LOUDSPEAKERS AND LOUDSPEAKER UNITS

SECTION 1

LOUDSPEAKER UNIT LSU/10

Introduction

The LSU/10 is an entirely redesigned cabinet-type loudspeaker unit for quality checking. The RK loudspeaker, which has been used for this purpose for a number of years, has been replaced by a Parmeko dual loudspeaker, LS/1, comprising a 15-inch cone, with a separate high-frequency horn, the two units having a common axis.

A commercial amplifier, coded LSM/8, is used to drive the two units, the output of the amplifier being connected to the loudspeaker speech coils through a filter, F/28, which has a cross-over frequency of 1,200 c/s.

The loudspeaker, amplifier and filter are housed in a redesigned acoustic cabinet, LB/8.

Loudspeaker LS/1

The Parmeko loudspeaker has two concentric units, the larger consisting of a straight-sided cone diaphragm (Fig. 1.1) 15 inches in diameter carrying a speech coil 3 inches in diameter situated in the annular gap of a large permanent magnet. This unit has a fundamental resonance of 30 c/s and is used to radiate frequencies below 1.200 c/s. The smaller unit has a light aluminium diaphragm of domed construction and 1¾ inches in diameter ; it is attached to a speech coil of the same diameter placed in the gap of a second magnet smaller than the first and situated at the rear of it. A tapered hole is formed in the centre pole of the front magnet to form the throat of a high-frequency

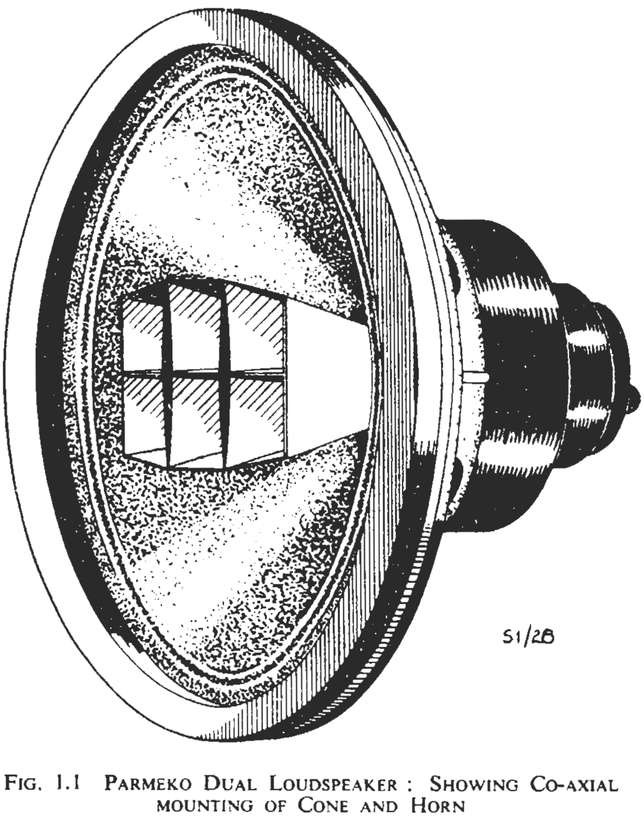


FIG. 1.1 PARMEKO DUAL LOUDSPEAKER : SHOWING CO-AXIAL MOUNTING OF CONE AND HORN

horn into which the high-frequency unit radiates. The throat leads to an external multi-cellular horn bolted to the face of the centre pole. To give wide-angle radiation this external horn is divided into six sections arranged 3 cells wide by 2 cells deep. The cells are of metal and the space between them is filled with sound-deadening material to prevent the walls ringing.

Because of the horn-loading and the higher flux density in the gap, the smaller unit is more efficient than the other ; it is therefore given a higher impedance to ensure approximately correct distribution of power between the two units when they are connected in parallel. The parallel connection is made via a cross-over filter designed to feed frequencies above 1,200 c/s to the horn and frequencies below 1,200 c/s to the cone.

Reduction of H.F. Pick-up

To reduce h.f. pick-up, which might otherwise give trouble at certain locations, the loudspeaker framework and F/28 filter chassis have been earthed to the programme earth of the unit. For the same reason R21 and R22 have been added to the LSM/8.

LOUDSPEAKER AMPLIFIER LSM/8

General Description

The LSM/8 amplifier is a commercial product, manufactured by H. J. Leak & Co., Ltd., and known as type TL/12, but the programme input circuit has been modified to make the amplifier suitable for use in the loudspeaker unit LSU/10. The performance of this amplifier is similar to that of the MPA/1, but it is more sensitive and has a lower output impedance.

The output stage consists of two triodes in push-pull and these are preceded by a cathode-coupled phase-splitting stage. The phase splitter is preceded by a voltage-amplifying stage consisting of an RC-coupled pentode, to which is applied a negative feedback voltage obtained from the output stage.

An input level of —20 db is required to give the maximum output of 10 watts. The amplifier incorporates its own mains unit and is constructed on a conventional chassis for base-board mounting.

Electrical Design Considerations (Fig. 1)

The output stage consists of two KT66 beam tetrodes connected as triodes and operating in push-pull. The valves are used under Class-A conditions and the anode current remains steady during operation, permitting the use of a mains unit in which no special precautions need be taken to ensure good regulation. The valves are connected as triodes to keep the anode a.c. resistance low, and this is further reduced to give a low output impedance by the use of voltage feedback.

A double-triode valve is used for phase-splitting, the circuit being similar to that used in the LSM/4 and other BBC amplifiers. One of these triodes (*a*) operates as an RC-coupled amplifier, feeding one of the output valves, but has a high-value (11kΩ) cathode resistor. The signal p.d. developed across this resistor is applied to the second half (*b*) of the double-triode valve, the anode of which is coupled to the second output valve. To obtain a push-pull output from the double valve, the two cathodes must be bonded, and the grid of the second valve must be earthed. Thus the common cathode resistor carries both anode currents and the alternating components cannot be precisely equal. Equality in output voltages is obtained, however, by making the anode load of triode (*b*) larger than that of (*a*).

The first stage is an RC-coupled pentode giving high voltage gain. A negative feedback voltage from the secondary winding of the output transformer is injected into the cathode circuit, the component values in the feedback loop being chosen to give the desired overall gain. The amplifier has a signal-input socket connected directly in the grid circuit of the first stage, but for BBC use this socket is replaced by an input transformer with a gain control connected across the secondary winding.

The mains rectifying and smoothing circuit is conventional but an unusual feature is that all smoothing and decoupling capacitors are of paper dielectric, no high-voltage electrolytic capacitors being used anywhere in the amplifier.

Mechanical Design Considerations

The amplifier is constructed on a chassis measuring 12½ inches by 10 inches by 3 inches and is fitted with a base plate which is slightly longer than the chassis and overlaps it for a short distance at either side. The flanges thus formed have bolt holes which are used for securing the amplifier in the LSU/10 compartment.

The five valves are mounted above the chassis in a row at the front of the amplifier. Behind them are the input, output and mains transformers ; the choke and the smoothing-capacitor block and their tag connections project through the hole in the chassis so that there is no wiring above the chassis. The remaining small components are located underneath the chassis on a single tag panel which occupies almost the whole length of the amplifier.

When the amplifier is used in the LSU/10 a baffle plate is secured to the chassis between the valves and the large components to assist ventilation by deflecting hot air out of the amplifier compartment.

On the right-hand side of the amplifier are mounted the loudspeaker output socket, mains input socket, mains fuse, mains-transformer primary-tapping selector, and a terminal block at which an external mains switch may be terminated.

The front panel carries the gain control which has a pointer moving over a scale arbitrarily calibrated from 0 to 10. In the LSU/10 this control projects through a hole at the right-hand side of the cabinet.

On the left-hand side of the amplifier is a 4-pin plug for connection of programme input.

Circuit Description (Fig. 1)

The programme input is connected via the input plug and socket to the primary winding of a screened transformer Type AGG/1SA. This has a turns ratio of 1 : 2 and is loaded on the secondary side by a 50-kΩ gain control R1, giving the amplifier a balanced input impedance of 12,500 ohms.

The slider of the gain control is connected to the grid of the voltage amplifier stage V1, an EF37 pentode with an anode resistor (R4) of high value (470kΩ). The screen V1 is fed from a potential divider (R6, R7) and is decoupled to cathode by the 0·25-μF capacitor C2. The anode and screen supplies are smoothed and decoupled by the 220-kΩ resistor R5 and the 4-μF capacitor C10. The cathode circuit of V1 includes a 2·2-kΩ resistor R3 which provides most of the grid bias, and a 100-Ω resistor R2 which is part of the feedback circuit. To avoid current feedback which would reduce the gain of V1, R3 is decoupled by the 50-μF capacitor C1. R2, of course, must not be decoupled, but its value is so small that it causes negligible current feedback.

The output of V1 is coupled to grid (*a*) of the 6SN7 double-triode valve V2 by the 0·25-μF capacitor C3 and 1·5-MΩ grid leak R8. This grid leak, and the grid leak R11 of the valve (*b*) are both returned to the junction of the 1-kΩ resistor R9 and the 10-kΩ resistor R10, in the common cathode circuit. Thus R9 provides grid bias for both halves of the phase-splitter, whilst the two cathode resistors in series provide coupling between the two halves. Grid (*b*) of the 6SN7 is earthed via the 0·25-μF capacitor C4. The anode resistors of the two halves of the phase-splitter are slightly different in value, R13 being 57kΩ and R12 68kΩ, to make up for inequality in the a c. components of the anode currents. The time constants of the grid-circuit components are longer than usual to minimise phase-shift at low frequencies and prevent instability due to negative feedback.

Valve (*a*) of the phase-splitter stage is coupled to V4 by the 0·25-μF capacitor C6 and the 470-kΩ grid leak R15, the time constant again being long for the reason given above. Valve (*b*) is coupled to the grid of V3 by C5 and R14 which have the same values as C6 and R15 respectively. The KT66 output valves are used as triodes, the anodes being strapped to the screen grids by 100-Ω resistors R19 and R20 which are included as a precaution against parasitic oscillation. The valves are biased by 600-Ω cathode resistors R16 and R17, this giving a cathode current of 65 mA per valve with an h.t. supply of 470 volts. These cathode resistors are decoupled by 25-μF capacitors C7 and C8 respectively. To enable the amplifier to deliver its full output at high audio frequencies, 0·001-μF capacitors C14 and C15 are connected across each half of the output-transformer primary winding. The secondary winding is in four sections which may be connected in series, parallel or a combination of both to suit output loads of between 1 and 16 ohms. When the amplifier is used in conjunction with an LS/1 loudspeaker the secondary winding is connected for a 4-ohm load as shown in Fig. 1.

Negative voltage feedback is obtained by coupling the output-transformer secondary winding to the cathode of V1 by R18 and R2, and to avoid instability at high frequencies R18 is shunted by capacitor C9. The gain of the amplifier from input to anode of V3 or V4 is largely determined by the output transformer ratio and the values of

R18 and R2, which together fix the gain of the feedback loop. As the transformer ratio must be altered to suit different values of output load, the value R18 (and hence C9) must be altered also to keep the feedback and amplifier gain constant. The table in Fig. 2 gives values of R18 and C9 for various output loads.

Input Loss-pad

To bring the normal setting of the volume-control potentiometer to a higher part of the range, where fine control of level may more easily be carried out in studios, it has been found necessary to insert a fixed loss-pad prior to the input plug and socket of the LSM/8. This loss-pad is carried by a resistance holder mounted in the amplifier compartment of cabinet LB/8, and comprises a 4·7-kilohm resistor in each leg of the programme circuit followed by a 1·2-kilohm resistor in shunt. Where the resultant attenuation is not required the series resistors are replaced by straps and the shunt resistor is also omitted. Neither the loss-pad nor the resistance holder is normally fitted to loudspeaker units in recording and reproducing rooms.

The mains rectifying equipment includes the transformer T3, a U52 full-wave rectifying valve V5 and a π-type smoothing circuit.

No feed-measuring facilities are included in the amplifier and the anode currents should be measured by the p.d's. developed across the cathode-bias resistors, using the meter on the range specified in the Valve Data table.

General Data

Impedances

Normal Source, 300 ohms.

Input, 12,500 ohms ±10% (balanced).

Output, 0·5 ohms max. at 1,000 c/s (connected for 4-ohm load).

Load, 4 or 16 ohms (unbalanced).

Maximum Gain

38 db into 4-ohm load.

Sensitivity

—20db input gives +18 db across 4-ohm load corresponding to 9·5 watts output. (Avo. reading 6·2 V a.c.)

Frequency Characteristic

Within ±0·3 db from 60 c/s to 8,000 c/s

Within ±1·5 db from 30 c/s to 15,000 c/s

Input —20 db. Gain control set for output of +2 db.

Total Percentage Harmonic Content

Level across 4-ohm load	Power output	60 c/s	1,000 c/s
+18 db	9·5 watts	0·5%	0·2%
+10 db	1·6 watts	0·25%	0·1%

Noise

—70 db compared with normal output volume.

Valve Data

Stage	*Type*	*Bias Resistor*	*P.D. Across Bias Resistor*	*Filament Voltage*	*Filament Current*
V1	EF37	R3	* 1V ±15%	6·3V	0·2A
V2	6SN7	R9	* 4·5V ±10%	6·3V	0·6A
V3	KT66	R16	†37·5V ±10%	6·3V	1·27A
V4	KT66	R17	†37·5V ±10%	6·3V	1·27A
V5	U52	—	—	5·0V	3·0A

* *Avometer Model* 40 *Range* 12V. † *Avometer Model* 40 *Range* 120V.

H.T. Voltage 470 volts measured across C12. *Avometer Model* 40 *Range* 1,200V.

Filter Unit F/28 (Fig. 1.2)

The high-frequency unit of the loudspeaker LS/1 must not receive low-frequency inputs because the large amplitudes which can be developed at these frequencies might cause damage. It is also undesirable for the cone unit to radiate high frequencies because these would cause interference with the output from the h.f. unit. A filter unit, F/28, is therefore included between amplifier and loudspeaker to ensure that only high-frequency signals are fed to the h.f. unit and only low frequencies to the l.f. unit. The frequency at which the cross-over occurs is determined by the design of the loudspeaker and is 1,200 c/s for the LS/1.

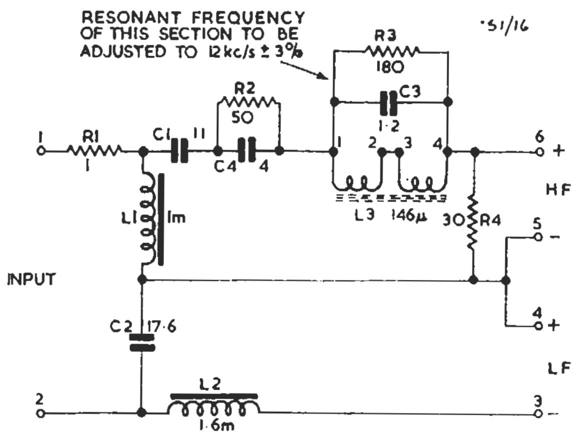


Fig. 1.2 Filter F/28 : Circuit

The filter is basically a simple series type the main components being L1C1 and L2C2. L1 and C2 are connected across the input terminals and resonate at 1,200 c/s. At this frequency equal voltages are developed across L1 and C2 but as frequency is reduced the reactance of C2 increases, causing a greater voltage to be fed to the l.f. unit of the loudspeaker, and the reactance of L1 falls, causing a smaller voltage to be delivered to the h.f. unit. The performance of the filter is improved by the inclusion of L2 which, in conjunction with the l.f. speech-coil impedance, forms a potential divider which further reduces the signal fed to the l.f. unit at frequencies above 1,200 c/s and by the inclusion of C1 which similarly attenuates the signal fed to the h.f. unit at frequencies below 1,200 c/s.

The h.f. unit is more efficient than the l.f. unit and, with a filter consisting simply of L1C1 and L2C2, the output from the loudspeaker shows a sharp increase or " step " as frequency is increased through 1,200 c/s. To eliminate this, the components R2 and R4 are introduced ; these reduce the output from the h.f. unit to approximately the same value as that from the l.f. unit at frequencies near the cross-over value. The attenuation so introduced is too great at high frequencies and a fixed capacitor C4 is shunted across R2 to reduce the loss at these frequencies.

To eliminate a peak in the loudspeaker output at about 12,000 c/s a parallel-tuned circuit L3C3 is inserted in series with the h.f. unit and the Q of the circuit is reduced to the desired value by the fixed resistor R3.

The input impedance of the filter unit with the loudspeaker in circuit has a minimum value of approximately 4 ohms and the secondary windings of the LSM/8 output transformer are connected to match this load. When the LS/1 is used in conjunction with an MPA/1 amplifier the two secondary windings on the output transformer should be connected in parallel as for a 4-ohm load.

The output impedance of the LSM/8 is less than that of the MPA/1 and when an LSM/8 is used with the filter unit and loudspeaker a 1-ohm resistor R1 is inserted in one leg of the filter input circuit. This resistor is short-circuited when an MPA/1 is used to ensure that the filter unit is always effectively fed from the same source impedance.

Loudspeaker Amplifier LSM/10

Certain LSU/10 units are now fitted with a commercial amplifier type LSM/10 in place of the LSM/8. The circuit of the LSM/10 is basically similar to that of the LSM/8 and is given in Fig. 2 (Serial Nos. 101-470) and Fig. 2A (Serial Nos. 471 onwards).

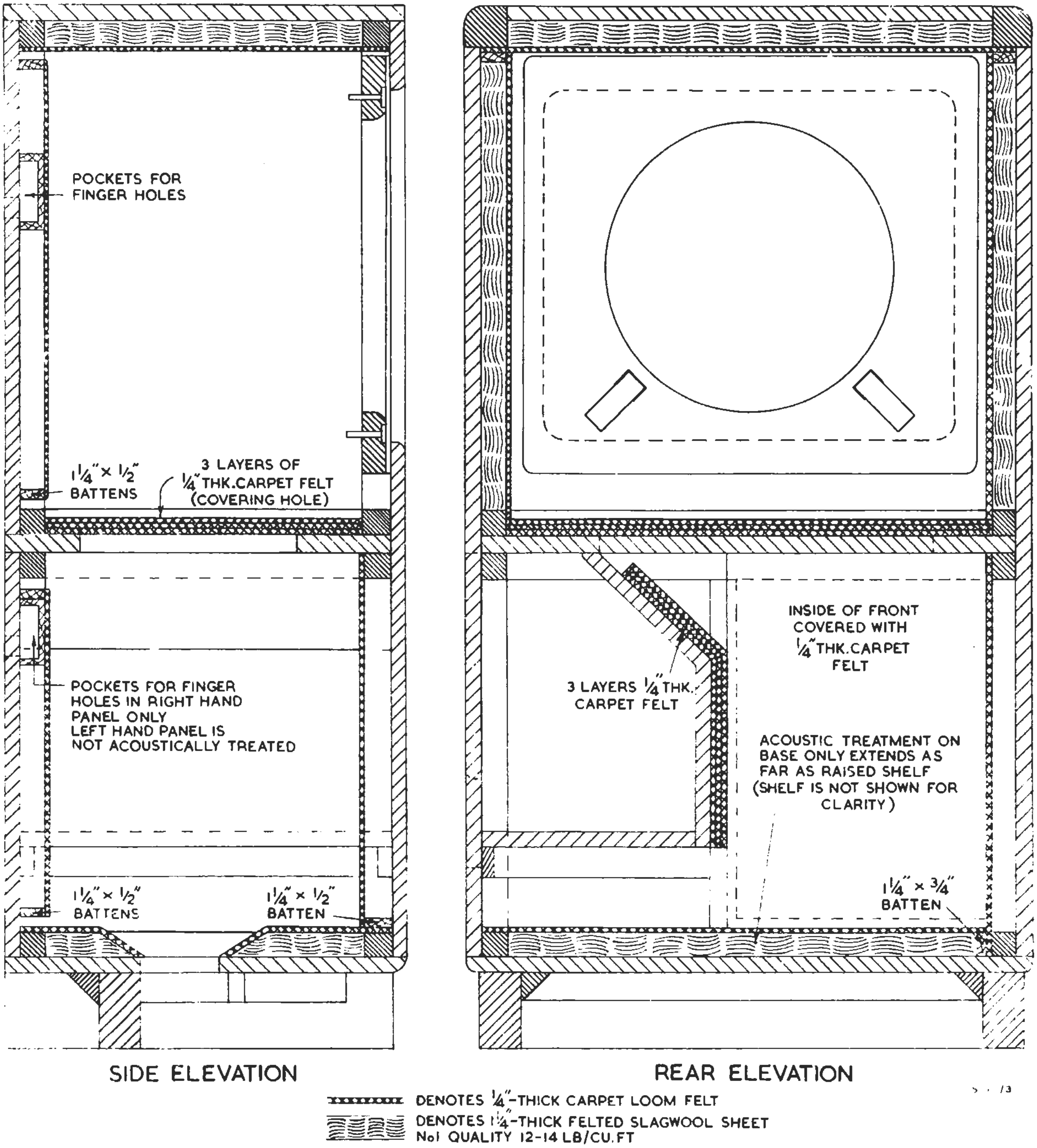


FIG. 1.3 LOUDSPEAKER CABINET LB/8: CONSTRUCTION

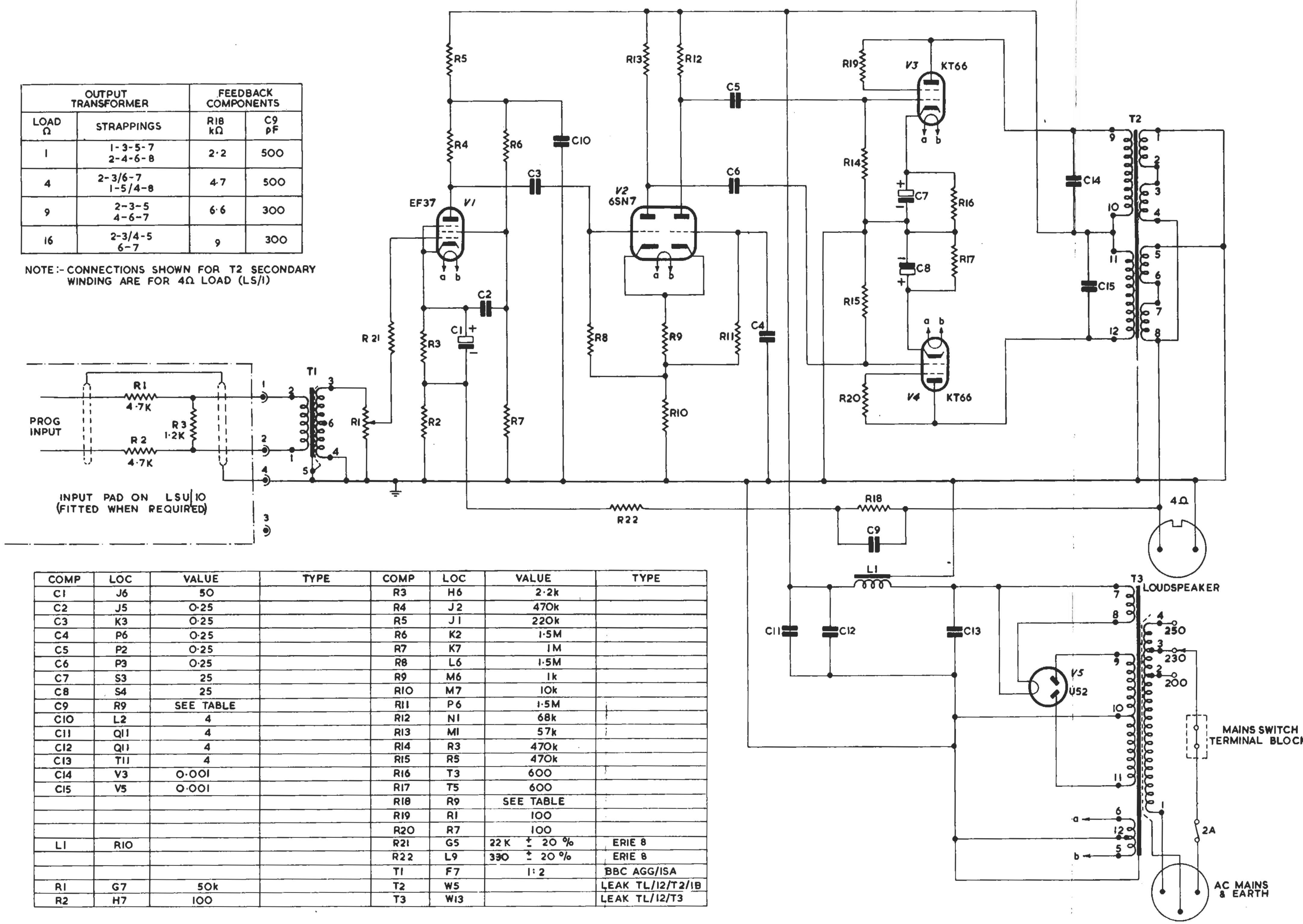
Cabinet LB/8 (Fig. 1.3)

The cabinet is constructed in the form of a vented enclosure which gives a smoother and wider-range bass response than the box baffles used hitherto. The rear of the cabinet is completely boxed in and an opening or vent in the form of a rectangular hole is provided in the base. This vent opens into a cavity between the base and the floor and is bounded by the plinth which supports the cabinet. The plinth is arranged as three sides of a square and directs sound waves transmitted through the vent outwards from the front of the cabinet. The vent and associated cavity have the nature of an acoustic inductance whilst the air enclosed inside the cabinet behaves as a capacitance and the dimensions are chosen to give resonance at the lowest frequency it is desired to reproduce. Low-frequency sound waves generated at the rear of the loudspeaker diaphragm are transmitted through the vent and, over a limited frequency range, are in phase with the radiation from the front of the loudspeaker. The design is such that the useful range of the loudspeaker is extended downwards by about half an octave.

To prevent high-frequency sound waves being transmitted through the vent the upper half of the cabinet is lined with about 1¼-inch thick slag wool. This is obtained in pre-formed slabs which are stuck to the sides of the cabinet and are then covered with a layer of carpet loom felt. Such treatment is effective in suppressing high-frequency sound waves but does not sufficiently eliminate low-frequency vertical air-column resonance which occurs at about 120 c/s. This is suppressed by three ¼-inch layers of carpet loom felt stretched horizontally across the centre of the cabinet where the standing waves have maximum particle velocity. Very little high-frequency radiation reaches the lower half of the cabinet and the only acoustic treatment necessary is provided by a single layer of carpet loom felt. If a thin layer of absorbing material were attached directly to the walls the absorption would be low because particle velocity is a minimum close to a reflecting surface. For this reason the felt in the lower half of the cabinet is attached to battens to space it about 1¼-inch from the walls.

The loudspeaker amplifier LSM/8 is situated on a shelf within a small compartment in the lower half of the loudspeaker cabinet and at the right-hand side (viewed from the front) and the gain control is accessible through a hole in the lower right-hand panel. This panel and the rear panel adjacent to the amplifier have windows of expanded metal to provide ventilation and a baffle is fitted to the amplifier chassis to direct hot air out of the amplifier compartment. Before the amplifier can be removed the side and rear panels of the amplifier compartment must be detached. These are each held in place by a number of screws and the amplifier itself is secured to the shelf by four bolts. There is, of course, no need for acoustic treatment of the interior of the amplifier compartment but the outside is lagged with three layers of carpet felt.

FIG 1 S8



OUTPUT TRANSFORMER		FEEDBACK COMPONENTS	
LOAD Ω	STRAPPINGS	R18 kΩ	C9 pF
1	1-3-5-7 2-4-6-8	2·2	500
4	2-3/6-7 1-5/4-8	4·7	500
9	2-3-5 4-6-7	6·6	300
16	2-3/4-5 6-7	9	300

NOTE:- CONNECTIONS SHOWN FOR T2 SECONDARY WINDING ARE FOR 4Ω LOAD (LS/1)

COMP	LOC	VALUE	TYPE	COMP	LOC	VALUE	TYPE
C1	J6	50		R3	H6	2·2k	
C2	J5	0·25		R4	J2	470k	
C3	K3	0·25		R5	J1	220k	
C4	P6	0·25		R6	K2	1·5M	
C5	P2	0·25		R7	K7	1M	
C6	P3	0·25		R8	L6	1·5M	
C7	S3	25		R9	M6	1k	
C8	S4	25		R10	M7	10k	
C9	R9	SEE TABLE		R11	P6	1·5M	
C10	L2	4		R12	N1	68k	
C11	Q11	4		R13	M1	57k	
C12	Q11	4		R14	R3	470k	
C13	T11	4		R15	R5	470k	
C14	V3	0·001		R16	T3	600	
C15	V5	0·001		R17	T5	600	
				R18	R9	SEE TABLE	
				R19	R1	100	
				R20	R7	100	
L1	R10			R21	G5	22K ± 20 %	ERIE 8
				R22	L9	330 ± 20 %	ERIE 8
				T1	F7	1:2	BBC AGG/ISA
R1	G7	50k		T2	W5		LEAK TL/12/T2/1B
R2	H7	100		T3	W13		LEAK TL/12/T3

AMPLIFIER LSM/8

57/JWG/001/DJE
EA 8874

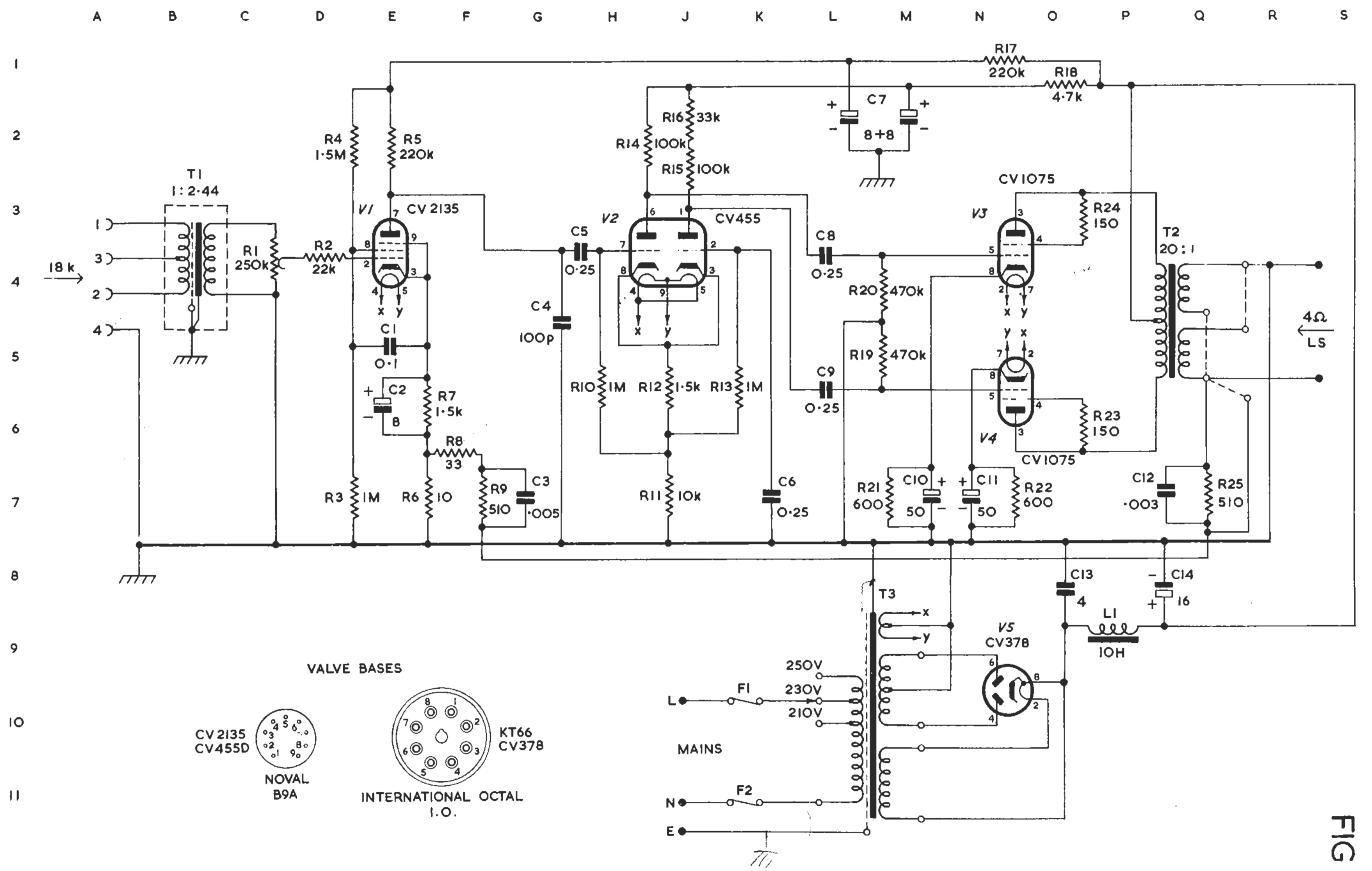


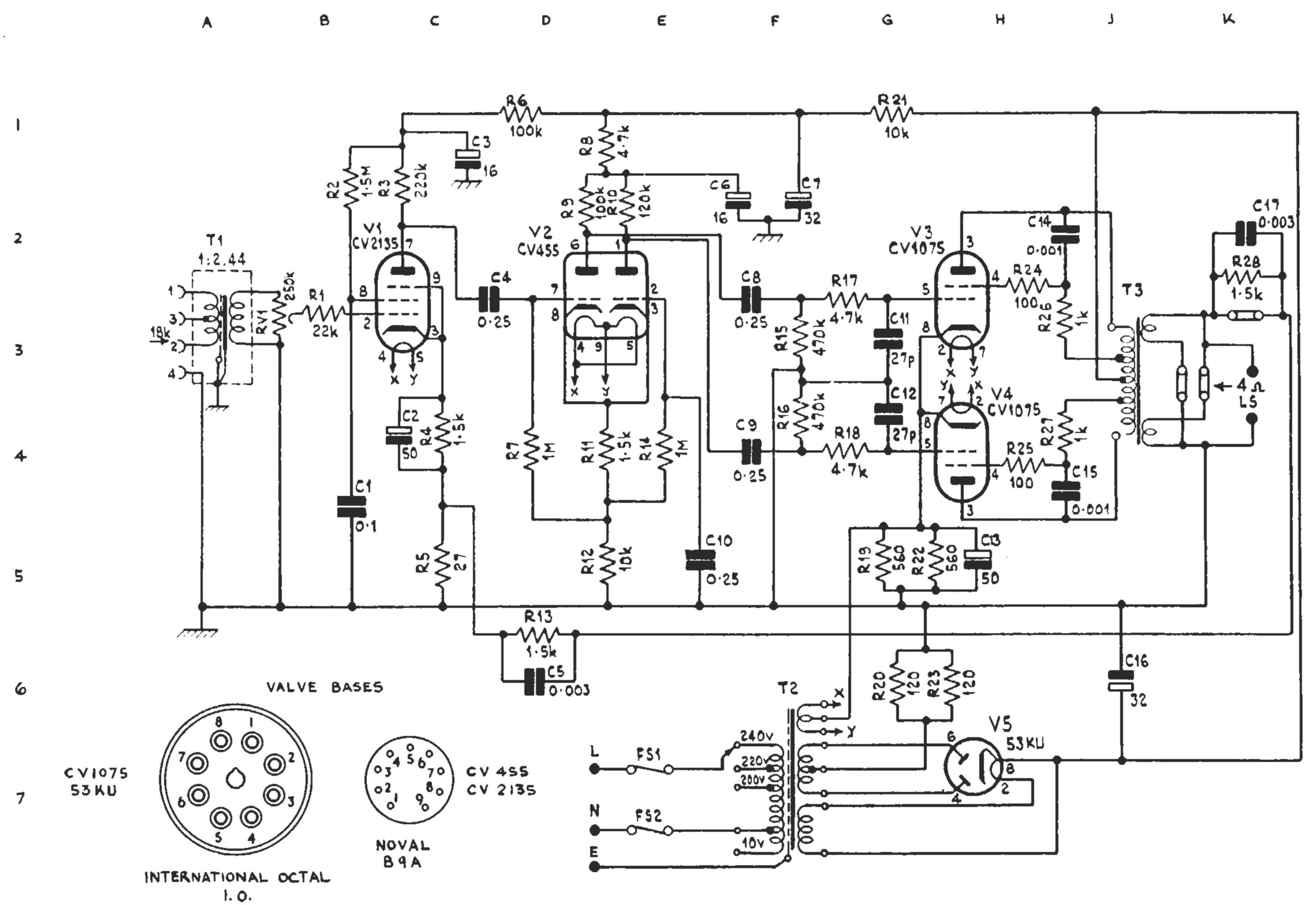
FIG 2

LOUDSPEAKER AMPLIFIER LSM/10 CIRCUIT

SERIAL Nos 101 TO 470

S8

61/GH/101
EA10873



LOUDSPEAKER AMPLIFIER LSM/10: CIRCUIT DIAGRAM

SERIAL Nos 471 ONWARDS

FIG 2A
ISSUE 2

S8