instruction manual

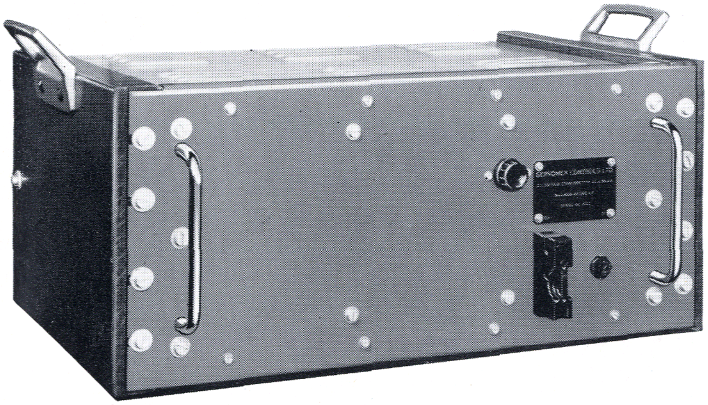
IMPORTANT—The user wants to read this manual before starting work. Please make sure he gets it.

A.C. Voltage Stabiliser
type A.C.2 Mk. IIB

Servomex Controls Limited
Crowborough Sussex Crowborough 1247 & 3566

SERVOMEX

VOLTAGE STABILISER



A.C.2 Mk. IIA

9 AMP. A.C.

(shown fitted with wooden ends for bench use)

A.C.2 Mk. IIB

9 AMP. A.C.

(shown as normally supplied for rack-mounting)

The following technical specification should be read in conjunction with our "Notes on A.C. Voltage Stabilisers."

GENERAL

The A.C.2 Mk. II is a development from the old A.C.2 Mk. I and the previous A.C.1 stabiliser. Hundreds of these instruments are now in use in most of the leading scientific and industrial concerns in the country. The latest model uses the same circuit as the type A.C.7, in which all capacitors and resistors have been derated strictly in accordance with current Inter-Service requirements, and the whole instrument is very much stronger both electrically and mechanically than its predecessors. The A.C.2 Mk. IIA is a model that has been designed specially for applications where no controls are required to appear on the front panel. This model was introduced at the request of a Government department, and is the preferred model where the instrument is to be used at a fixed voltage and where meters are not required. It is naturally somewhat cheaper than the model B, although the electrical circuit is identical. The A.C.2 Mk IIB is a de luxe laboratory instrument, fitted with two meters, and with mains on/off switch and voltage setting control available on the front panel. There is also a three-pin five Amp. socket on the front panel, and a 13 Amp. socket at the rear which is sometimes convenient.

The specification which follows is covered by guarantee and the first part of it applies to both models.

RANGE

The instrument is primarily intended to provide a stable output voltage at the nominal value of the supply, which may be anywhere between 200 and 250 volts. For any given output voltage, the input voltage can vary between minus 17.5% and plus 8.75% from the output voltage.

It is also possible to use the stabiliser as a variable voltage supply, provided one understands the following limitations. Firstly, the control will cease to work if the demanded output voltage lies outside the range of correction just stated. Secondly, the valve heaters are supplied from the output voltage, so that some care is needed to avoid damaging the heaters of the valves. At the back of the instrument is a 6-way selector with tappings marked 200, 210, 220, 230, 240 and 250 volts. The continuous control provided by the potentiometer should not be used to give a variation of more than plus or minus 10 volts away from the value set up on the 6-way selector. If a larger variation is required it is a simple matter to alter the selector position.

CURRENT RATING

Zero to 9 Amps. at 25°C. Zero to 7 Amps. at 50°C.

ACCURACY

The R.M.S. value of the output voltage is stabilised to about plus or minus 0.25% (steady-state) over the following range of variations :—

Input Voltage from minus 17.5% to plus 8.75%.
Load Current from 0 to 9 Amps.
Load power factor from 0 to 1 lagging or leading.
Frequency from 45 to 65 cycles per second.
Temperature variations up to 20°C.
Accelerations up to 40 g.
Input voltage waveform from sine wave to square wave.

SPEED OF RESPONSE

For errors up to about 3 volts the bandwidth is roughly 2 cycles per second, and errors of this order of magnitude are corrected in about 0.25 seconds. On a larger error, the motor runs up to the synchronous speed of 15 volts per second. Thus a sudden jump of 15 volts will be fully corrected in very slightly more than 1 second.

METERING

The model A has no meters. Model B is fitted with two Ernest Turner moving iron meters to read voltage (input and output) and load current respectively.

DISTORTION

The A.C.2 Mk. II stabilises the true R.M.S. voltage regardless of the input waveform, which is neither improved nor degraded. The distortion introduced by the stabiliser is effectively zero. This will be apparent from the method of working which is described below.

CONSTRUCTION

The instrument is normally supplied for rackmounting on a standard panel 8¾″ × 19″ (22.23 × 48.26 cms.) to G.P.O. dimensions. The overall depth behind the front is 13″ (33 cms.). A strongly made dust cover is provided, with quick release fasteners enabling the dust cover to be removed with great ease. All ferrous parts are finished to the requirements of current Inter-Service specifications. The front panels are stove enamelled, the A.C.2 Mk. IIA to British Standard Tint No. 631 (light grey) and the A.C.2 Mk. IIB to British Standard Tint No. 632 (dark grey). The net weight of the A.C.2 Mk. IIA is 68 lbs. (30.8 kg.) and of the A.C.2 Mk. IIB, 70 lbs. (31.8 kg.). Both instruments have the input and output taken from a screw terminal block available from the back. The model B has also a 5-Amp. 3-pin outlet on the front panel, and a 13-Amp. outlet at the rear.

While the wiring and construction are to the highest standards of the British Instrument Industry, the instrument has been designed with a view to strength and reliability rather than beauty.

For bench use, a pair of polished wooden ends with carrying handles are available as an extra item if needed. When packed for export the gross dimensions are 29½″ × 19½″ × 24½″ (74.8 × 49.5 × 62.2 cms.) and gross weight is 149 lbs. (67.6 kg.).

METHOD OF WORKING

A variable transformer is used to supply a buck or boost voltage as may be necessary to correct the input to the required value. This variable transformer is driven by a small two-phase servo motor. The output voltage is applied to a bolometer bridge which gives zero output when the output voltage is exactly correct. If the voltage wanders from the set value, the bridge output increases, and, after amplification, drives the motor to restore the voltage to the correct value. Velocity feedback is used to provide stability and make the instrument independent of friction. The instrument uses no relays, thyratrons, or electrolytic capacitors. Only two valves are used, both very heavily underrun.

It will be seen from this description that there is virtually no distortion. Even at the worst condition, when the input is at the lowest value, if the output voltage is set to 230 volts, this is made up of 190 volts directly from the mains and 40 volts boost supplied from the variable transformer. Thus, even if the variable transformer did give appreciable distortion, the distortion in the output voltage would be very considerably less. In practice, the mains supply contains several per cent. of distortion, and the extra distortion added by the stabiliser is so infinitesimal compared with this as to be completely undetectable.

GUARANTEE

Departures from the specification during the first 12 months of proper use will be corrected free of charge.

SERVOMEX CONTROLS LIMITED

CROWBOROUGH HILL · JARVIS BROOK · SUSSEX · CROWBOROUGH 1247

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Notes on

A.C. VOLTAGE STABILISERS

BY SERVOMEX CONTROLS LTD.

While the general purpose of an A.C. Voltage Stabiliser is quite obvious, it is felt that these notes may be of assistance to those who are wondering which is the best type to buy. These remarks should be read in conjunction with the full technical specification of the instruments.

WHY IS A STABILISER NEEDED?

For two reasons. Firstly because the generated e.m.f. varies, secondly because the supply lines have a finite impedance so that changes in load current cause a change in terminal voltage even when the generated e.m.f. is constant.

Under normal conditions, the generated e.m.f. will vary a few per cent up or down. In the case of a badly regulated motor generator set the variations may easily be as much as 10% up or down. When the generator is lightly loaded the distribution of errors is likely to be symmetrical. Under present-day conditions, however, with the enormous increase in the consumption of electrical energy, public supply authorities all over the world are chronically over-loaded, with the result that large downward variations of voltage are much commoner than large upward variations.

The drop of terminal voltage when the load varies naturally depends on the location. It is a fact that at the Servomex factory, the voltage falls by 15–20 volts when full load is switched on in the factory.

THE TRUE POWER OF AN A.C. STABILISER

The power needed from the stabiliser is the product of maximum load current × maximum boost voltage. Thus a stabiliser rated at 20 Amps. for a range of plus and minus 5% would only give about 10 Amps. if the range was increased to plus and minus 10%.

As a result, the true power varies much more widely than the load current would indicate. For example, a stabiliser giving a maximum load current of 1 Amp. over a range of plus and minus 7% has a maximum boost power of only 16 watts. On the other hand the Servomex A.C.2 Mk. II, with a load current of 9 Amps., has an effective boost power of 360 watts, and the A.C.7 has an effective boost power of nearly 1,400 watts.

THE RANGE OF CORRECTION NEEDED

Since the range of correction is only increased at the expense of the output power, it is necessary to have a clear idea of the variations of voltage normally encountered. Very few users of electrical energy can furnish reliable information on this point. Our experience shows that in the U.K. drops of 30 volts and rises of 10–15 volts are quite often encountered. Our A.C.2 Mk. II stabiliser covers variations between minus 40 volts and plus 20 volts, while the A.C.7 covers from minus 46 to plus 23 volts. We believe that with either of these instruments the output voltage will be maintained constant throughout the year under present-day conditions. It is worth pointing out that if by chance the supply voltage falls even below the range of correction of our instruments, all that happens is that the output voltage falls by the same proportion.

ACCURACY

While it is obviously desirable to make the accuracy of the stabiliser as high as possible, it happens to be a fact that the higher the accuracy the greater is the cost per controlled VA. Thus our A.C.7 with a boost power of 1,400 watts actually costs considerably less than a very high precision electronic stabiliser with a boost power of only 16 watts. It should be clear from this example that the wise man will buy a stabiliser good enough for the work he has in mind but not enormously better. The approximate degrees of accuracy needed for various sorts of work are given below:—

Electric machine tools driven by induction motors can tolerate very wide variations in voltage and there is no point in considering a stabiliser in the normal way. On the other hand we have known of a refrigeration plant which would not start without the aid of a stabiliser.

Electric lights may need a stabilised supply under really bad conditions, because a 1% drop in supply voltage causes the light to fall by 4%. Furthermore, quite small increases of voltage above the nominal value result in a very great shortening of the life of a filament lamp.

Electrical measuring equipment, particularly electronic apparatus, is usually worth stabilising. While it is quite common for such apparatus to be designed with a view to small main changes, it is most unusual to stabilise the heater voltage for valves, and these should be kept within about 5% to get the best results. For directly heated tungsten filament valves the heater voltage should be kept within 1 or 2%. The expense of replacing valuable tungsten filament transmitting valves damaged through small increases of the supply voltage would easily pay for the cost of a stabiliser, but this precaution is frequently overlooked. Apart from the question of the heater voltage, it is more economical to design the equipment to run from a stabilised voltage, and normally results in improved performance. On an electronic installation of any size, it is actually cheaper to stabilise the entire A.C. input rather than make each item capable of accepting large changes in the mains voltage. For what one might call "preliminary stabilisation" of this kind, the permissible error should certainly not exceed 1 or 2% and the normal Servomex accuracy of 0.25% is perfectly acceptable.

SPEED OF RESPONSE

When the mains supply voltage drops 10% suddenly, the output voltage drops 10% also, and then returns to the proper value in a time which depends on the method of operation. Certain types of "constant voltage transformer" and certain electronic stabilisers have a correction time of not more than 30 to 50 mSecs. Most types of electronic stabiliser and saturating reactor stabilisers require between 100 and 200 mSecs. for full correction. Electro-mechanical stabilisers normally run at between 1 and 15 volts per second, so that a 10% jump is corrected in between 1.6 seconds and 23

THE SERVOMEX A.C.2 MK.II (Models A and B)

Operating Instructions

SERVOMEX CONTROLS LIMITED
Crowborough,
Sussex, England.

Tel: Crowborough 1247

WARNING : The instrument will be severely damaged if the brush of the variable transformer is allowed to wear out. The instructions given later under "Maintenance" must be attended to.

SPECIFICATION

The instrument will stabilise the output voltage at any value between 200 and 250 volts. The r.m.s.voltage is stabilised to ± 0.25% for input voltages between - 17.5% and + 8.75% from the output voltage.

The instrument will accept frequencies between 45 and 65 c/s and the r.m.s. value is stabilised regardless of the waveform. The output waveform from the stabiliser is the same as the input waveform from the mains supply.

The continuous current rating is 9 amps at an ambient temperature of 25°C and 7 amps at 40°C.

The load power factor can assume any value whatever.

INSTALLATION

The input lead should be connected to the screw connector at the rear of the instrument. While the stabiliser will operate with the polarity reversed or without the earth connection, in the interests of safety and good engineering practice it is recommended that three wires be used, correctly poled.

In the model A the output is taken from the three output terminals and as this model is intended for fixed installations, there are no switches or other plugs and sockets provided. In the model B the sockets at the front and rear are in parallel with the three-way screw connector, so that the output may be taken from any one of the three outlets or a combination of them as may be most convenient.

OPERATION

The 6-way voltage selector at the back of the instrument must be set as close as possible to the output voltage at which the instrument is to be used. This will normally be the nominal or "declared"voltage from the public supply. After making this adjustment, the output voltage should be adjusted by means of the voltage setting knob (on Model B) or the pre-set fine control (on Model A).

Having set the output voltage in this manner, the stabiliser will maintain it for input variations as low as -17.5% and as high as + 8.75%. For example, if the output voltage is set to 230 volts, the input voltage can vary between 190 and 250 volts. If the input voltage should now fall to 185 volts all that will happen will be that the output voltage will fall from 230 to roughly 225 volts; meanwhile the variable transformer is against the end stops and no damage will be caused to the instrument.

Sometimes it is required to work with the output voltage set permanently to a value other than the nominal value of the supply voltage. For example, the supply voltage may be nominally 220 volts and the output may be set to 240 volts. This is perfectly permissible, and the 6-way selector will naturally be set to 240. The instrument will now accept voltages between 200 and 260. Therefore, the mains voltage (nominally 220) can now fall 20 volts and rise 40 volts. Thus, some of the available "boost" power has been lost. The only way to avoid this is to fit an auto transformer between the supply and the stabiliser. In this example the auto transformer would have to raise the voltage 20 volts and would therefore be rated at 180 VA.

Another variation is to use the instrument as a VARIABLE VOLTAGE SUPPLY. This is often useful, particularly when testing electrical apparatus. When using the instrument for this purpose, the output voltage can be varied by means of the control provided, to the extent of ± 10 volts from the value at which the 6-way voltage selector has been set. The two valves in the stabiliser are run from the output voltage, so that if the selector is set to 230 and the output voltage is set to 230 the valve heaters receive exactly 6.3 volts. A variation of ± 10volts represents a 5% error in the heater voltage which is the most that should be inflicted on them. If a larger variation is required the proper procedure is to alter the 6-way selector appropriately. For example, if the mains is roughly 230 volts and one requires to test an apparatus at 253 volts, set the 6-way selector to 250 and by means of the controls adjust the output voltage to 253. This is a perfectly permissible procedure and adds greatly to the use of the instrument in research work. At all times the stabiliser is subject to the over-riding limitation that the input voltage must lie within the range -17.5% to + 8.75% from the output voltage. (NOT WITH RESPECT TO THE NOMINAL VOLTAGE OF THE MAINS). Thus, in the example just quoted, if the output voltage is set to 253 volts, and the mains supply is nominally 230 volts but falls to 210 the stabiliser will be unable to accept the situation and the output voltage will fall to roughly 250.

MEASURING THE STABILISED OUTPUT VOLTAGE.

These stabilisers stabilise the r.m.s. value of the voltage, so that it is not satisfactory to "test" the stabiliser by applying a rectifier type of instrument to the output terminals as has sometimes been done in the past. Waveform errors and changes of waveform error occur frequently and may be caused either by apparatus on another circuit, for example a welding machine, or by the load attached to the stabiliser itself, such as a spark gap spectrometer.

MAINTENANCE

The only part of the stabiliser which requires regular routine maintenance is the variable transformer. If the brush is allowed to wear down too far sparking may develop, and if this is allowed to go unchecked, the winding of the variable transformer may be ruined in a very short time. Therefore it is essential to examine the brush and the winding of the variable transformer every 1,000 hours of running. If the brush is approaching the end of its useful life (when the spring comes close to the metal of the brush arm) the brush should be replaced. Replacement brushes are available from Servomex Controls Ltd., by return of post. At the same time, any blackened patches of the winding should be cleaned with a piece of rag. It is a good plan to apply the thinnest possible film of vaseline to the track after this has been done, to reduce oxidation of the copper. When this procedure is carried out properly, the life of the variable transformer is virtually unlimited, and the brush will probably need replacing about every 5,000 hours of running, which is equivalent to several years normal use.

CIRCUIT NOTES

Referring to the theoretical diagram, it will be seen that the neutral wire is connected straight through from input to output. The live wire has the secondary of transformer number 79 in series with it and the buck and boost voltages are developed in this transformer so as to keep the output voltage at the required value. The variable transformer is connected across the stabilised output voltage, and a proportion of the voltage across the variable transformer is applied to the primary of transformer number 79. The variable transformer is driven by the small motor in accordance with 'instructions' received from the servo-system.

Transformer number 93 supplies H.T. and heater power for the two valve amplifier. There is a special winding (terminals M and P) which feeds the lamp bridge. The resistance of the lamp increases as the voltage across it is increased, so that at one particular voltage, the resistance of the lamp is such that the bridge is balanced and no output is obtained. If the voltage at terminals M and P is either higher or lower than the balance voltage an output is obtained from the bridge, varying in amplitude, and reversing in phase as the bridge passes through the balance condition. The output voltage from the bridge is connected to the input transformer which is contained in a mumetal can. This gives roughly twenty to one step up of voltage and feeds the amplifier. The output transformer (number 15) is connected to terminals 2 and 5 of the servo motor and thus drives the variable transformer in such a way that the bridge is permanently balanced. The motor requires two driving voltages with the phase differing by 90°. Therefore the heater winding of the transformer number 93 is applied to terminals 1 and 4 of the motor and it is arranged that the unbalance voltage derived from the bridge is displaced in phase by roughly 90° by suitable choice of the time constants in the amplifier. The phase displacement will vary with frequency but is not at all critical.

It is found that when the bridge is balanced, there is no 50 c/s output from the bridge, but there is an unwanted 150 c/s output, and for this reason a simple RC filter is fitted between the input transformer and the first valve. This is adjusted to reject the third harmonic.

The third winding of the motor (between terminals 5 and 3) is used to provide velocity feedback. At terminal 3 there appears a voltage which varies according to the speed the motor is running. By applying this voltage to the input of the amplifier the servo system is stabilised. It will be found that if the feedback is removed by short circuiting terminals 3 and 5 of the motor the system becomes unstable and the whole servo will 'hunt' at about 1 or 2 cycles per second. This does provide quite a useful test of sensitivity of the instrument because the sensitivity is such that if the gain of the amplifier falls considerably the mechanical friction will be sufficient to prevent hunting. The test is made by joining terminals 3 and 5 of the motor together and giving the gear wheel of the motor a small movement with the finger. If the system hunts it may be assumed that the sensitivity is full up to specification.

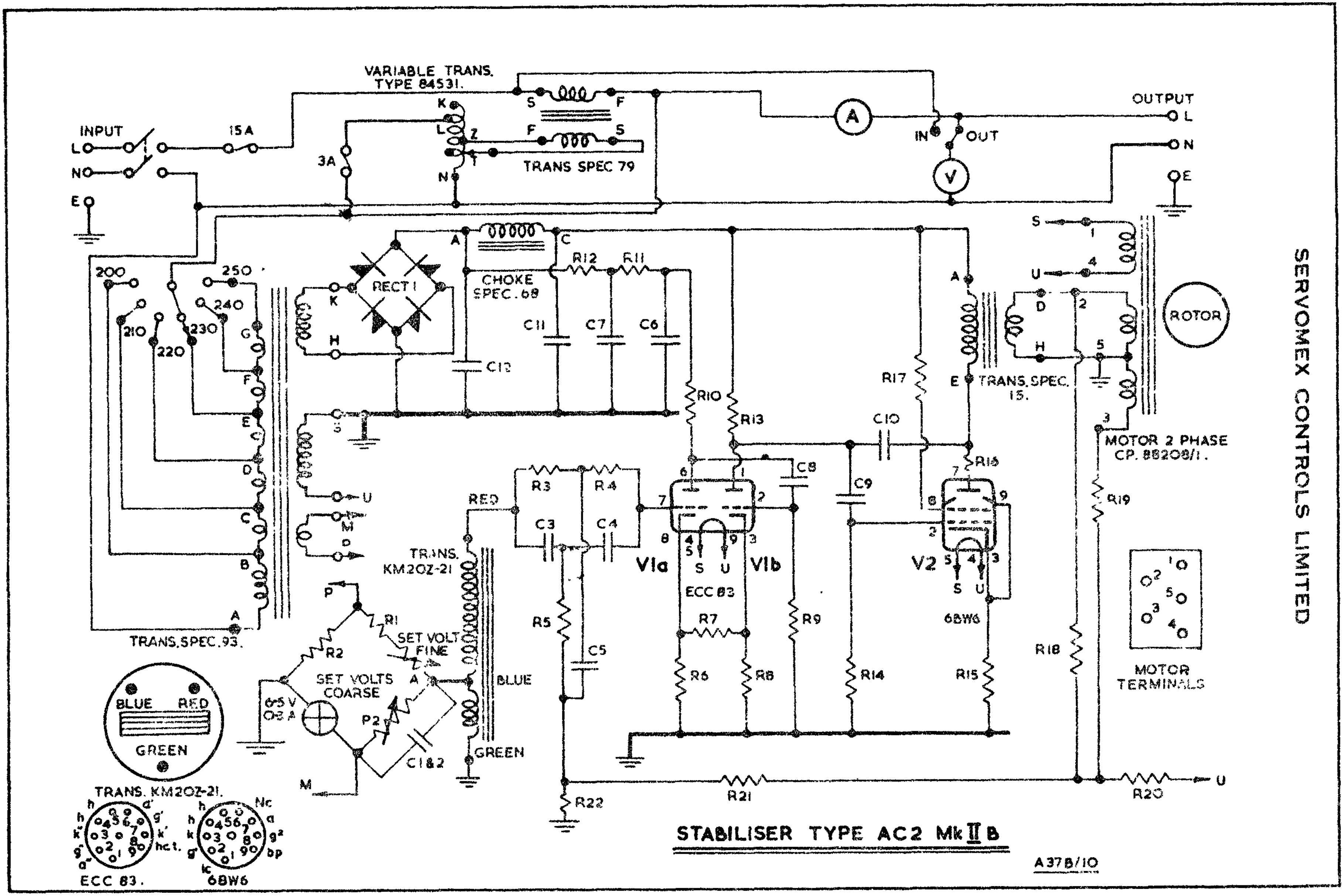
The valves are running under very favourable conditions, with the heater voltage stabilised and the current far below the rating. Our experience has shown that the original pair of valves will most often not need replacing for 5,000 hours of running, and very likely may last several times as long. On the other hand there is always the possibility that the valve will fail due to some unknown defect at any time, and we do not recommend that the valves should be changed until such time as they are quite definitely defective. The idea that one can instal a new set of valves and thereby obtain a greater expectation of trouble free running is false. A pair of valves that has already run for several thousand hours is more likely to continue satisfactory service than a brand new pair of valves. This statement is particularly true in this instrument where large declines in the amplification will have only a very trivial effect on the performance of the instrument.

The following voltages and currents may be useful in trying to find faults, and they are all measured on an Avometer Model 8 (20,000 ohms per volt). These readings will only be correct when the output voltage from the stabiliser is exactly equal to the value set up on the 3-way voltage selector.

H.T.Voltage	278 - 298 volts
Output valve pin 7	230 volts
Output valve pin 8	262 volts
Output valve pin 3	16 volts
ECC 83 pin 1	210 volts
Pin 6	170 volts
Pin 3	1.34 volts
Pin 8	1.81 volts

Total H.T.current measured on J on the H.T.transformer - 42.5 mA

These readings should be used with discretion, quite large variations may occur without meaning that there is a fault.



STABILISER TYPE AC2 Mk II B

A 37B/10

COMPONENTS REFERENCE LIST - A.C.2 Mk. IIB

COMPONENTS REF.NO.	NOMENCLATURE
R1	470 ohms RWV4-L
2	15 ohms RWV4-L
3	470 K ohms type 108
4	470 K ohms " "
5	330 K ohms " "
6	10 K ohms " "
7	330 K ohms " "
8	2.2 K ohms " "
9	1 Megohm " "
10	470 K ohms " "
11	180 K ohms " "
12	150 K ohms " "
13	100 K ohms " "
14	100 K ohms " "
15	390 ohms " RWV4-L
16	100 ohms " RC7-J
17	8.2 K ohms " 108
18	18 K ohms " "
19	1 K ohm " "
20	100 K ohms " RC3-N
21	560 ohms " RC3-N
22	470 ohms " " A.O.T.
C1	.01 mfd " Minicap 500V
2	.005 mfd " " 500V
3	.002 mfd " " 500V
4	.002 mfd " " 500V
5	.005 mfd " " 500V
6	1 mfd " Dubilier 4700 350V
7	1 mfd " " " 350V
8	.05 mfd " " " 500V
9	.5 mfd " " " 500V
10	.02 mfd " " " 750V
11	4 mfd Nitrogol 600V Dubilier type B51
12	4 mfd " 600V " " B51
P1	100 ohms Colvern type CLR 4001 868 1.0 watt
P2	1000 ohms " " CLR 4001 9S 1.0 watt
Rect.1	Rectifier,bridge,Westinghouse type 14B/144
V1	Valve type ECC 83
V2	Valve type 3BW6