SECTION 2

LEDEX-OPERATED SWITCH EQUIPMENT

Introduction

Ledex equipment consists of Oak rotary wafer switches combined with a solenoid-operated 'Ledex' turning mechanism. The switches complete with Ledex mechanism are made by N.S.F. Limited and are used extensively for remote-control purposes at the Television Centre.

Each switch comprises a number of wafers mounted on a shaft operated by a Ledex mechanism, and coded units are available embodying either 11-way or 23-way wafers. Switch panels are also supplied incorporating two, four or six five-wafer units. The units and panels described in this Section are:

1. Switch units UN9/501 and UN9/502, comprising five 11-way and five 23-way wafers respectively.
2. Switch panels PA18/502, PA18/503 and PA18/504, mounting respectively four, two and six units each comprising five 23-way wafers.

Further combinations have also been designed.

Ledex Mechanism

General Description (Figs. 2.1 and 2.2)

The Ledex principle is a method of converting the reciprocating action of a solenoid into a rotary motion, using three inclined ballraces, as illustrated in Figs. 2.1 and 2.2. When a voltage is applied, the solenoid attracts an armature, which is supported by three ball bearings that travel around and down in three inclined ballraces. The armature is thereby forced to rotate until the balls have travelled to the deepest ends of their respective races. The armature turns the switch shaft.

When the switch has gone round one position, an auxiliary commutator contact opens, cutting off the armature current, and a coil spring returns the armature to its original position ready for the cycle to be repeated. The cycle occupies about one-twentieth of a second. A ball and spring-plate detent mechanism on the further end of the shaft ensures accurate location of the switch after each stroke. The rotation is not reversible, and to go, for example, from position 10 to position 9 the

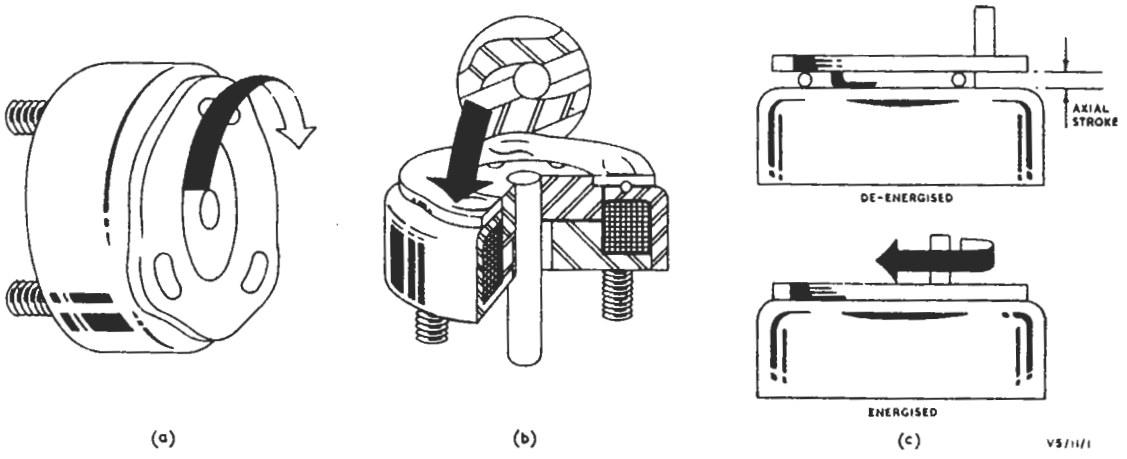

Fig. 2.1. Ledex Mechanism (a) General View (b) Sectional View (c) Action

switch must travel almost completely round. The solenoid is rated for intermittent operation only and must not be continuously run. A maximum duty cycle restricted to about 10 seconds of operation in any one minute is advisable.

The switch-wafer contacts used on BBC equipment are gold plated, because gold gives a lower contact resistance than the coin-silver alloy used for Ledex-operated switches commercially supplied.

Both the Ledex mechanism, including the detent, and the switch contacts (except the auxiliary contacts) require liberal lubrication* with Aeroshell DTD 825 grease, which may be applied with a camel-hair brush. Cleaning fluids, such as carbon tetrachloride, which dissolve the lubricant away, cause rapid wear and must not be used.

MK(4)-1, appears in the diagram. Also, instead of using switch SB, it is convenient to start the Ledex remotely with a P.O. 3,000-type relay, a contact of which, labelled RM-1, also appears. As a 3,000-type relay is not fast enough to stop the Ledex correctly, the faster sealed relay RL1 is used for this purpose as stated.

After operation, all relays are allowed to drop out, but without special precautions the stop relay RL1 would close its contact before the remote start relay RM had opened, allowing the Ledex to move on a further two or three steps. To prevent this a holding current for RL1 is passed through the 8·2-kilohm resistor shown.

In circuits where common marking is used, a rectifier is necessary to prevent the holding current

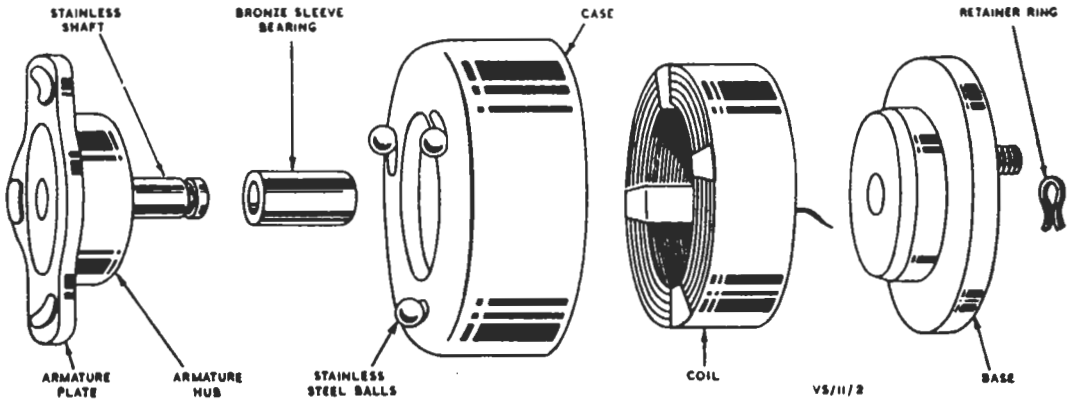

Fig. 2.2. Ledex Mechanism: Exploded View

Control Circuit (Fig. 2.3)

Fig. 2.3 shows at (a) the basic control circuit for the Ledex mechanism. In operation, the channel required is selected or 'marked' on a remote switch (SA in the diagram) which puts an earth on the Ledex control wafer; the switch labelled SB in the diagram is then pressed to connect the 50-volt supply to the solenoid. The Ledex now motors round until it reaches the marked position, when a fast-acting miniature sealed relay RL1 operates and disconnects the 50-volt supply from the solenoid.

In practice, the basic control circuit of Fig. 2.3 (a) is normally replaced by a circuit of a type similar to that shown in Fig. 2.3 (b). Instead of the marking switch SA, a series of marking relays is provided; a contact of one of these, labelled

*Once every two or three years only.

from being paralleled off on to other relays of Ledex switches that are already stopped at the marked position.

The Ledex solenoid has considerable inductance, and to minimise interference with other circuits due to arcing, a 1-μF capacitor and 10-ohm resistor are connected as shown.

Vision-circuit Wiring (Fig. 2.4)

It was found experimentally that the best way to switch vision circuits with a rotary-action wafer switch was to fit a plate immediately on either side of the wafer which switched the inner conductor of the coaxial cable and to divide the outer conductor into two at the end, taking one tail to each plate, as shown in Fig. 2.4 (a).

As a multiway switch is difficult to wire in this

manner, however, in practice the arrangement shown in Fig. 2.4 (b) is used. The plates are dish-shaped with holes near the edge to take coaxial adaptors. Alternate channels are fed through opposite plates using thin coaxial cable (T.3172) and straps are connected between the plates in several places.

Switch Units UN9/501, UN9/502

General Description

The UN9/501 and UN9/502 are 5-wafer Ledex-operated switch units designed for selecting vision sources at the Television Centre. The UN9/501 has 11-way wafers and the UN9/502 has 23-way wafers. Fig. 2.6 shows the UN9/502.

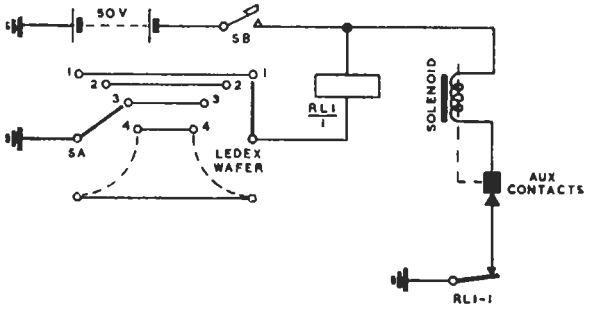

Fig. 2.3. Ledex-operated Switch: Typical Control Circuit

On each switch unit, one of the five wafers is used for control purposes, one for vision-circuit switching, and the remainder for indication and sound or as required. The vision-circuit connections are via P.O. No. 1 coaxial plugs and the remaining connections via Painton Multicon plugs. Because of the large number of cables required to connect a bay of these units, the coaxial plugs are mounted on the rear panels and the Multicon plugs on the front, the bays being fitted with suitable cable-carrying arrangements.

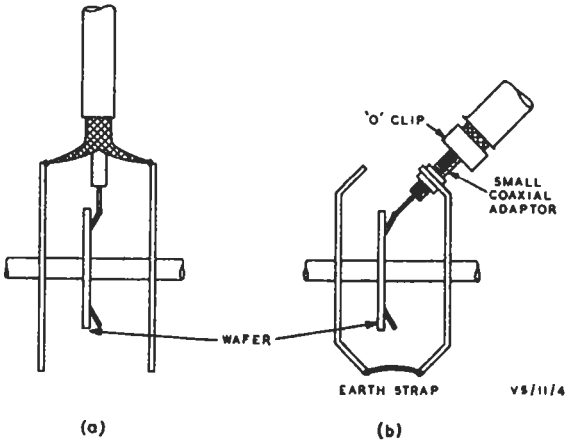

Fig. 2.4. Connection of Coaxial Cable to Switch Wafer
(a) Experimental Method (b) Practical Method

Each unit is built inside a box structure with dust cover about 7 in. wide, $6\frac{1}{8}$ in. high and $9\frac{1}{2}$ in. deep, with a somewhat larger front panel, measuring $8\frac{3}{8}$ in. by $6\frac{5}{8}$ in. It is intended that two units shall be plugged side-by-side on a 7-in. panel PN3/8, the units being held by quick-release fasteners. Panel PN3/8 is designed for 19-in. bay mounting.

Control and Muting Circuits (Figs. 2 and 3)

The control circuit of each unit is essentially that of Fig. 2.3, relay RL1 in this diagram becoming RLA in Figs. 12 and 13, which show the UN9/501 and UN9/502 respectively.

On the UN9/501 two muting relays are also provided, shown in Fig. 2 as RLB and RLC. RLB mutes while the switch is in motion and RLC when it reaches position 11.

RLB is wired in parallel with RLA, and thus operates when the marked position is reached; its contacts then change over to a through-path connection. The operation of RLC is obtained by connecting the 50-volt d.c. supply in series with the switch wiper and the relay winding, which are connected together in series via the wafer in position 11.

On the UN9/502 only RLB is fitted, and on this unit the relay has one change-over contact and one break contact, as shown in Fig. 3.

Switch Panels PA18/502, PA18/503, PA18/504

General Description

These panels are designed for vision-circuit switching at the Television Centre. They carry a varying number of 5-wafer 23-way Ledex-operated rotary switches arranged so that any output can be connected to any input irrespective of the others.

Panel PA18/502 has four switches and is intended for use in central mixer source selection. This panel is shown in Figs. 2.7 and 2.8. Panel PA18/503 has two switches and is intended for central mixer preview switching. Panel PA18/504 has six switches and is intended for studio preview switching, two panels being used in conjunction in order to provide 12 outputs.

front panel. The switch-shafts are extended to pointer knobs on the front panels. These knobs, in conjunction with engraved scales, indicate the position of each switch and can also be used for emergency manual operation.

The panels resemble a pan chassis Type CH3/1 in construction, but have greater depth and are completely enclosed. The PA18/502 and PA18/504 each occupy 14 in. of bay space and the PA18/503 seven inches.

Control and Muting Circuits (Figs. 4, 5, 6)

The control circuit of each switch panel is basically similar to that of Fig. 2.3, although the four-switch panel PA18/502 carries no relays, and its control circuit is therefore external. The PA18/503 and PA18/504 have plug-in relays on their rear panels. In Fig. 5 the control relays of the

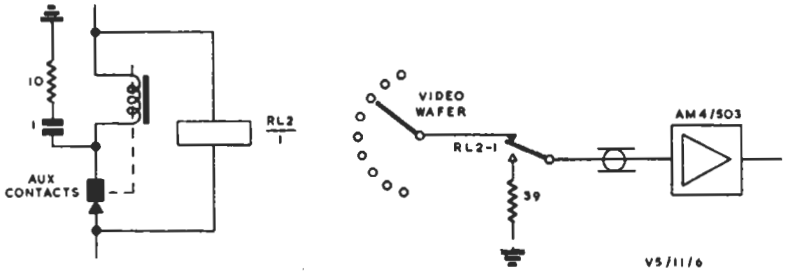

Fig. 2.5. PA18/503 and PA18/504: Muting Circuit

The vision-circuit inputs to each panel are via P.O. No. 1 coaxial plugs. On the PA18/502 and PA18/503 these terminate in 75-ohm resistors but on the PA18/504 they are brought out again to a further 23 P.O. plugs for connection to the second panel of a pair. The vision-circuit outputs are through Belling-Lee coaxial sockets, which are located at the top and bottom of the units. (Top only on PA18/503.) This arrangement permits the use of a very short connecting lead to the high-input impedance amplifier AM4/503 or AM4/505 which is required at each output. All other connections, including those for control voltages, are via 24-way Painton Multicon plugs.

The switches are fixed on Silentbloc B124 mountings, which reduce the noise transmitted during operation. The PA18/502 has also a sheet of Polyurethane foam to reduce the noise from the

PA18/503 are labelled RLC and RLD, while in Fig. 6 those of the PA18/504 are labelled RLG, RLH, RLJ, RLK, RLL and RLM; all these relays correspond to RL1 in Fig. 2.3.

Each switch takes a peak current of one ampere at 50 volts d.c., but it is unlikely in practice that this current will be drawn by more than one switch at a time.

Muting arrangements are provided on the PA18/503 and PA18/504 only, the vision-circuit output from any switch being disconnected while the switch is in action by relay RL2 across the Ledex mechanism as illustrated in Fig. 2.5. In Fig. 5 the muting relays of the PA18/503 are labelled RLA and RLB, while in Fig. 6 those of the PA18/504 are labelled RLA, RLB, RLC, RLD, RLE and RLF; all these correspond to RL2 in Fig. 2.5.

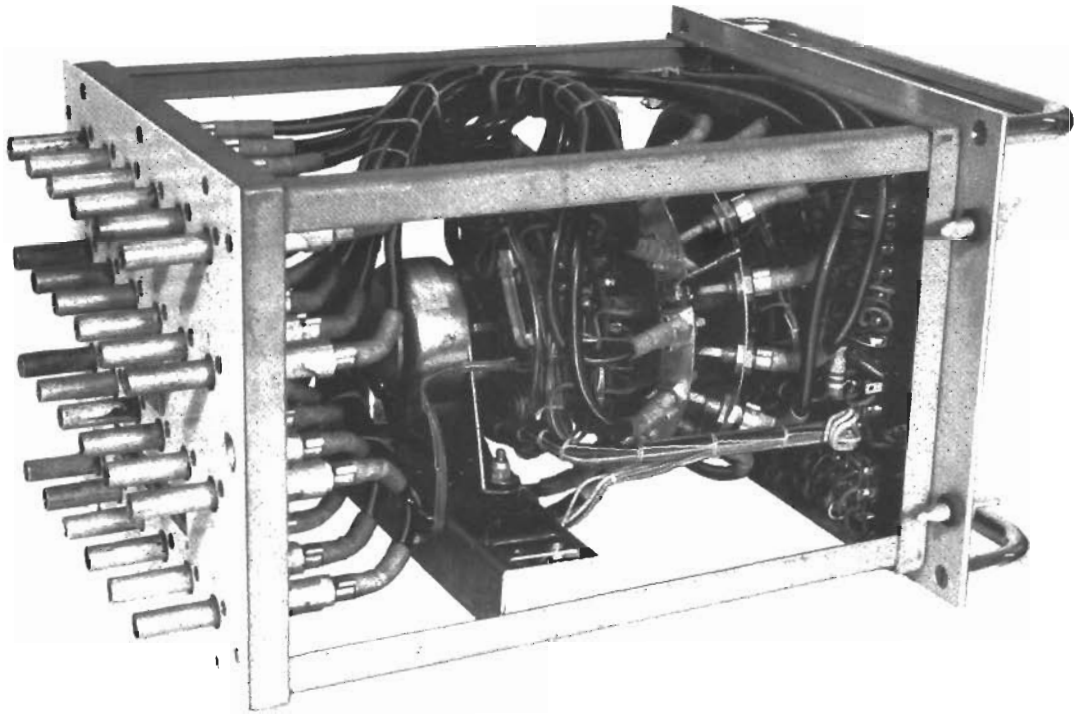

Fig. 2.6. Switch Unit UN9/502 (One Relay Removed)

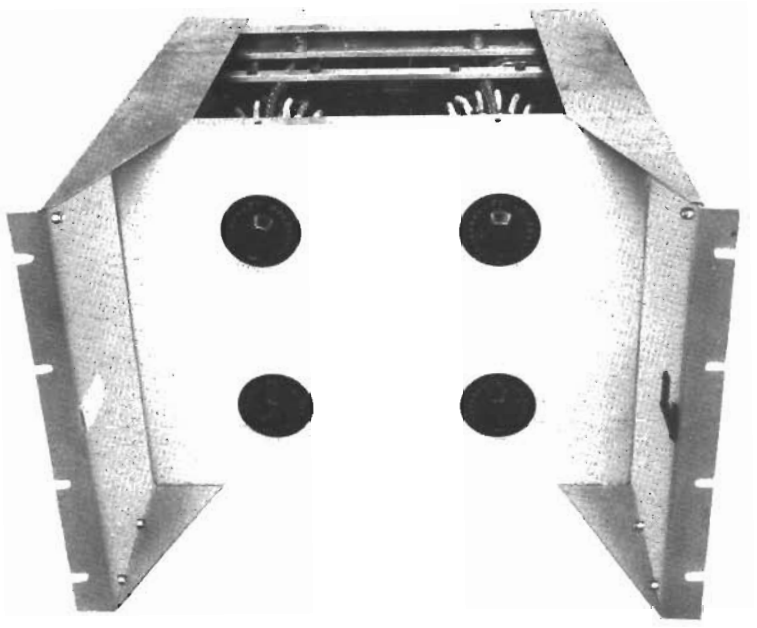

Fig. 2.7. Switch Panel PA18/502: Front View

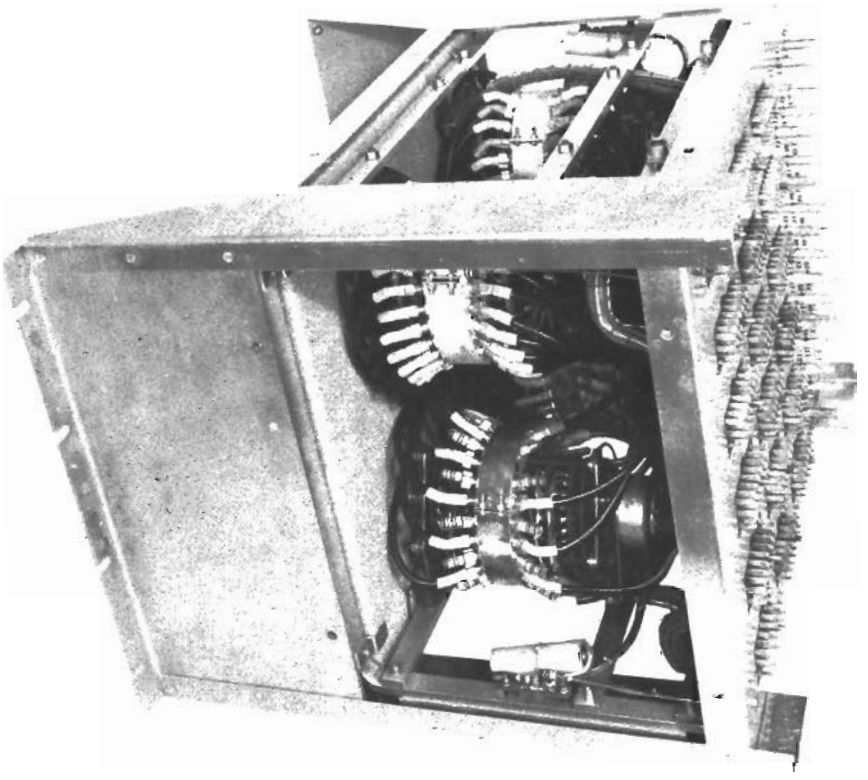

Fig. 2.8. Switch Panel PA18/502: Oblique View

Vision-switching Circuits

(a) General

The vision-switching circuits on each panel are arranged so that the output from any wiper can be connected to any input between 1 and 23 irrespective of the positions of the other wipers. Fig. 2.9 shows the system employed. Each input goes to all the switches in parallel and also to a 75-ohm resistor. The wiper of each switch is connected to a high-input impedance amplifier Type AM4/503 or AM4/505. Since the amplifiers are of high impedance, several or all of them may be connected to the same source at the same time. In these circumstances, however, the total shunt impedance (mostly capacitive) could be excessive unless special precautions were taken. It is for this reason that

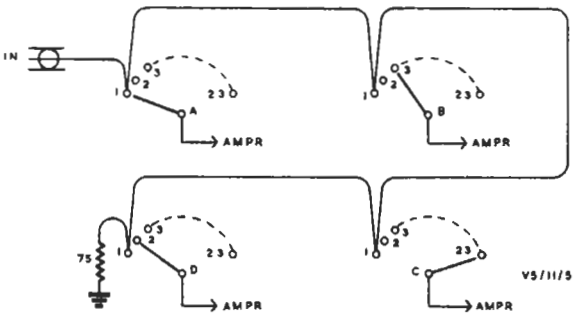

Fig. 2.9. General Principle of Switch-panel Vision-switching Circuit

Belling-Lee coaxial sockets are used for the outputs, these having lower capacitance than P.O. No. 1 plugs; the sockets are so located that they need only very short connecting leads to the PN3/2 panels carrying the amplifiers. (AM4/503s connected to the outputs at the bottom of the PA18/502 are inverted.)

(b) Crosstalk

Crosstalk between different sources is due mainly to capacitance between adjacent contacts on the wafers of each switch, and capacitance between adjacent channels in a six-switch unit is clearly six times as great (i.e. 15·5 dB worse) than with a single switch. In practice this would be excessive at 3 Mc/s and to minimise crosstalk a channel sequence of the following type is used:

Switch	A	B	C	D
	1	5	9	13
	2	2	2	2
	3	7	11	15
	4	4	4	4
	5	9	13	17
	6	6	6	6
	7	11	15	19
	8	8	8	8
	9	13	17	21
	10	10	10	10
	11	15	19	23
Channel	12	12	12	12
Sequence	13	17	21	1
	14	14	14	14
	15	19	23	3
	16	16	16	16
	17	21	1	5
	18	18	18	18
	19	23	3	7
	20	20	20	20
	21	1	5	9
	22	22	22	22
	23	3	7	11

The channels are staggered so that no two channels are adjacent on more than one switch, e.g. channel 19 on successive switches comes between 18 and 20, 14 and 16, 10 and 12, 6 and 8, and so on. The control circuits are similarly staggered so that, externally, all switches appear identical except for the different order displayed on the indicators on the front panel.

The crosstalk varies slightly with different channels and the position of the wipers, but a typical figure is −50 dB at 3 Mc/s.

(c) Frequency Response

The frequency response depends on the number of amplifiers bridged across the channel under consideration and the length of their connecting leads. For a typical PA18/502, with all four outputs taken from the same source the attenuation at 3 Mc/s relative to 1 Mc/s is about 0·1 dB. It is expected, however, that in practice more than two outputs will rarely come from one source.

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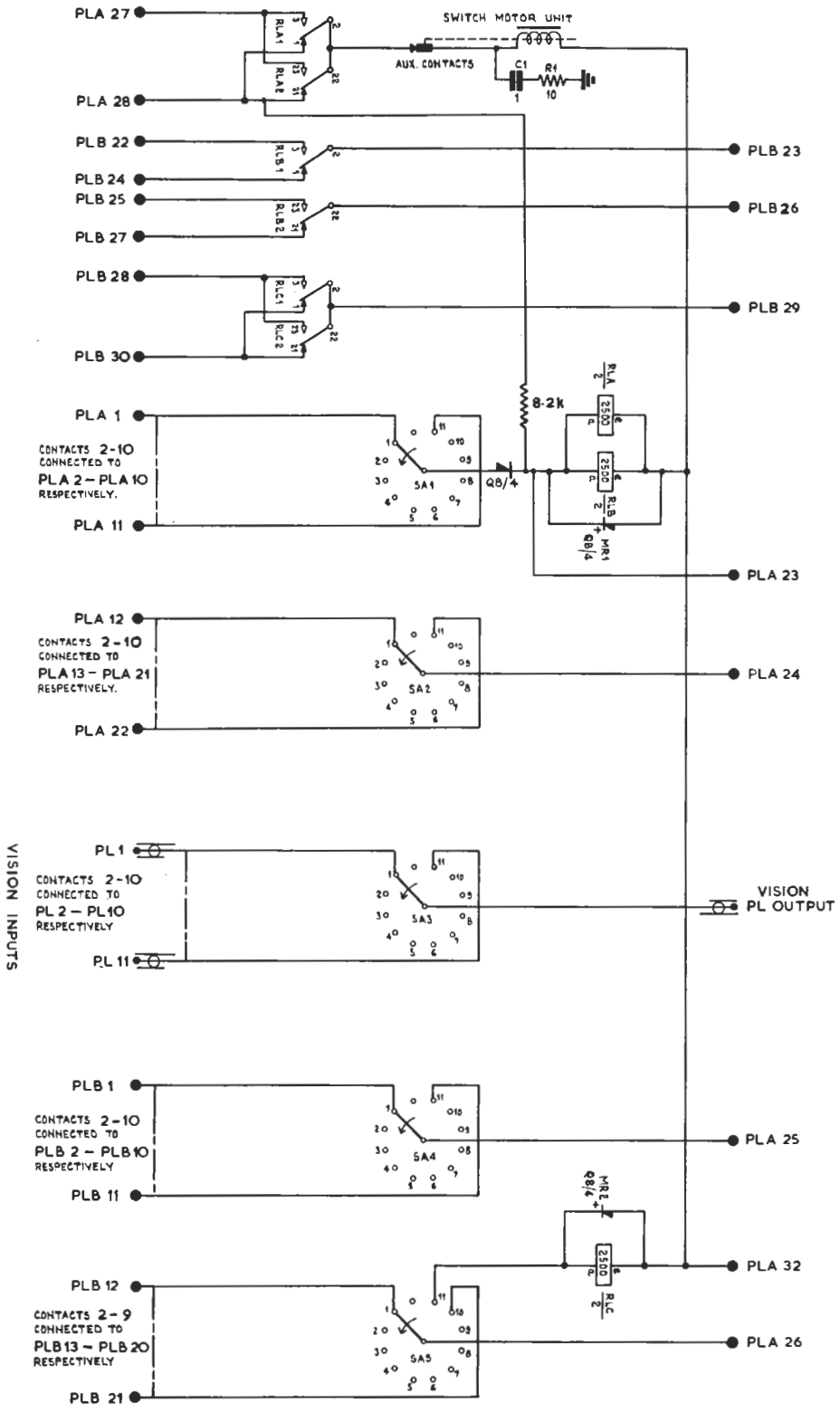

SWITCH UNIT UN9/501: CIRCUIT

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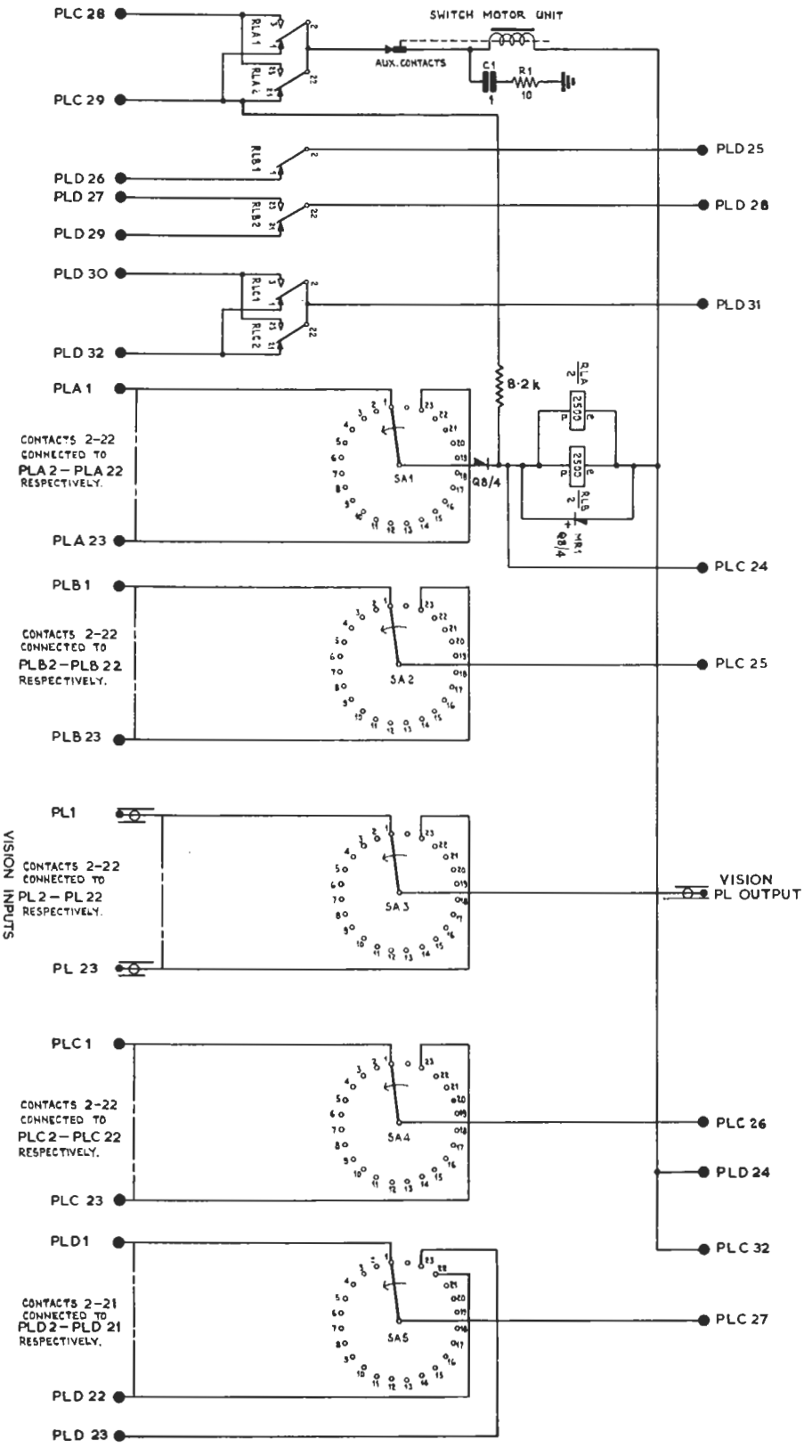
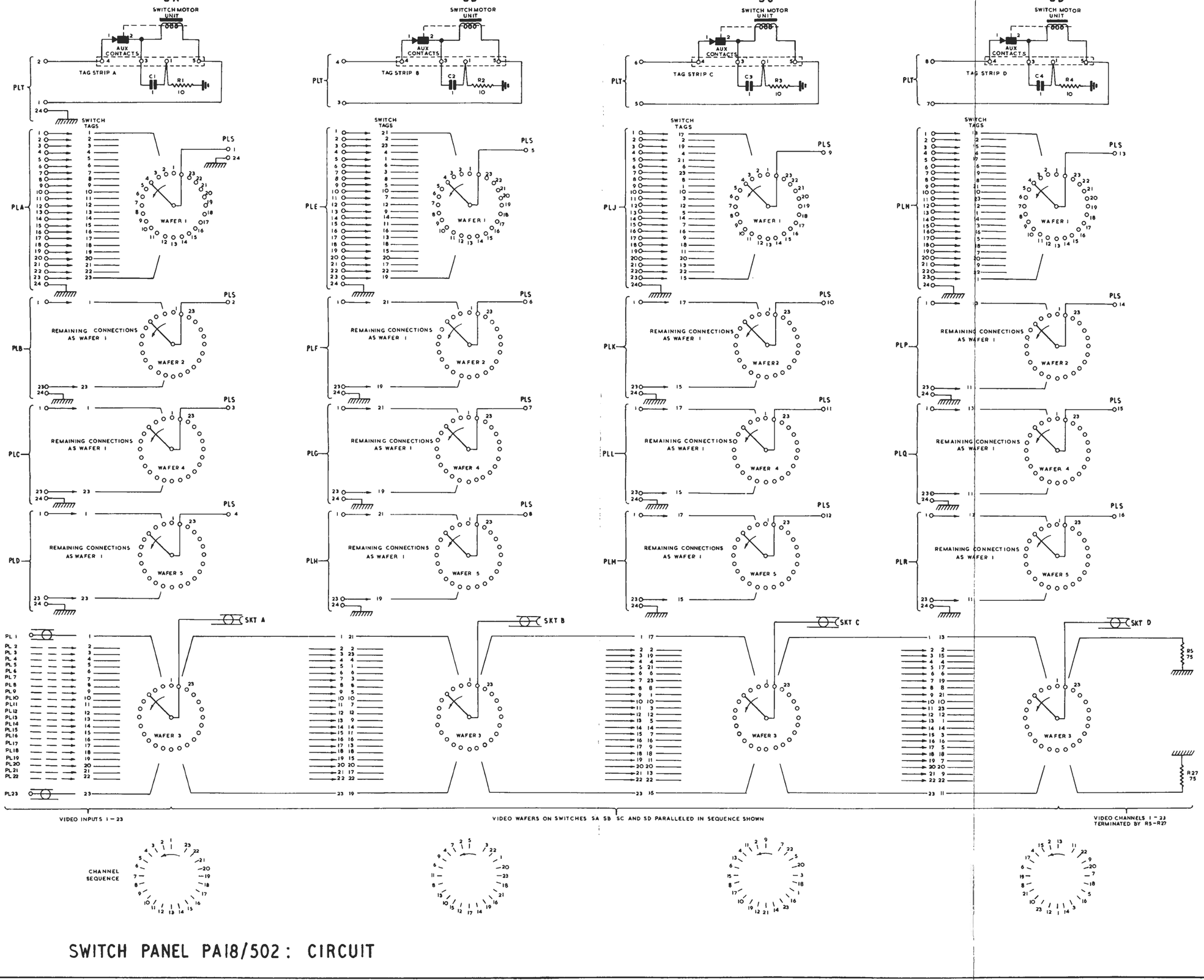
EC10364

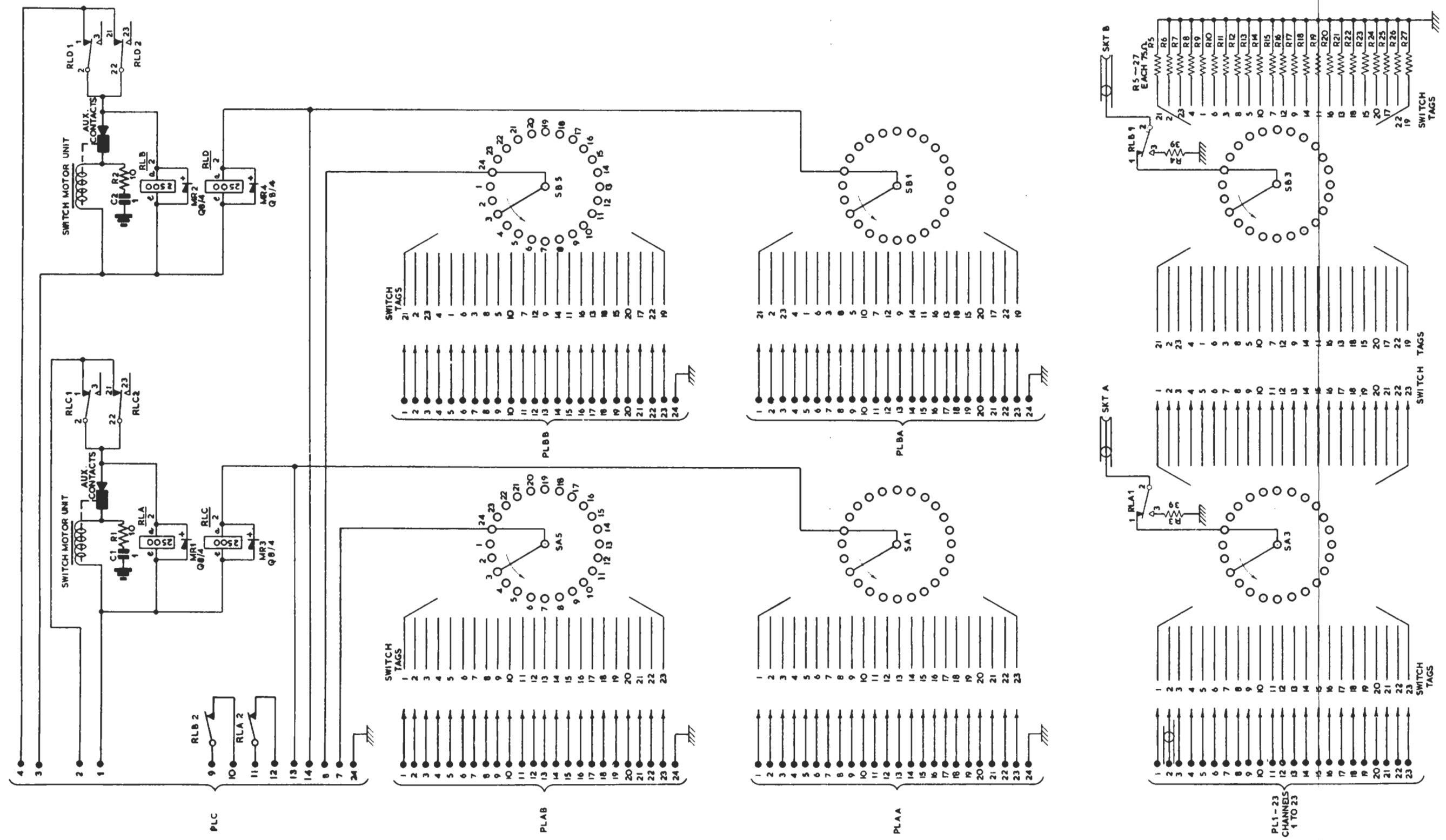
LEDEX
V.12
SECTION 4
~~FIG~~ 3



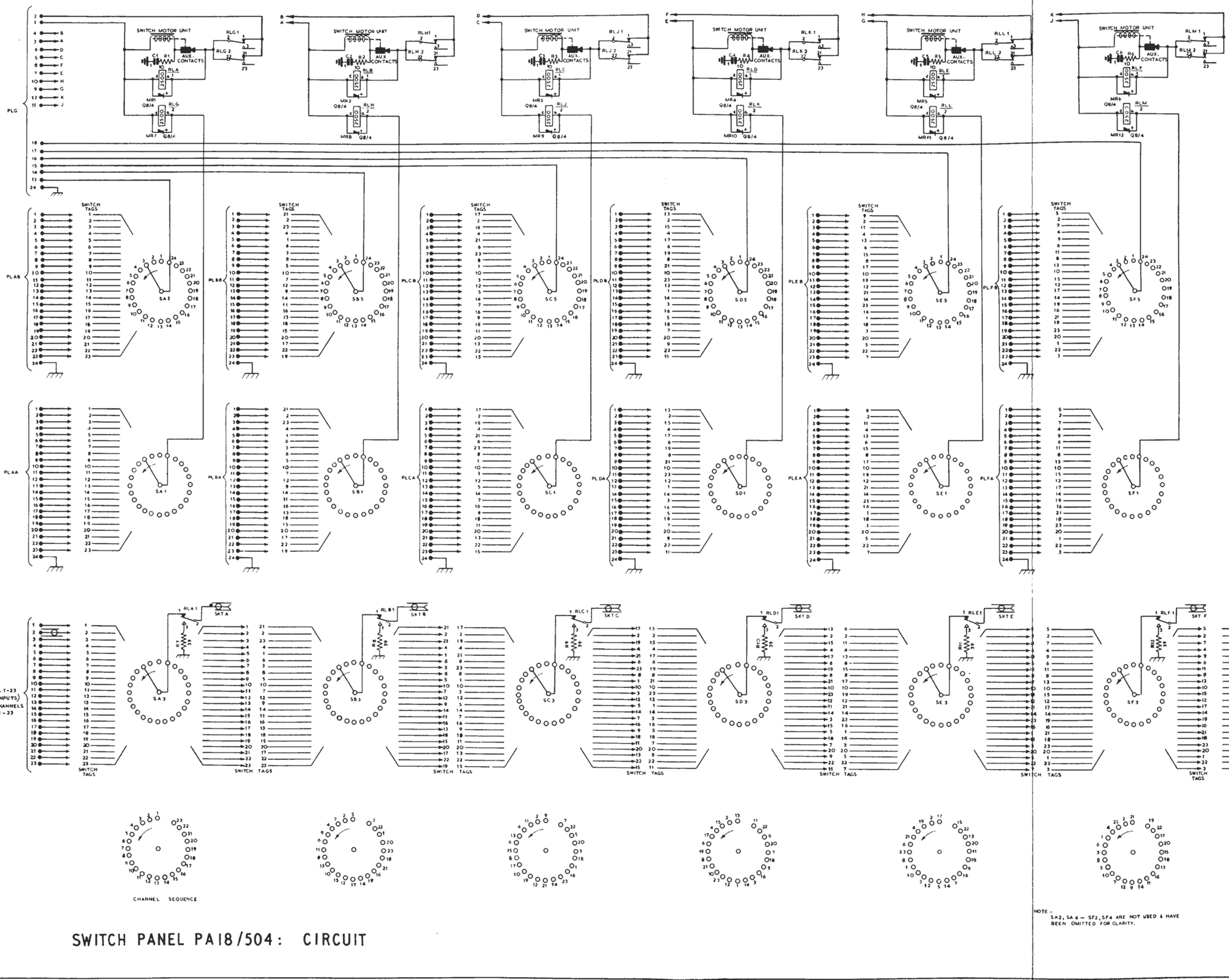
SWITCH UNIT UN9/502 : CIRCUIT



SWITCH PANEL PA18/502 : CIRCUIT



SWITCH PANEL PA18/503 : CIRCUIT



NOTE:-
SA2, SA 4 — SF2, SF4 ARE NOT USED & HAVE BEEN OMITTED FOR CLARITY.

SWITCH PANEL PA18/504: CIRCUIT

PA18/504