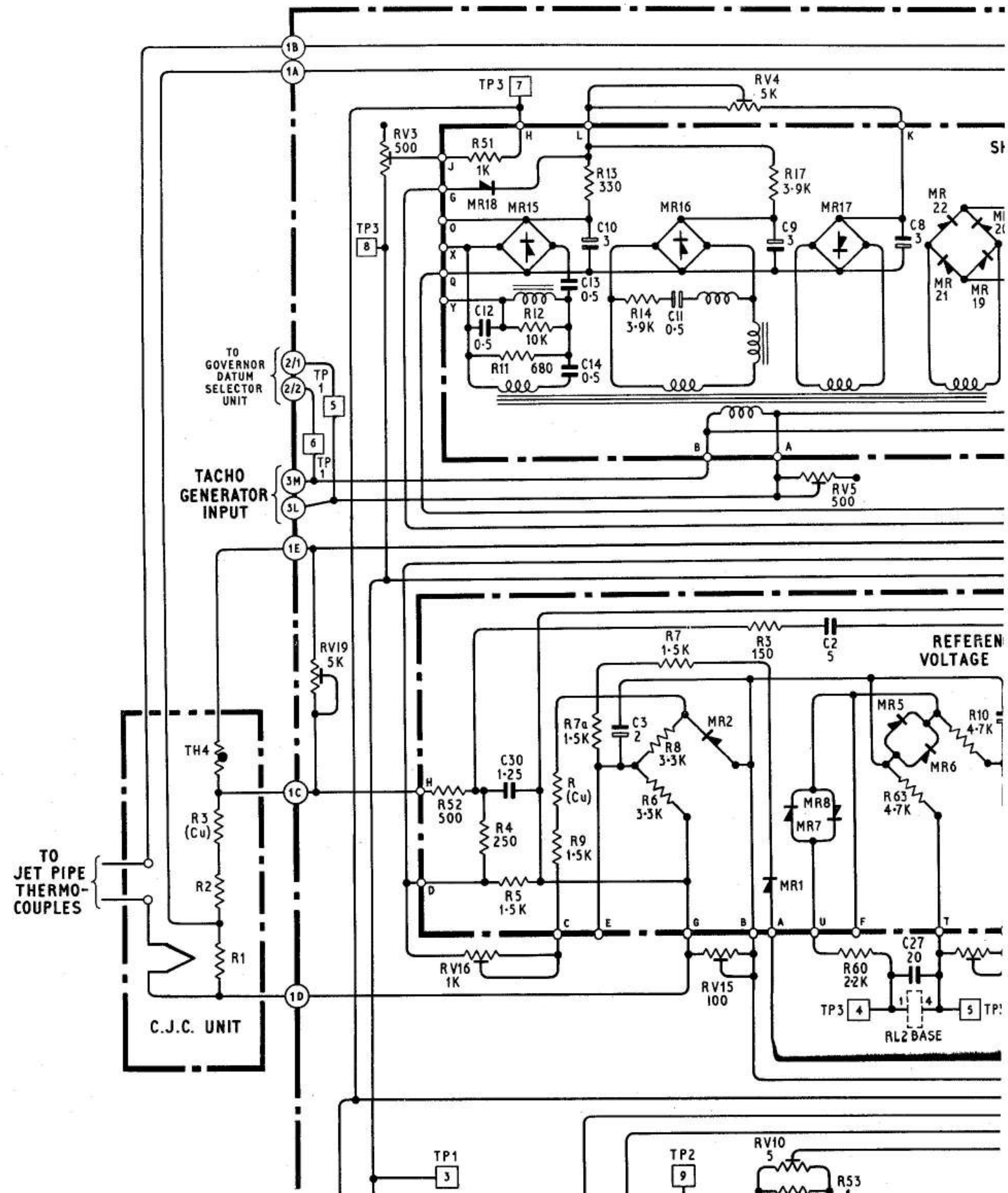
Fig.5 Am

4013 373568 10/64 P. P. LTD 950-2



plifier unit, Ultra, Type A401/3 – circuit

RESTRICTED



TO JET PIPE THERMO-COUPLES
C.J.C. UNIT
TH4
R3 (Cu)
R2
R1
TO GOVERNOR DATUM SELECTOR UNIT
TACHO GENERATOR INPUT
TP3 7
TP3 8
RV3 500
R51 1K
MR18
MR15
MR16
MR17
RV4 5K
R13 330
R17 3·9K
C10 3
C9 3
C8 3
C13 0·5
C12 0·5
R12 10K
R11 680
C14 0·5
R14 3·9K
C11 0·5
RV5 500
RV19 5K
R52 500
C30 1·25
R4 250
R5 1·5K
R (Cu)
R9 1·5K
R7a 1·5K
C3 2
R8 3·3K
R6 3·3K
MR2
R7 1·5K
R3 150
C2 5
REFEREN
VOLTAGE
MR5
MR6
R10 4·7K
R63 4·7K
MR8
MR7
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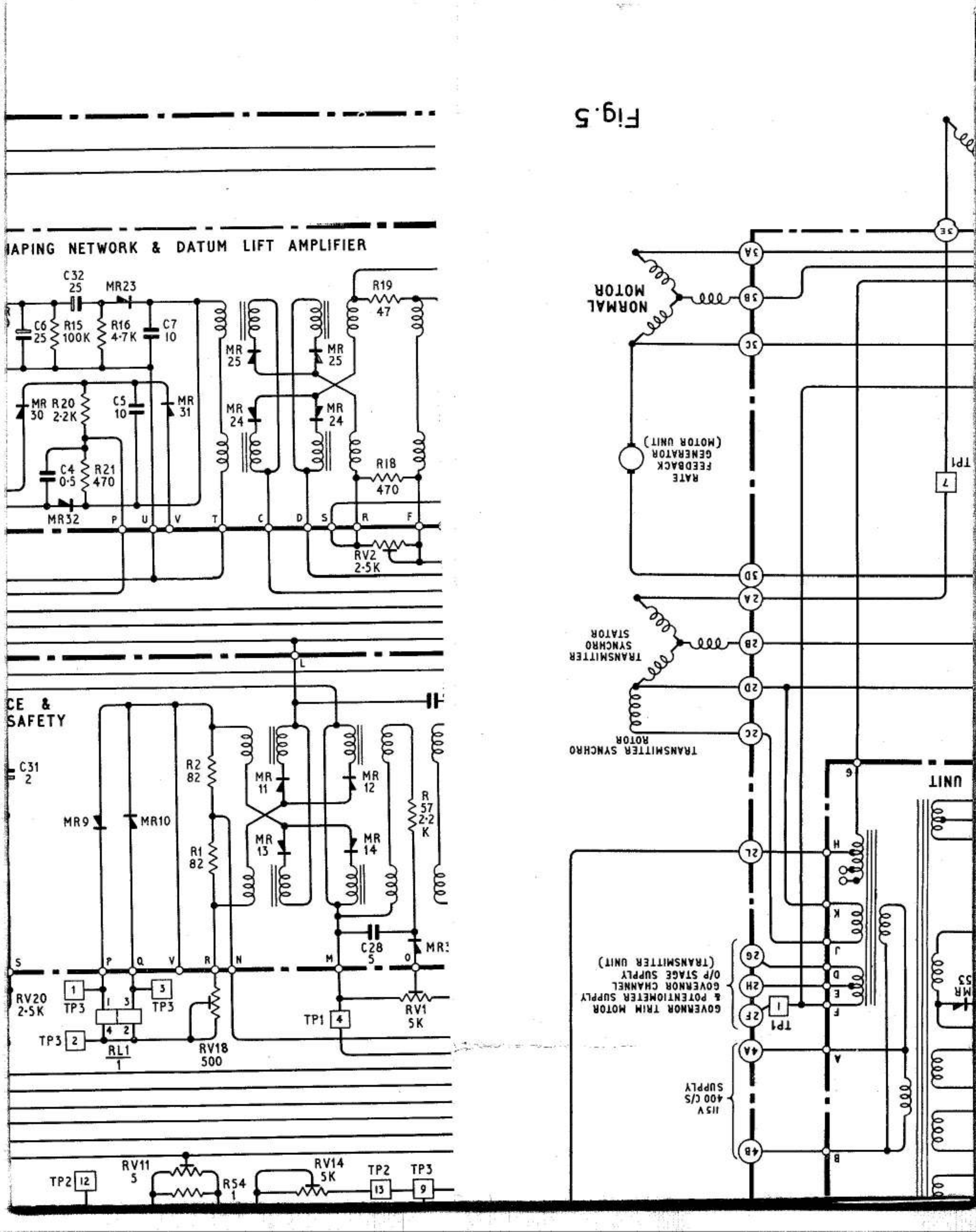
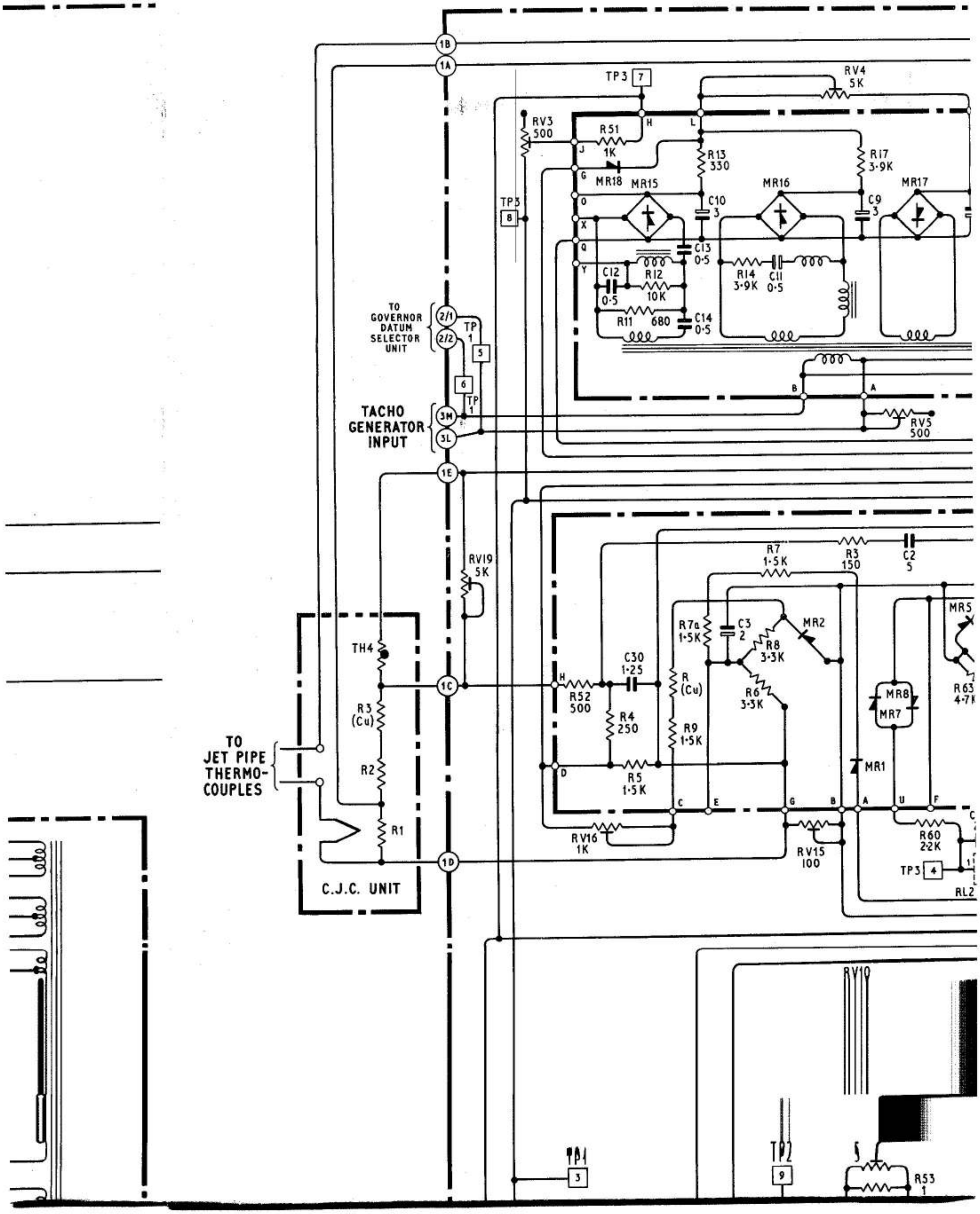
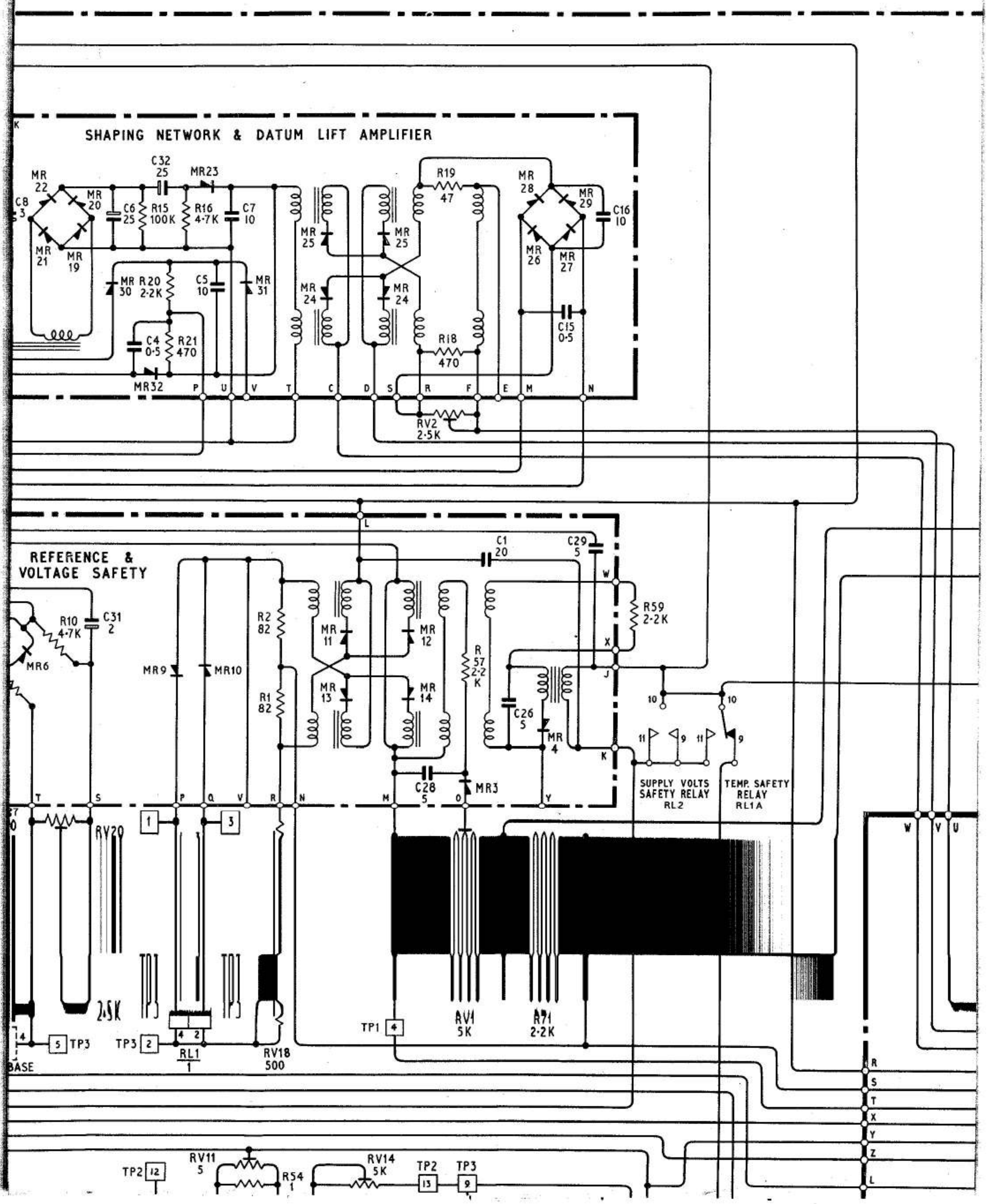
TP2 9
RV10 5
R53



SHAPING NETWORK & DATUM LIFT AMPLIFIER
C32 25
MR23
C6 25
R15 100K
R16 4·7K
C7 10
MR 25
MR 24
R19 47
R18 470
MR 30
R20 2·2K
C5 10
MR 31
C4 0·5
R21 470
MR32
RV2 2·5K
CE &
SAFETY
C31 2
MR9
MR10
R2 82
R1 82
MR 11
MR 12
MR 13
MR 14
R 57 2·2 K
C28 5
RV1 5K
TP1 4
RV20 2·5K
TP3 1
TP3 3
TP3 2
RL1 1
RV18 500
RV11 5
R54 1
RV14 5K
TP2 12
TP2 13
TP3 9

Fig. 5


TP3 7
RV4
5K
RV3
500
R51
1K
H
L
J
G
MR18
MR15
R13
330
R17
3·9K
MR16
MR17
TP3
8
O
X
Q
Y
C10
3
C9
3
C13
0·5
C12
0·5
R12
10K
R14
3·9K
C11
0·5
R11
680
C14
0·5
TO
GOVERNOR
DATUM
SELECTOR
UNIT
2/1
2/2
TP
1
5
6
TACHO
GENERATOR
INPUT
3M
3L
B
A
RV5
500
1B
1A
1E
1C
1D
RV19
5K
TH4
R3
(Cu)
R2
R1
C.J.C. UNIT
TO
JET PIPE
THERMO-
COUPLES
R7
1·5K
R3
150
C2
5
R7a
1·5K
C3
2
MR2
R8
3·3K
R6
3·3K
C30
1·25
R
(Cu)
R52
500
R4
250
R9
1·5K
R5
1·5K
MR5
R63
4·7K
MR8
MR7
MR1
D
C
E
G
B
A
U
F
RV16
1K
RV15
100
R60
2·2K
TP3 4
RL2
RV10
TP1
3
TP2
9
R53
1



SHAPING NETWORK & DATUM LIFT AMPLIFIER
MR 22
MR 20
C8 3
MR 21
MR 19
C32 25
MR23
C6 25
R15 100K
R16 4·7K
C7 10
MR 30
R20 2·2K
C5 10
MR 31
C4 0·5
R21 470
MR32
MR 25
MR 24
R19 47
R18 470
MR 28
MR 29
MR 26
MR 27
C16 10
C15 0·5
RV2 2·5K
P U V T C D S R F E M N
REFERENCE & VOLTAGE SAFETY
R10 4·7K
C31 2
MR6
MR9
MR10
R2 82
R1 82
MR 11
MR 12
MR 13
MR 14
C1 20
C29 5
R 57 2·2 K
R59 2·2K
C26 5
MR 4
C28 5
MR3
W X J K
T S P Q V R N M O Y
RV20
2·5K
SUPPLY VOLTS SAFETY RELAY RL2
TEMP. SAFETY RELAY RL1A
TP3
TP1
RV1 5K
R71 2·2K
RV18 500
RL1 1
BASE
W V U
R S T X Y Z L
RV11 5
R54 1
RV14 5K
TP2

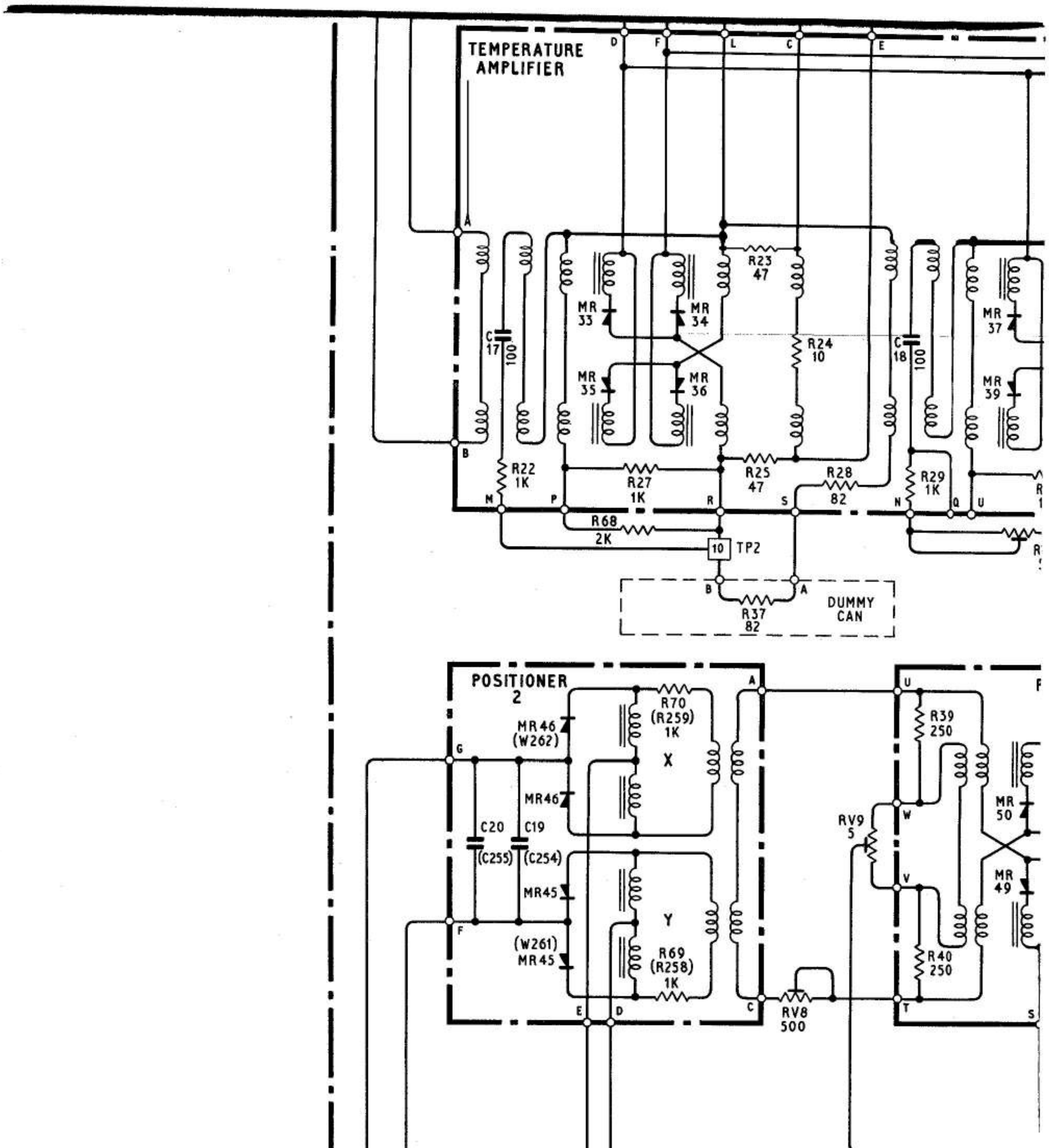


Fig. 5

Am

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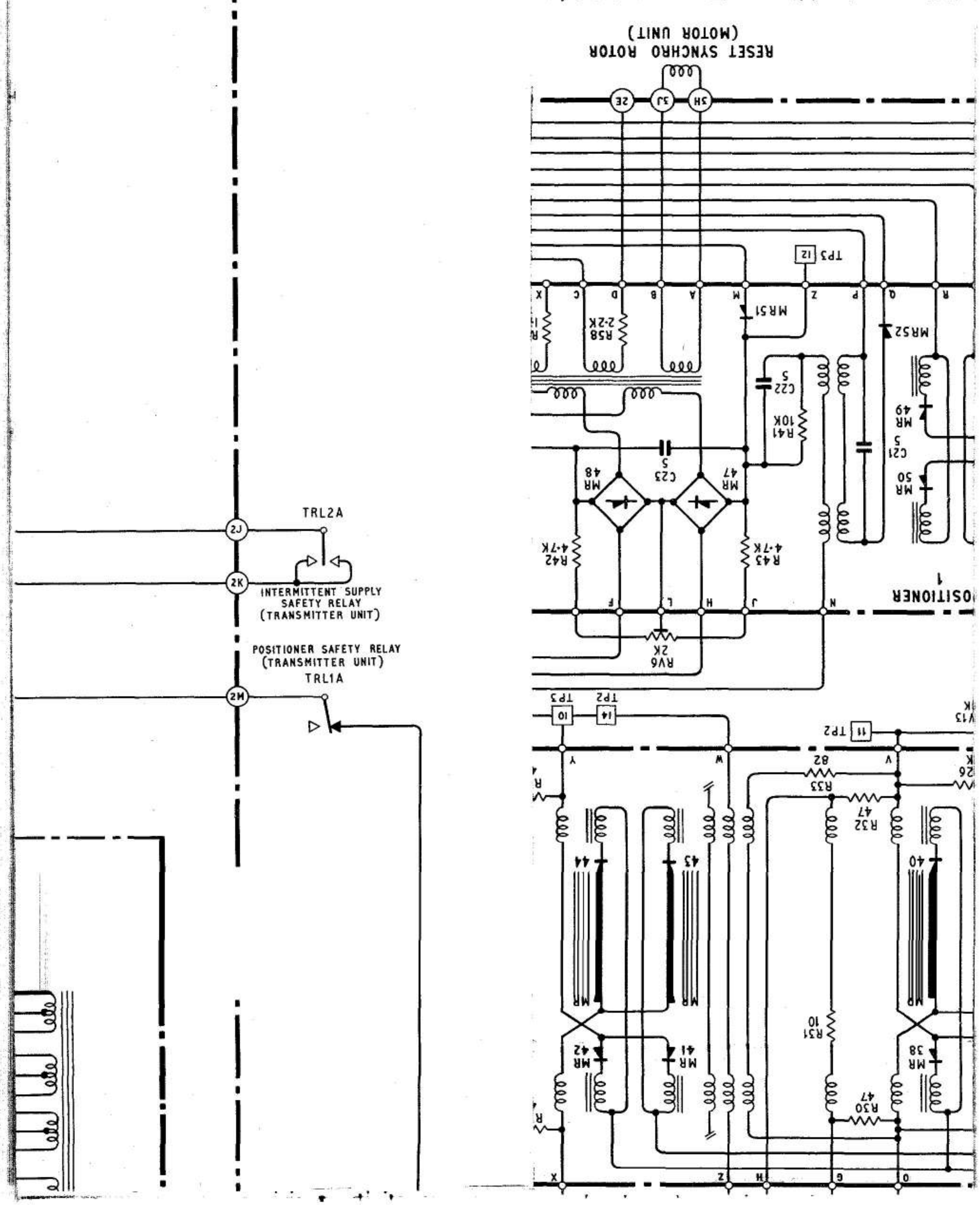
RESTRICTED

plifier unit, Ultra. Type A401/3-



Appendix A

STANDARD SERVICEABILITY TEST FOR AMPLIFIER, ULTRA, TYPE A401/3

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. The tests detailed in this Appendix may be applied to the unit before it is put into service, or at any time to determine its serviceability.

TEST EQUIPMENT

2. The following test equipment is required :—

(1) Test set, Ultra, Type QT4066

(2) Power amplifier, Ultra, Type QT4063

(3) Slave transmitter, Ultra, Type T401/1 or T401/2

(4) Slave throttle motor, Ultra, Type, M174/1

(5) Mounting jig for throttle motor

(6) Mounting jig for transmitter

(7) Multimeter, Type 12889 (2-off)

(8) 250V d.c. insulation resistance tester

(9) Stopwatch

(10) Cambridge workshop potentiometer

(11) Galvanometer with 250Ω series resistor

(12) Dummy C.J.C. unit

(13 Dummy thermocouples

(14) Slave C.J.C. unit, Ultra, Type C402

(15) Test set, Ultra, Type Q2A8

POWER SUPPLIES

3. The following power supplies are required :—

(1) 250V, 50 c/s capable of supplying a current of up to 5A.

(2) 28V, d.c. capable of supplying a current of up to 3A.

TEST PROCEDURE

Insulation resistance

4. Measure the insulation resistance beween all plug poles and the case of the unit using :—

(1) A Multimeter, Type 12889, on the Ω x 100 range.

(2) A 250V d.c. insulation resistance tester.

Test connections

5. Secure the slave throttle motor and slave transmitter to their respective mounting jigs and attach the protractors. Connect the test equipment, slave units, amplifier and power supplies as shown in fig. 1.

(1) Set the AMPLIFIER RACK switch to STANDBY and 2 minutes later, set the H.T. switch to ON.

(2) Adjust the voltage and frequency of the supply to 115V, 400 c/s.

(3) Ensure that the reading of METER 5 does not exceed 0·85A, that the warning lamp is not illuminated and that the trim indicator reads zero.

(4) Allow a 15 minute warming-up period.

Reference angle

6. (1) Set the transmitter angle to 28° and depress the shorting switch between lines T.1.1 and T.1.2.

(2) Link poles 3 and 4 on the transmitter test socket.

(3) Using OVERRIDE control, increase the throttle motor angle by approximately 15° then revert to NORMAL control.

(4) The final angle reached by the throttle motor is the reference angle and should be 37°. Set the throttle motor protractor accordingly.

(5) Repeat sub-para. (3) three times and check that the reference angle setting is correct.

(6) Remove the short circuit between lines T.1.1 and T.1.2 and remove the link between poles 3 and 4 of the transmitter test socket.

Normal positioning

Positioner sense

7. With NORMAL control selected, rotate the transmitter shaft from 0° to 70° and check that the throttle motor shaft rotates from 0° to 90°. Rotate the transmitter shaft through varying angles around the centre of its travel and check that the throttle motor follow-up is smooth and without overshoot. There should be no tendency towards hunting when the throttle motor reaches its final angle.

Positioner balance

8. (1) Set the throttle motor to approximately 45° and set the SELECT LOAD switch to DUMMY.

(2) Connect a Multimeter (1), on the 10mA a.c. range, between the DISCRIMINATOR I/P CURRENT test points in place of the link.

(3) Connect a further Multimeter (2), on the 250V a.c. range, between the POS. 2 VOLTS test points.

(4) Set the SELECT DISCRIMINATOR I/P control to SIMULATED and adjust the SET DISCRIMINATOR I/P controls to obtain a minimum reading on Multimeter (1).

(5) The reading on Multimeter (2) should be less than 40V.

Positioner sensitivity

9. (1) With the Multimeters connected as in para. 8, rotate the SET DISCRIMINATOR I/P controls in a counter-clockwise direction from the position obtained in sub-para. 8 (4) until the reading on Multimeter (1) is 0·5mA.

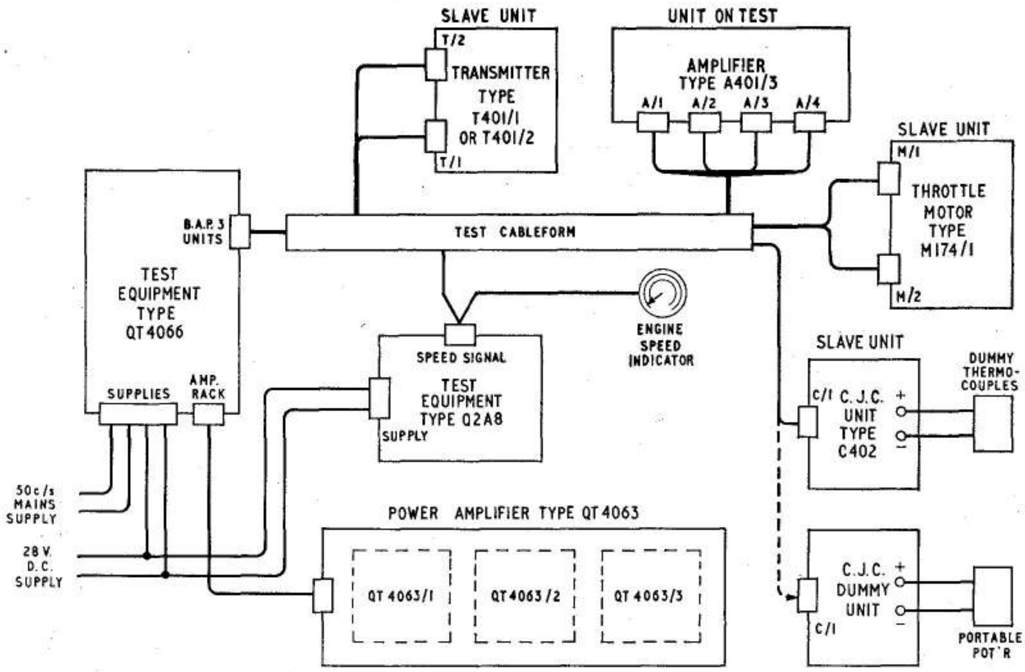


Fig. 1. Test equipment inter-connections

(2) The reading on Multimeter (2) should now be 100V ± 15V.

(3) Rotate the SET DISCRIMINATOR I/P controls in a clockwise direction so that the reading on Multimeter (1) falls to a minimum and then rises again to 0·5mA.

(4) The reading on Multimeter (2) should be within 15V of the reading obtained in sub-para. (2).

Positioner torque

10. (1) Repeat the tests detailed in para 9 to obtain readings of 1·5mA on Multimeter (1).

(2) The corresponding readings on Multimeter (2) should be 135V ± 25V.

(3) Remove the Multimeters.

Positioner deadband

11. (1) Set the SELECT LOAD switch to THROTTLE MOTOR and replace the link between the DISCRIMINATOR I/P CURRENT test points. Set the SELECT DISCRIMINATOR I/P switch to NORMAL.

(2) Set the transmitter angle to approximately 35° and allow the throttle motor to come to rest.

(3) Using the OVERRIDE controls reduce the throttle motor angle by approximately 15°.

(4) Revert to NORMAL control and note the final throttle motor angle.

(5) Using the OVERRIDE controls, increase the throttle motor angle by approximately 15° from the angle obtained in sub-para. (4).

(6) Revert to NORMAL control.

(7) The final angle reached by the throttle motor should not be less than the angle noted in sub-para. (4) nor more than 1° greater.

Note . . .

Both final angles should be reached without overshoot.

Positioner rate

12. (1) With NORMAL control selected, rotate the transmitter shaft from 0° to 70° in less than one second.

(2) The time for the throttle motor angle to increase from 10° to 70° should be within the limits 2·75 to 3·75 seconds (16 to 22°/sec.).

Governor sense and range

13. (1) Set the R.P.M. GOV. switch, on the display unit, Type D400, to ON. Set the transmitter angle to 55° and note the throttle motor angle.

(2) Connect the speed signal cable, on the test cableform, to the speed signal socket on the left-hand equipment panel.

(3) Set the SUPPLY switch, on the control unit, Type QC2A80, to ON ; set the TACHO GENERATOR LOAD switch to NO LOAD ; set the SELECT METER TEST switch to 1 ; set the SPEED SIGNAL, COARSE control 45° from the fully counter-clockwise position ; set the SPEED SIGNAL, FINE control fully counter-clockwise.

(4) Depress the engine speed indicator START switch.

(5) Rotate the SPEED SIGNAL, COARSE and FINE controls slowly clockwise to obtain a speed signal above the datum set by the SELECT R.P.M. control on the display unit, Type D400.

(6) Check that the throttle motor angle decreases smoothly by 18·5° ± 2° from the angle noted in sub-para. (1) above.

(7) Check that the trim indicator reading increases to a maximum. (1/2 F.S.D. on D400).

(8) Reduce the speed signal below the selected datum and check that the throttle motor returns smoothly to the original angle. Set the R.P.M. GOV. switch, on the Display Unit, Type D400, to OFF.

Temperature control system

Reference datum

14. (1) Connect the C.J.C. socket on the test cableform to the dummy cold junction compensator.

(2) Connect the Cambridge Workshop Potentiometer to the +ve and –ve thermocouple terminals of the dummy C.J.C. unit, using copper leads.

(3) Connect the galvanometer terminals, on the left-hand equipment panel, to pins 7 and 8 of amplifier test panel 3.

Note . . .

This test panel is located immediately above the four amplifier connectors.

(4) Adjust the potentiometer to give zero deflection of the galvanometer. Note the potentiometer reading and, using the millivolt/temperature conversion table (Sect. 10, Chap. 4), determine the equivalent temperature. This is the reference datum and should be 556° ± 4°C.

Datum stabilisation

15. (1) Vary the voltage of the 115V, 400 c/s supply between 107V and 121V.

(2) Check that the reference datum does not change by more than ±5°C from the value determined in sub-para. 14(4).

(3) Vary the frequency of the 115V, 400 c/s supply between 380 c/s and 420 c/s.

(4) Check that the reference datum does not change by more than ±5°C from the value determined in sub-para. 14(4).

Datum curve

16. (1) Inject a speed signal as described in sub-para. 13(2) to 13(4).

(2) Rotate the SPEED SIGNAL, COARSE and FINE controls slowly clockwise to obtain the speed signals listed below.

(3) At each speed signal setting, measure the temperature reference datum using the procedure detailed in para. 14.

Speed signal (c.r.p.m.)	Reference datum (°C)
4,000	556 ± 15
6,500	
8,000	
9,000	
10,000	
11,000	556 ± 4
12,000	

Acceleration lift

17. (1) Set up the temperature and speed signal injection circuits as for the datum curve test (para. 16).

(2) With a speed signal of 10,000 c.r.p.m., inject a temperature signal corresponding to 620 $\pm$ 5°C.

(3) Increase the speed signal from $10{,}000^{+400}_{-0}$ c.r.p.m. to $12{,}000^{+0}_{-400}$ c.r.p.m. in a time of 10 sec. (i.e., corresponding to a compressor acceleration of 200 c.r.p.m. /sec).

(4) Check that the galvanometer deflection returns through zero during the time the acceleration is applied.

(5) Set the temperature input to 575 $\pm$5°C and the speed signal to $6{,}000^{+400}_{-0}$ c.r.p.m.

(6) Increase the speed signal from $6{,}000^{+400}_{-0}$ c.r.p.m. to $8{,}000^{+0}_{-400}$ c.r.p.m. in a time of 10 sec. (i.e. corresponding to a compressor acceleration of 200 c.r.p.m. /sec.).

(7) Check that the galvanometer deflection does not return to zero during the time the acceleration is applied.

Amplifier balance

18. (1) Disconnect the galvanometer and connect a Multimeter, on the 50μA d.c. range between pins 9 and 10 on amplifier test panel 3.

(2) Adjust the temperature injection potentiometer to give zero deflection on the Multimeter.

(3) The simulated temperature input should be 556 $\pm$ 4°C.

(4) Short circuit pins 1 and 3 on amplifier test panel 3, and remove the Multimeter from pins 9and 10.

Transient control

19. (1) Set the transmitter angle to 55° and note the throttle motor angle.

(2) Adjust the temperature injection potentiometer to give a temperature input of 600 $\pm$ 10°C.

(3) Check that the throttle motor closes.

(4) Reduce the temperature input to 510 $\pm$ 10°C and ensure that the throttle motor opens to the original angle.

Phase advance

20. (1) With temperature input as in sub-para. 19(4), short circuit the terminals of the temperature injection potentiometer.

(2) Remove the short circuit and note that the throttle motor angle decreases and immediately opens to its original value.

(3) Disconnect the temperature injection potentiometer and remove the short circuit between pins 1 and 3 of the amplifier test panel 3.

Safety circuits

Temperature safety balance

21. (1) Transfer the C.J.C. socket, on the test cableform, to the slave C.J.C. unit ensuring that the 3·2Ω dummy thermocouple is connected.

(2) Connect a Multimeter, on the 2·5V d.c. range, between pins 1 and 3 on amplifier test panel 3.

(3) The meter reading should be less than 0·1V.

Temperature safety sensitivity

22. (1) Set the transmitter angle to 55°.
(2) Lift the following open circuiting switches and check that the safety warning lamp lights under each fault condition :—

A.1.A.
A.1.B
A.1.C
A.1.D

Note . . .

The safety circuit will latch on in each case and must be unlatched by setting the OVERRIDE — OFF — NORMAL switch to OFF for a period of five seconds.

(3) With the safety circuit latched on, but with no fault present, a Multimeter connected as in sub-para. 21(2) should read 1 $\pm$ 0·2V.

(4) Depress the short circuiting switches between each of the following pairs of lines and check that the safety warning lamp lights under each fault condition :—

A.1.A and A.1.B	A.1.B and A.1.C
A.1.A and A.1.C	A.1.B and A.1.D
A.1.A and A.1.D	A.1.B and A.1.E
A.1.A and A.1.E	A.1.C and A.1.D

(5) Check that when the open circuiting switch on line A.1.E is lifted the throttle motor does not move.

(6) Check that when lines A.1.C and A.1.E are shorted, the throttle motor does not move.

(7) Depress the A.3.D PRESS TO O/C button and check that the throttle motor does not move by more than 5°.

(8) Remove the DISCRIMINATOR I/P CURRENT link and check that the throttle motor does not move by more than 5°.

Intermittent supply circuit

23. Note . . .

This test should be performed only on those amplifiers which are to be installed with a transmitter, Type T401/2. A T401/2 slave transmitter should be used for this test.

(1) Using the OVERRIDE-OFF-NORMAL switch, interrupt the 115V, 400 c/s supply for a period of 0·1 sec.

(2) Check that the warning lamp lights and remains alight after re-connection of the supply.

(3) Unlatch the safety circuit by switching the 400 c/s supply off for a period of 2 to 3 sec. and then switching on again. Check that the warning lamp does not light.

Final check

24. Repeat the insulation check detailed in para. 4.