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OPERATION AND MAINTENANCE OF TWT AMPLIFIERS

(1 – 18 GHz Instrumentation Series)

THOMSON-CSF

DIVISION TUBES ELECTRONIQUES

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OPERATION AND MAINTENANCE OF TWT AMPLIFIERS (1–18 GHz Instrumentation Series)

1 - INTRODUCTION

1. 1 - General Description

The THOMSON-CSF Instrumentation Series of traveling-wave-tube amplifiers (TWTA's) covers the entire 1 to 18-GHz frequency range. The series consists of two free-standing or rack-mounted metal cabinets, each housing a power supply and associated monitoring and protection devices/circuitry, and five different plug-in RF-amplifier units. These different units are associated as shown in Table I.

These TWTA's are used for delicate measurements in the UHF and SHF bands, such as checking RF sources for modulation, stability or noise ; antenna-pattern measurements ; sweeping and so on. They can also be used as radar or telecommunications amplifiers. For measurement applications, they have the advantage of having been designed so that their own characteristics don't risk altering the results of the measurements being made. Making extensive use of solid-state circuitry and designed for simple operation, this lightweight and compact equipment also incorporates protection devices that make it nearly impossible to damage the TWT by operating mistakes. Because of the high standards of reliability to which these TWTA's have been designed and built, maintenance has been greatly reduced.

Amplifier cooling is by a ventilation system built into the power-supply/support units.

1. 2 - Technical Characteristics

Each of these Instrumentation Series TWTA's is composed of :

- one power-supply/support unit, model ALT 1410 or ALT 1411,
- one plug-in RF-amplifier unit.

Table I shows the association of units according to the frequency range in which the amplifier is to be used.

TABLE I - Instrumentation-Series TWTA's

Power-supply/support unit	Amplifier unit	Operating frequency (GHz)
ALT 1410	AMP 1413 AMP 1415	1 - 2 2 - 4
ALT 1411	AMP 1416 AMP 1417 AMP 1418	4 - 8 8 - 12. 4 12. 4 - 18

1. 2. 1 - ALT 1410 or ALT 1411 Power-supply/support unit

The power-supply/support units deliver all of the voltages and currents necessary to power the plug-in RF-amplifier units. Their technical characteristics are summarized by Table II. Each unit is delivered with a power cord and a technical manual. As an option, if so ordered the unit can be delivered in a configuration for mounting in a standard 19" rack.

TABLE II - Characteristics of the Power-Supply/Support Units

Electrical			
Line supply	127 or 220 V ± 10 %/50 or 60 Hz		
Power use (approx.)	150 VA		
Operating temperature	+ 10 to + 40 °C		
Protection	TWT : Helix overcurrent, heater supply, overheating, VSWR* Line voltage		
Meters	TWT : Helix current, collector current		
Gain control	By anode voltage adjustment		
* Frequency ⩽ 8 GHz			
Mechanical	**ALT 1410**	**ALT 1411**	
Weight, approx.	16	13	kg
Width	445	445	mm
Height	148	148	mm
Depth, without handles	420	320	mm

1.2.2 - AMP 141X Plug-in RF-amplifier units

The main operational and mechanical characteristics of the different amplifier units are compiled in Table III. Typical curves of their output power at saturation, and the guaranteed minimums, are given in Figure 1.

TABLE III - Characteristics of the Amplifier Units

Unit designation	Frequency range (GHz)	Full-setting output power, min. (1) (W)	Gain, min. (dB)	Gain variation in the band (2) (dB)	Noise figure, max. (dB)	FM noise (3) (dB)	VSWR, max. (4)	RF connector type	Dimensions (cm)	Weight (kg)
AMP 1413	1.1 - 1.3 1.3 - 2.0	4 7.5	28 33	16	26	< −70	3 : 1	N	10 x 12.2 x 41.3	2.6
AMP 1415	2.0 - 2.2 2.2 - 4.0	6.5 8.5	31 33	16	26	< −70	3 : 1	N	10 x 12.2 x 41.3	2.6
AMP 1416	4.0 - 8.0	6	33	16	29	< −70	3 : 1	N	10 x 12.2 x 32.8	2.2
AMP 1417	8.0 - 12.4	3.5	38	11	29	< −70	3 : 1	N	10 x 12.2 x 32.8	2.1
AMP 1418	12.4 - 18.0	1.5	38	11	29	< −70	3 : 1	N	10 x 12.2 x 32.8	2.1

Notes to the table :

1 - Into a 50-ohm load with a maximum VSWR of 1.2 : 1.

2 - This value corresponds to the adjustment of the drive level necessary to obtain a constant output power at saturation.

3 - The FM noise measured in a 4-kHz window is referred to an FM reference signal having a peak-to-peak deviation of ± 280 kHz.

4 - Input and output. In the range 1 to 8 GHz, a special device automatically causes the amplifier to shut down when the VSWR exceeds this value. Above 8 GHz, the user should install an amplifier-output protection (e.g., a wideband isolator or circulator) if the load is liable to present a VSWR of > 3 : 1 in any part of the band.

5 - Maximum drive power (Zin = 50 Ω) is 50 mW, in all cases.

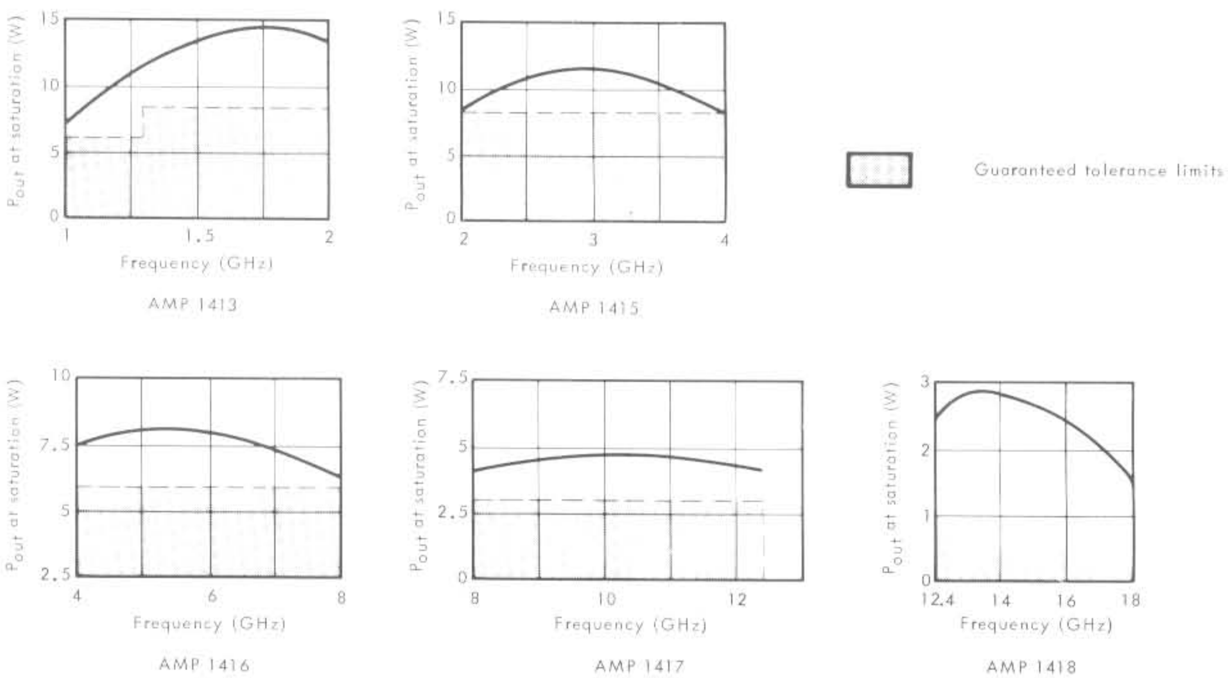


Figure 1 - Typical saturated output-power curves for the plug-in RF amplifier units, and the guaranteed minimum values.

2 - THEORY OF OPERATION

2. 1 - The Plug-in RF-Amplifier Units

These units are each composed of :

1 - a traveling-wave tube,
2 - the supporting electronics, including the gain control.

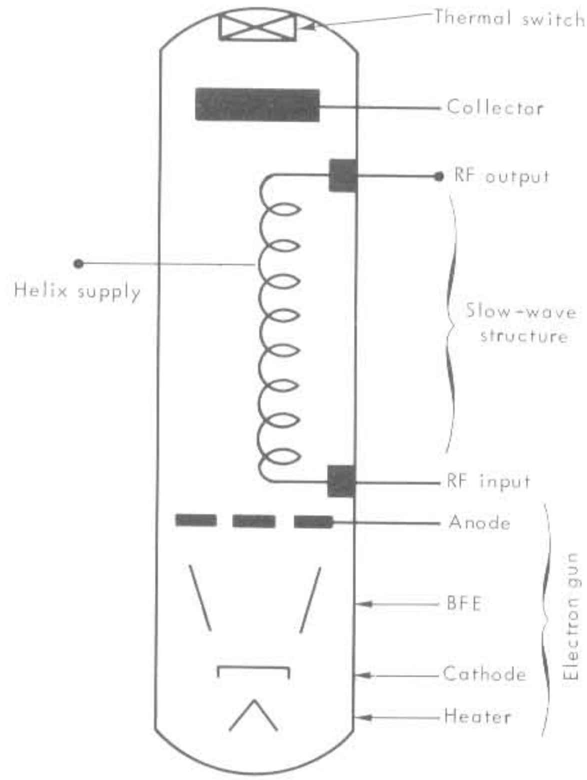


Figure 2 - Schematic diagram of a traveling-wave tube.

2. 1. 1 - The traveling-wave tube (Figure 2)

Traveling-wave tubes (TWT's) are designed to amplify microwave or RF signals. They are operated at frequencies whose wavelengths correspond, in order of magnitude, to the tube's linear dimensions. Amplification in TWT's is based on modulation of the velocity of a narrow and dense beam of electrons. That beam is formed in an "electron gun", consisting of an indirectly heated cathode, which emits the electrons, a beam-forming electrode (BFE) and an accelerating electrode : the anode.

As the beam travels through the tube it is kept tightly focused by a strong magnetic field, generated by permanent magnets. This narrow beam in fact passes along the long axis of a helix of conducting wire, to which an RF signal is applied, at the RF input. The signal propagates along the wire at the speed of light, inducing a current in the wire and causing an axial electric field to be formed. Because of the helical form of the wire, though, the electric field progresses through the TWT at a velocity much less than that of the RF electromagnetic wave. It is for this reason that the helix is known as the tube's "slow-wave structure".

The final main element of the tube is the collector, which catches the beam electrons after they leave the slow-wave structure and dissipates their remaining energy in the form of heat.

2. 1. 2 - Detailed theory of operation

The phase velocity of the RF wave, or the speed at which the microwave energy moves from the tube's input to the output, is made (by adjusting the helix pitch) synchronous with the velocity of the electron beam. Consequently, there is an inevitable interaction between the associated axial electric field and the beam electrons. Some electrons are retarded by the field, while others are accelerated, the number being decelerated being larger than the number accelerated.

Necessarily, the beam electrons tend to form bunches (faster electrons overtaking slower ones), which in turn interact even more strongly with the RF wave. Because on the average more electrons are slowed down than speeded up, the beam gradually surrenders energy to the electromagnetic wave, which grows in amplitude. This energy transfer continues all through the slow-wave structure, so that the RF signal is greatly amplified by the time it reaches the output end of the helix. Because there is also a wave propagating in the opposite direction in the TWT (the "backward wave"), which risks causing oscillation, attenuating sections are formed on the helix. Matching devices couple the helix to the input and output 50-ohm coaxial connectors.

To limit the amount of waste heat generated in the collector, it is operated at a potential somewhat lower than that of the helix. This is called "collector depression". One of the consequences is the absence of regulation of the collector voltage. (As a protective measure, the collector is equipped with a thermal circuit breaker adjusted to approximately 120 °C).

As illustrated by Figure 3, when the power at the tube input is progressively increased, the output power increases exponentially, so that the gain remains relatively constant. This value of gain (the horizontal line in Figure 3) is known as the "small-signal gain". Beyond a certain value of input power, however, the output power goes through a maximum and then falls off. The gain at the maximum value of output power is known as the "saturation gain".

The value of the helix potential is chosen as a compromise between the desired output power, the gain, and the bandwidth. This value is determined at fabrication for each tube and fixed by a resistive bridge, according to the reference high-voltage supply.

Figure 4 shows the polarities of the TWT power supplies used. The exact values of the voltages applied to the tube depend upon the TWT itself.

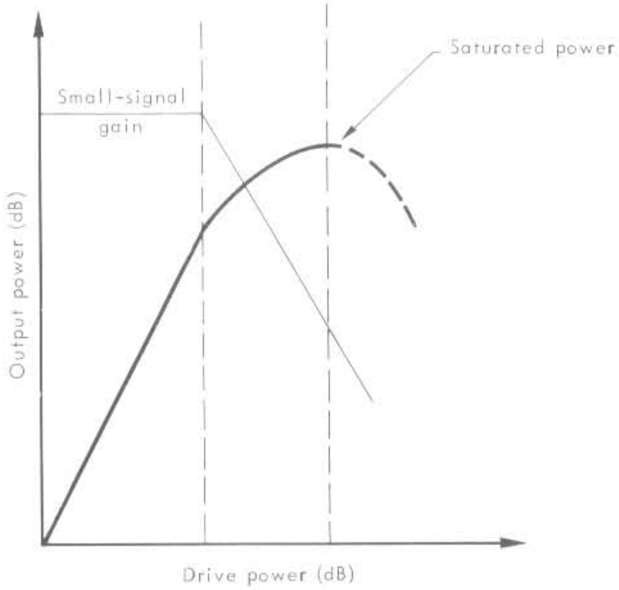


Figure 3 - Typical RF transfer characteristics of a TWT.

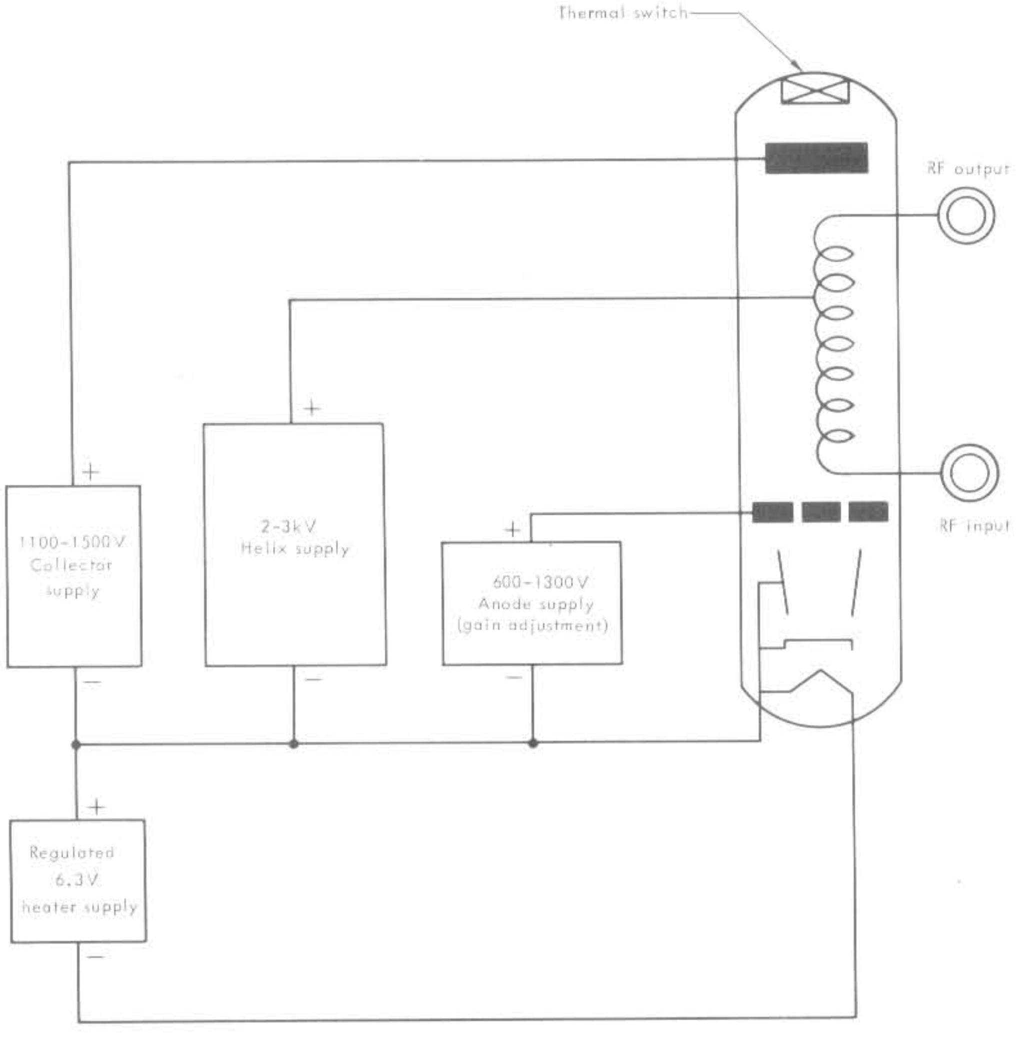


Figure 4 - Polarities of the TWT power supplies.

All of the amplifier units operating at up to 8 GHz are equipped with a detector-coupler mounted in series with the RF output. This protection device cuts off high voltage to the TWT whenever the VSWR of the load is unacceptably high (> 3 : 1). Above 8 GHz, the power delivered by the amplifier is sufficiently small so that this device is not strictly necessary for protection of the tube. Its performances, however, can be seriously degraded by an excessive load VSWR, so that the precautions indicated earlier (page 2) should be taken.

2. 2 - The Power-Supply/Support Units

The two power-supply/support units are assemblies of different conventional basic power supplies and multiple protection systems. The theory of operation of such transistorized/integrated-circuit power supplies is already well known. Figure 5 shows the block diagram for the ALT 1410 and ALT 1411.

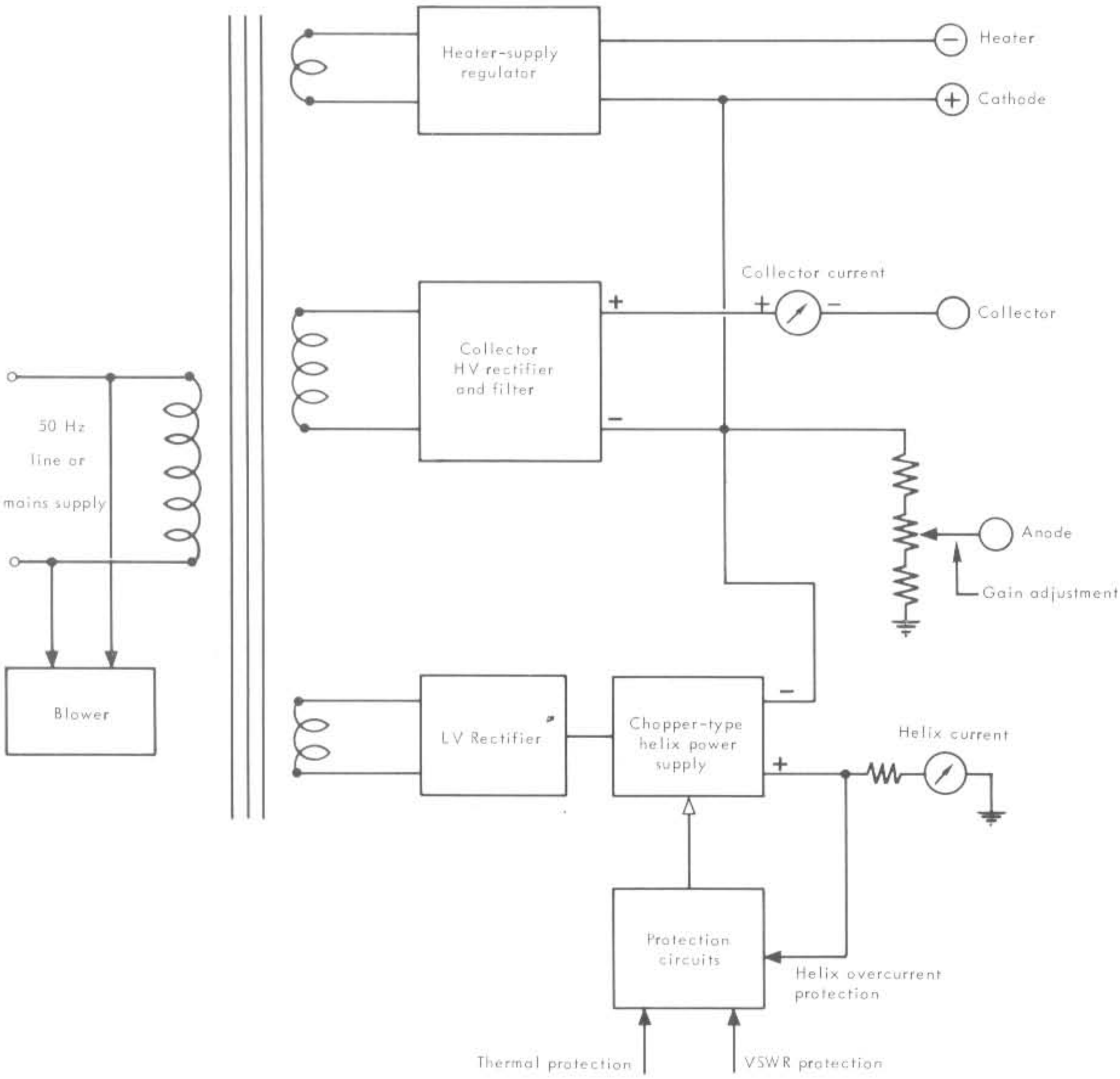


Figure 5 - Functional block diagram of an ALT 1410 or ALT 1411 power-supply/support unit.

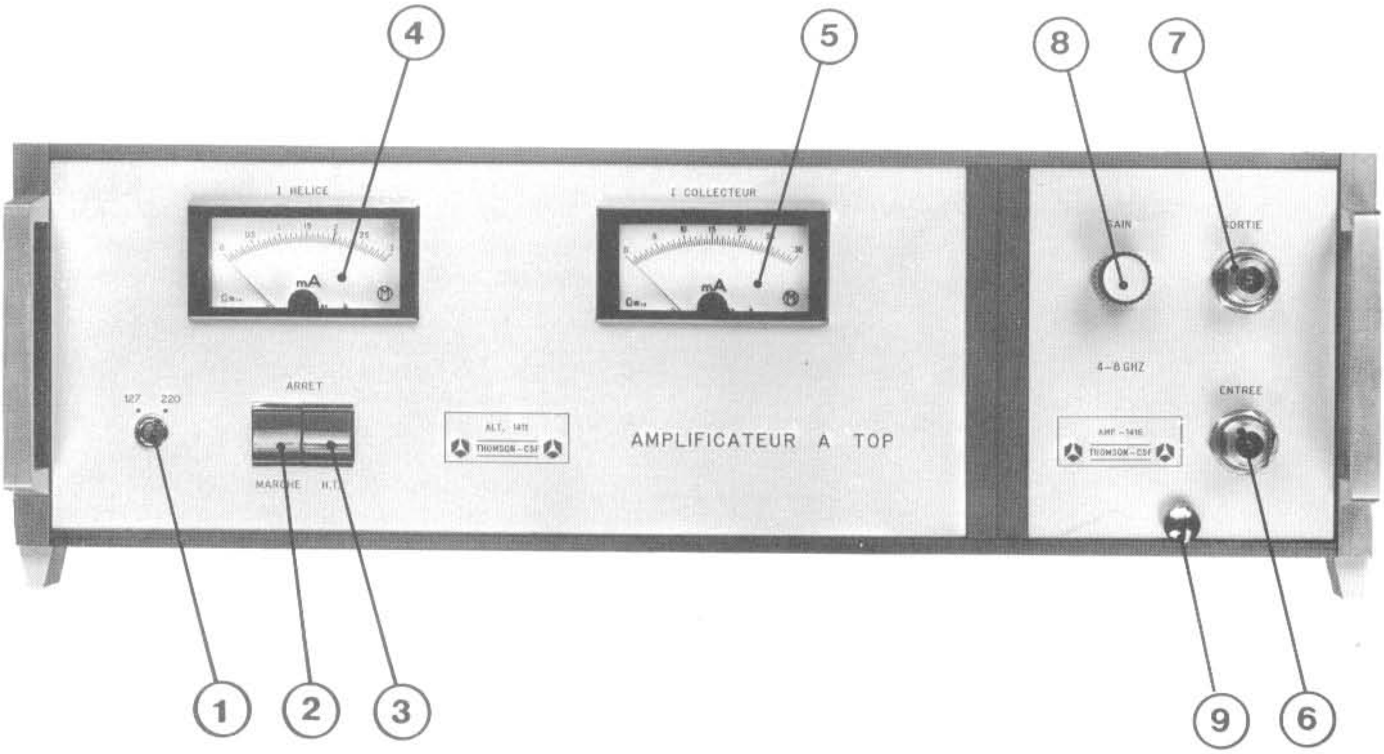
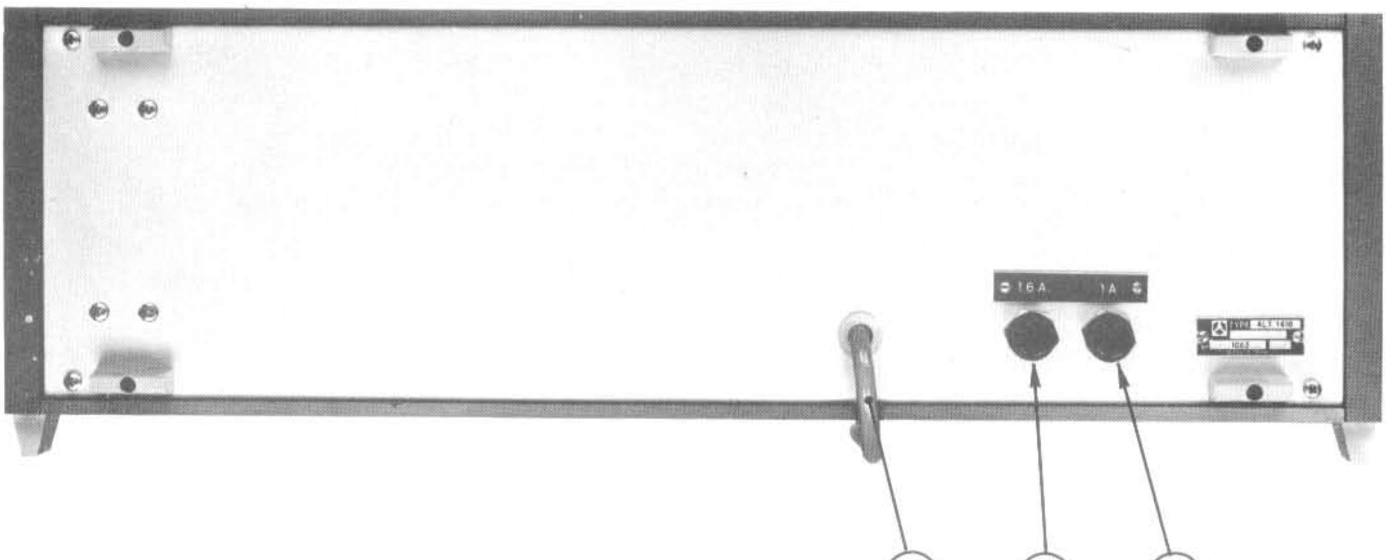


Figure 6 - Front view of a TWTA.

Figure 7 - Rear view of a TWTA.



3 - HOW TO USE THE TWTA

3. 1 - Location of the Different External Features

Figures 6 and 7 show the front and rear views of a TWTA (all are identical in appearance except for their numbering : ALT 1410 or ALT 1411, AMP 1413, AMP 1415, etc.). The different numbered features are identified below :

① Line-voltage selector.
② Line (mains) power switch, with built-in indicator lamp.
③ HV switch, with built-in indicator lamp.
④ Helix-current panel meter.
⑤ Collector-current panel meter.
⑥ RF-input coaxial connector.
⑦ RF-output coaxial connector.
⑧ Gain-control knob.
⑨ Screw for locking the amplifier unit in place.
⑩ Power cord.
⑪ 1. 6 A Fuse, for a 127V line (mains) supply.
⑫ 1 A Fuse, for a 220V line (mains) supply.

3. 2 - Function and Use of the Indicators and Controls

3. 2. 1 - Helix-current panel meter ④

This meter is used not only to check the helix current at tube startup, but also to continuously monitor that current, in milliamperes.

The green mark (at 2 mA for the ALT 1411, at 4 mA for the ALT 1410) indicates the circuit - breaking threshold, beyond which there is a risk of TWT destruction.

3. 2. 2 - Collector-current panel meter ⑤

This meter continuously displays the collector-current reading. The nominal collector current is given in each amplifier's acceptance-test report.

3. 2. 3 - Line-voltage Selector ①

Always set for a 220-volt line (mains) supply at delivery, the selector must be switched to the "127" position, using a screwdriver, if the supply on the user's premises is closer to 127 volts ac.

3. 2. 4 - Line (mains) power switch ② (green)

This is the equipment ON-OFF switch. The built-in lamp lights to indicate that the TWTA is "ON".

3. 2. 5 - HV Switch ③ (red)

This is the switch used to apply high voltage to the TWT, once the required warm-up period (three minutes) has elapsed.

3. 2. 6 - Gain-control knob ⑧

This knob is used to adjust the high voltage applied to the accelerating anode, thus raising or lowering the amplifier's gain and output-power level.

3. 3 - Operating the TWTA

NOTE : When the equipment is delivered, the line-voltage selector is set for 220 volts. **If the line (mains) voltage in the user's installation is closer to 127 volts (the other selector position), be sure to change the selector position before plugging the amplifier in.**

If the local voltage supply is more than 10 % different from one of the two nominal values (such as a 100 volt supply), an adjustable autotransformer should be used to bring the voltage applied to the TWTA to an acceptable value.

The position of the line-voltage selector is changed by means of a screwdriver having the correct blade-tip size.

1) Plug the RF-amplifier unit corresponding to the frequency range including the working frequency (see Table I) into the right side of the TWTA case. Note that the power-supply/support unit cannot be turned on until the amplifier unit is fully plugged in and locked in place with the locking screw.

2) Turn the amplifier gain-control knob all the way counterclockwise (CCW).

3) Connect the load to the amplifier's RF output (maximum load VSWR 3 : 1).

> **VERY IMPORTANT**
>
> **The RF output may be connected to the load via attenuators, couplers, ferrite isolators, ferrite circulators, etc. In all cases, and particularly for the ferrite components connected to the TWTA output, it is strongly recommended that these passive devices have a passband equal to or greater than the operating band of the amplifier plug-in. If, however, it is necessary to use a component having a smaller passband, a wideband attenuator must be placed between the RF output and that component (see the Annex).**

4) Connect the RF source (set for a zero or low output level) to the TWTA's RF input. If deemed appropriate, place an attenuator of the desired characteristics in series, to improve the impedance matching.

3. 3. 1 - Applying voltage - preheating

1) Ensure that operations 1) to 4), above, have been carried out.

2) Flip down the green line-power switch. The incorporated green indicator lamp should light and the panel meters should also be lit.

3) The normal warm-up time is three minutes, but if the TWTA has been unused for two or three months (or longer), allow it to warm up for about 30 minutes.

> **VERY IMPORTANT**
>
> **These TWTA's must be kept away from any magnetic materials. For example, if used on top of a swept BWO frequency generator, the TWTA HV may trip out, due to beam defocusing caused by the BWO's magnetic leaks. In such a case, a soft iron plate may be placed between the two equipment items, to act as a shield for the TWTA.**

3. 3. 2 - Putting into use

1) After waiting the appropriate warm-up time, flip down the red HV button. The incorporated indicator lamp should light, indicating that the TWTA is in normal operating condition.

2) Adjust the collector current to the maximum value, given on the acceptance-test report delivered with each amplifier. For that, turn the gain-control knob clockwise (CW).

3) With a zero RF-drive level, verify that the helix current corresponds to the value indicated on the acceptance-test report. In general, it must remain under 1 mA.

4) Slowly increase the RF-drive level. In most cases 1 mW of power at the RF input is sufficient to saturate the TWT (see the report).

> **IMPORTANT :**
>
> **The TWT amplifier must be correctly operated. This implies not overdriving the enclosed traveling-wave tube. If the drive power is raised beyond that necessary to saturate the tube, the helix current increases and the gain falls off.**

The amplifier's gain and output-power level can be lowered by turning the gain control knob CCW. This also decreases the collector current.

When the amplifier is not being used to amplify a signal, flip the red HV switch to "OFF". The TWTA then remains in hot standby and is rapidly ready for use after again flipping down the HV button.

The red HV switch is also used to return the TWTA to operation after a trip-out caused by excessive helix current in the TWT. This is normally caused by driving the tube beyond saturation, which not only decreases the output power but also causes the helix current to increase until it eventually reaches the green mark on the panel meter, i.e., the protection-activation value. Therefore, before using the red switch to reset the amplifier, reduce the RF drive level or check whether the load VSWR is not too high (it must be $\leqslant 3 : 1$).

To reset the amplifier, flip the red switch to "OFF", then back to "HV".

The indications of drive power, output power and gain given in the acceptance-test report will guide the user and help to avoid the use of trial-and-error procedures when putting the TWTA into use.

When the amplifier is to be used at a variable frequency, in a more or less wide band or in swept operation, it may be advantageous to operate it near saturation. This is because near saturation the change in the output-power level as a function of the frequency is much smaller than at low power levels. Normally a drive power of less than 10 mW suffices to bring the TWT near saturation. In any case, the maximum drive power allowed, without risking tube destruction, is 50 mW.

3. 3. 3 - Use as a modulated RF amplifier

The technology of the TWT employed in these amplifiers does not allow direct action on the tube to modulate the signal being amplified. This TWT can, however, amplify RF signals incorporating complex modulation, even of a pulsed nature, because its very large instantaneous bandwidth enables brief signals to be correctly transmitted.

By employing a PIN-diode modulator in front of the amplifier, amplitude modulation of from 0 to 100 % can be effected.

NOTE - See the Annex for Special Operating Remarks relating to the importance of mismatch effects in transmission lines and passive components used with the TWTA.

4 - CHECKOUT, TROUBLESHOOTING AND REPAIR

4. 1 - Information and Recommendations

NOTE : In this section, only minor repairs are considered. Only a technician thoroughly familiar with TWT's can carry out a major repair of the amplifier. If the TWTA does not operate correctly, it is always better to return it to our factory for repair or overhaul. However, a quick check inside the amplifier may allow locating the defective part that has caused the equipment to malfunction.

CAUTION

Because very high voltages are present within the amplifier, it is important to take all the usual safety protections. In particular, before touching any part of the amplifier's interior, make sure that the capacitors have been discharged.

At the end of this section, the user will find interior views of the power-supply/support units and photographs of their removable printed-circuit boards, upon which the main parts are marked. In addition, the electrical schematics and the list of spare parts are available as annexes.

Access to the interior of the equipment is extremely easy, the top and bottom of the case each being fastened down merely by four Phillips-head screws.

When abnormal operation of the equipment is noted, it is indispensable to dissociate the TWTA itself from the external circuitry. Only careful observation of the phenomenon and good comprehension of how the TWTA works can prevent hunting around blindly in trying to repair it.

In checking out the various parts, the usual precautions for using semiconductors must be strictly applied, in particular for soldering them. Any carelessness or accidental internal short circuit can cause immediate destruction of one or several semiconductors, or severe damage to them.

4. 2 - Necessary Test Equipment

To check out or troubleshoot these amplifiers, the following items of test equipment are essential :

1) a triggered-sweep oscilloscope,
2) a digital voltmeter,
3) a wattmeter or calorimeter, whose measurement range corresponds to the amplifier plug-in in use,
4) RF generators corresponding to the TWTA band,
5) a wideband spectral analyzer,
6) a coaxial load having a VSWR of less than 1. 2 : 1,
7) medium-power attenuator or couplers (for the frequency band in use),
8) a coaxial detector.

4. 3 - Electrical Characteristics of the TWT Power Supplies

Characteristics	Power-supply/support unit ALT 1410	ALT 1411	
Filament supply voltage	6. 3	6. 3	V
Maximum current drawn	0. 6	0. 6	A
Insulation with respect to ground	2	3	kV
Regulation	10^{-2}	10^{-2}	
Collector supply voltage, non-regulated	1100	1500	V
Collector current drawn	70	30	mA
Helix supply voltage, max.	2	3	kV
Adjustment range	1 to 2	2. 4 to 3	kV
Maximum helix current drawn	5	5	mA
Regulation	5×10^{-4}	5×10^{-4}	
Anode supply voltage (obtained from voltage divider) adjustable from	800 to 1300	650 to 950	V
Protections			
HV Time delay	180	180	s
Collector temperature	120	120	°C
Helix overcurrent	4	2	mA
RF Output mismatch	Max. VSWR 3 : 1	Max. VSWR 3 : 1	
Trip-out due to VSWR > 3 : 1	By coupler	By coupler only for AMP 1416 plug-in unit	

4. 4 - Troubleshooting Procedures

4. 4. 1 - If the HV lamp does not light :

1) Check transistor Q18 (see Figure 10).
2) Check the time delay, transistor Q22 (see Figure 10).
3) Turn the TWTA off and remove the 25-kHz square-wave generator board. Turn the TWTA back on. If the HV lamp lights, check transistors Q12 and Q13 (see Figure 11).
4) Change IC's Q20 and Q21 (Figure 10).

4. 4. 2 - If the HV lamp lights as soon as the TWTA is turned on :

1) The low-voltage helix regulation is malfunctioning. Check transistors Q14, Q15, Q16 and Q17 (see Figures 8, 9 and 10).
2) If all of the transistors are o.k., check diode D13 and integrated circuit Q21 (see Figure 10).

4. 4. 3 - If the needle of the collector-current meter does not deflect, although the HV lamp is lit :

1) 6. 3 V Filament-supply board (see Figure 12).

DANGER : This board is at a potential of 3000 volts with respect to ground.

a) If the filament voltage is approximately equal to 2 volts, check transistors Q4 and Q5.
b) If the fuse is blown, check Q1, Q2 and Q3.
c) If the board still doesn't work, check whether thyristor Q6 is non-conducting.

2) Collector-voltage supply

Verify that the shunts fastened to the back of the collector-current meter are in good condition :
R12 = 5. 6 Ω and R13 = 18 Ω.

4. 5 - Main Test Points (marked on the electrical schematic)

(1) Rectified voltage .... 12 V → **DANGER** : Voltage actually 2 to 3 kV above ground potential.

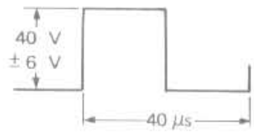
(2) Filament voltage .... 6. 3 V

(3) Non-regulated collector voltage : 1100 or 1500 V (± 10 %) → **DANGER** : The negative wire is actually 2 to 3 kV above ground potential.

(4) Rectified low voltage, approx. .... 36 V

(5) Dc voltage . . . . 15 V — Adjustable by means of potentiometer R25 on the square-wave generator board, to fine-tune the oscillation frequency of the 25-kHz square-wave generator.

(6)



(7) Regulated voltage . . . . 17 to 23 V — Adjustable by means of potentiometer R113 located on the plug-in amplifier unit. Controls the helix voltage.

(8) Helix high voltage. According to TWT, either . . . . 1 to 2 kV or 2. 4 to 3 kV, approximately

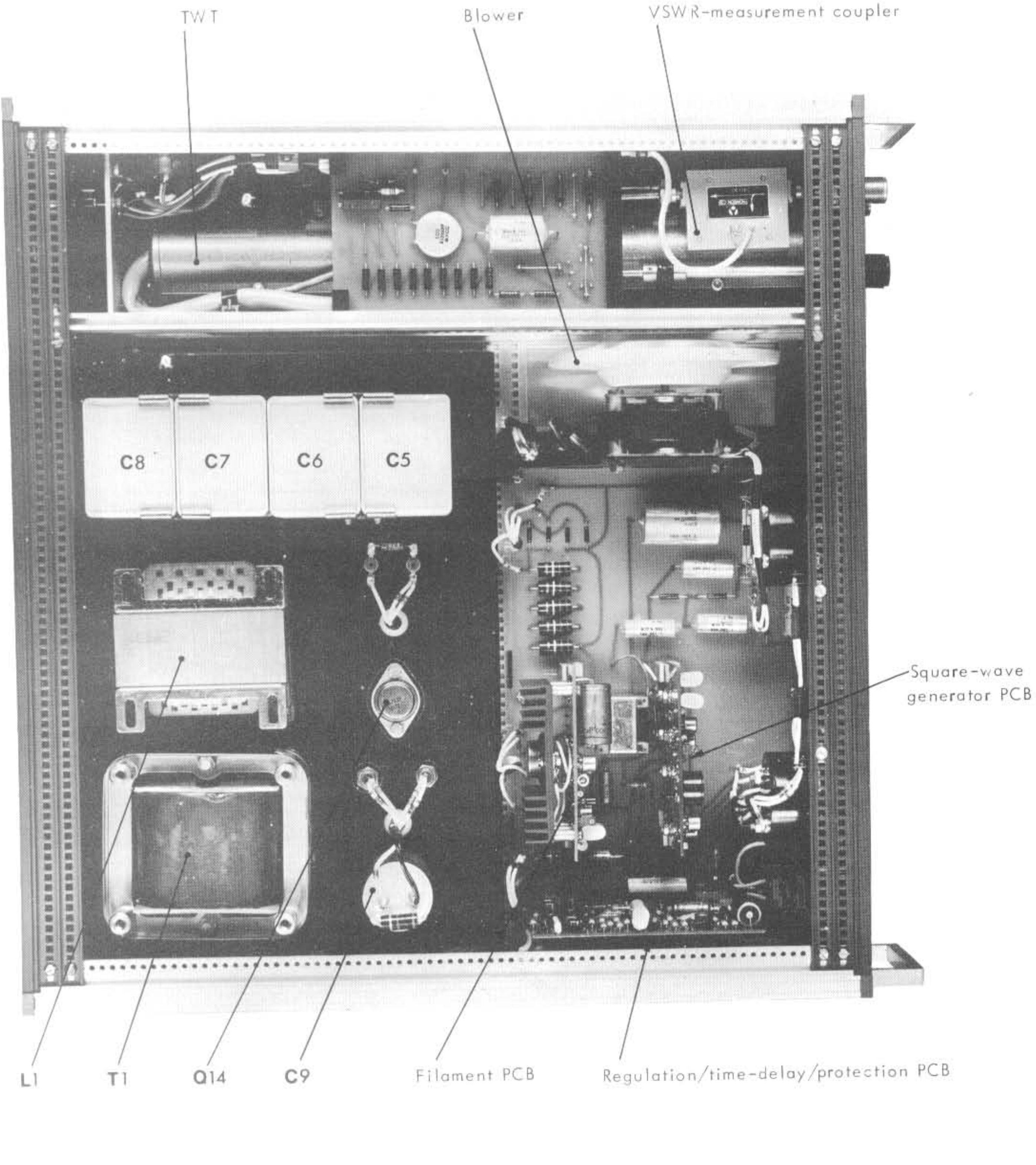


Figure 8 - Top view of the interior of an ALT 1410 power-supply/support unit.

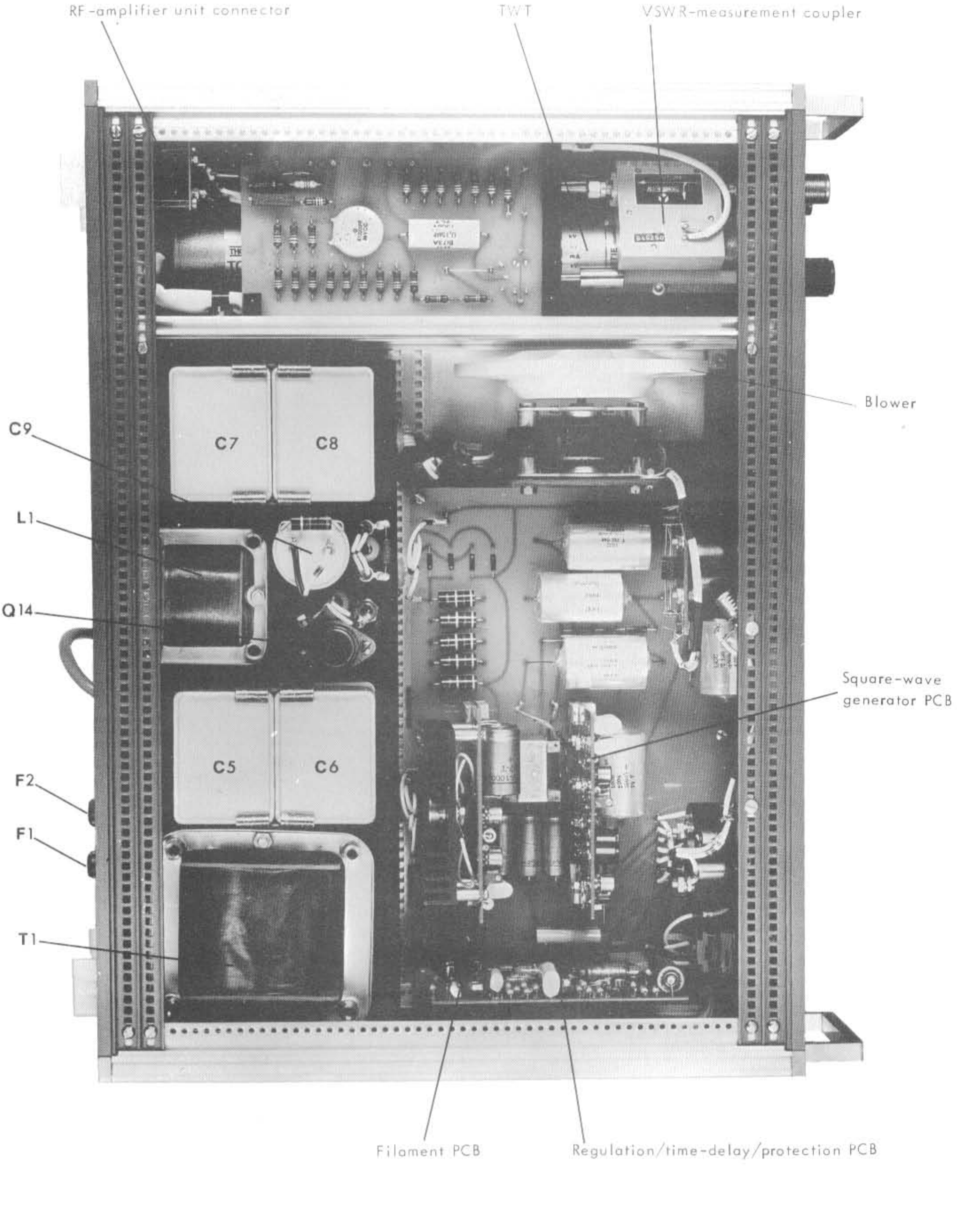


Figure 9 - Top view of the interior of an ALT 1411 power-supply/support unit.

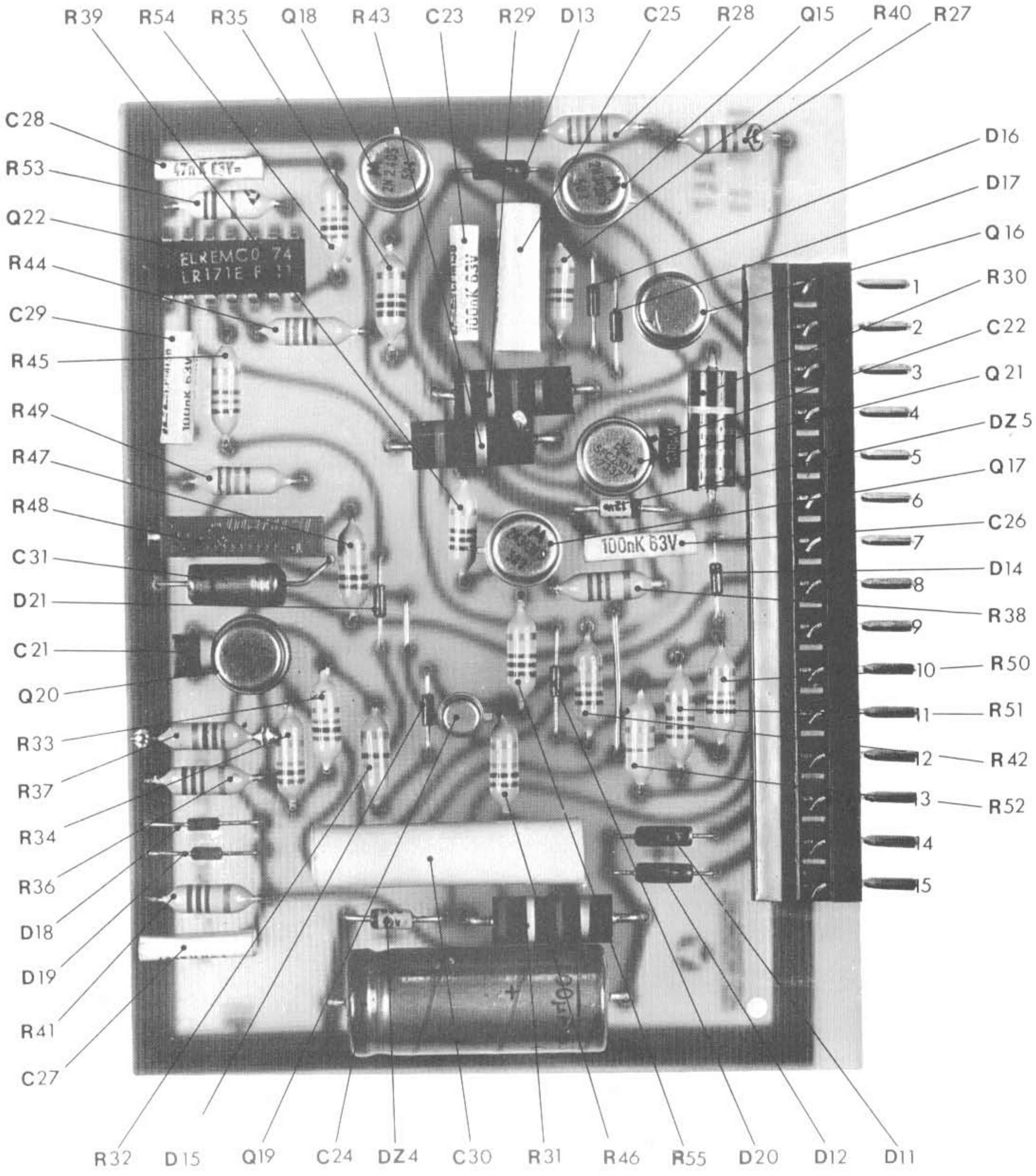


Figure 10 - Regulation/time-delay/protection printed-circuit board.

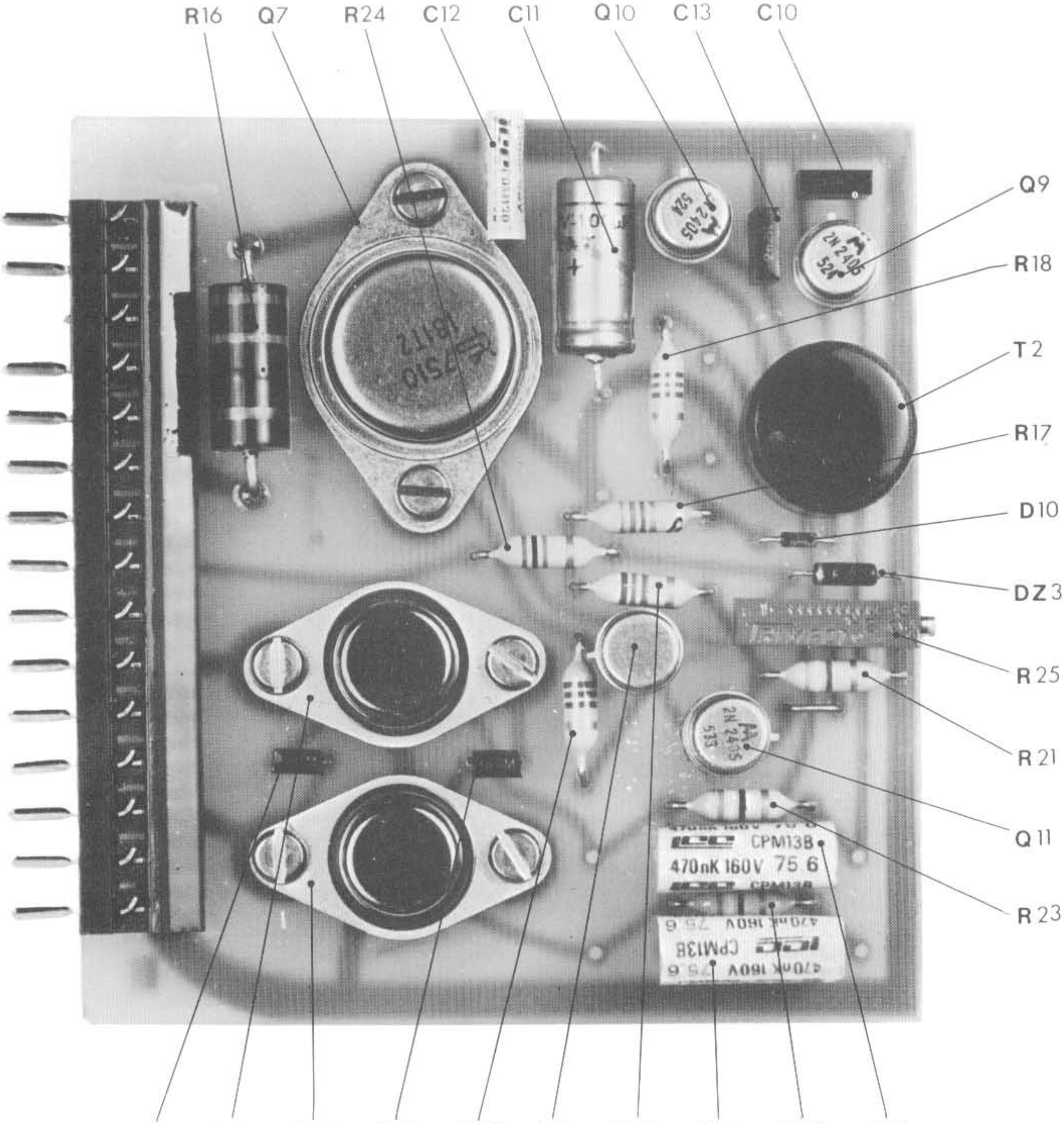


Figure 11 - Square-wave generator printed-circuit board

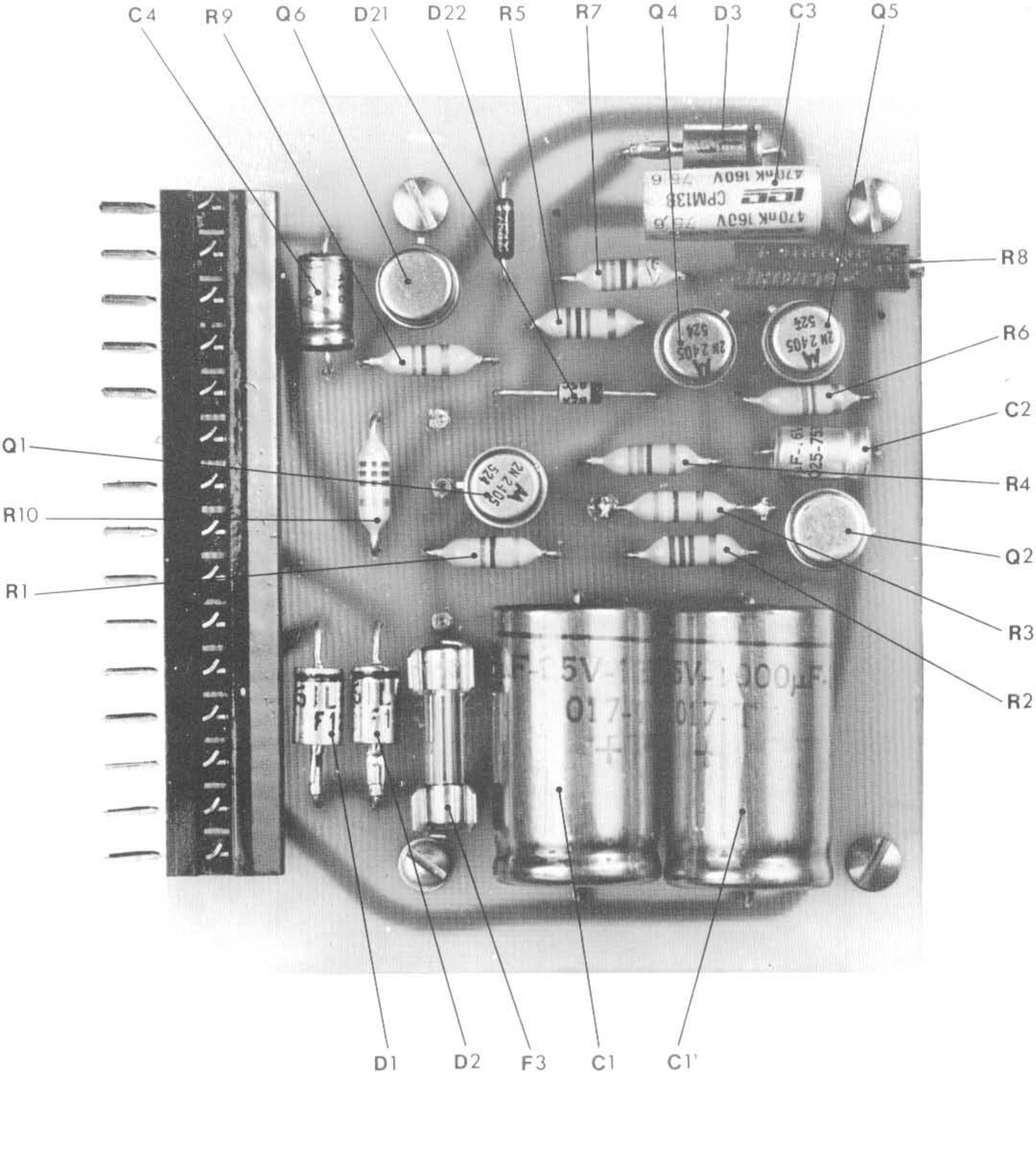


Figure 12 - Filament printed-circuit board.

ANNEX
SPECIAL OPERATING REMARKS

To obtain the optimum amplifier performance and efficiency, it is necessary to take certain precautions. The calibration errors introduced by the test equipment used must be taken into account. This equipment (attenuators, couplers, isolators, crystal or thermistor-detection systems) often introduces non-negligible errors which also vary as a function of the working frequency.

Example : Power loss introduced by the interconnecting coaxial cables :

Nominal output power (W)	Cable attenuation (dB)	Real output power (W)	Power loss (%)
10	0.5	8.913	11
10	1.0	7.943	21
10	1.5	7.079	30
10	2.0	6.310	37

Figure A1 is a diagram of the effects of a buffer attenuator placed between the amplifier and the load to improve the matching. For example, with a load VSWR of 6 : 1, the insertion of a 6-dB attenuator lowers the VSWR at the TWTA output to 1.43 : 1.

As illustrated by Figure A2, however, account must also be taken of the supplementary transmission losses caused by the mismatch of the attenuator inserted. These losses may be due to the attenuator's input connector, the attenuator itself, or its output connector, and are given in Figure A2 as a percentage of the power into the attenuator as a function of the input VSWR.

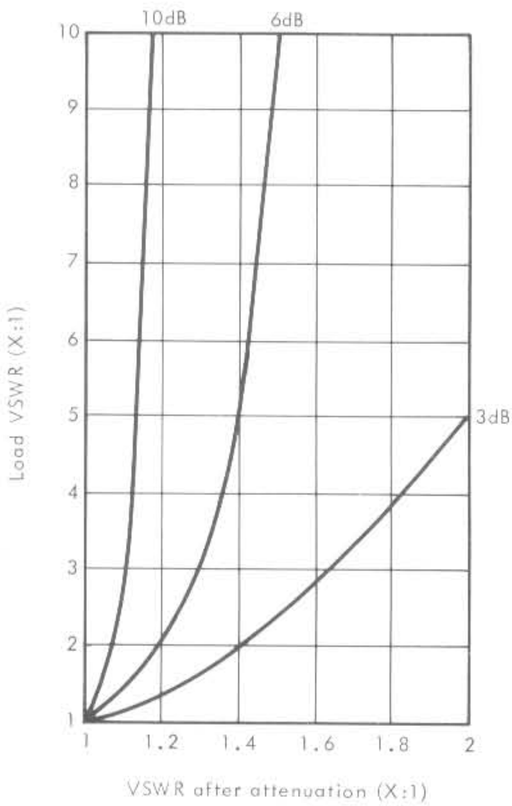


Figure A1 - Effects of a buffer attenuator between the TWTA and the load.

Figure A3 represents the lower right-hand corner of Figure A2, on a much smaller scale. In this figure, the transmission losses are expressed in decibels instead of as a percentage of the power transmitted to the load.

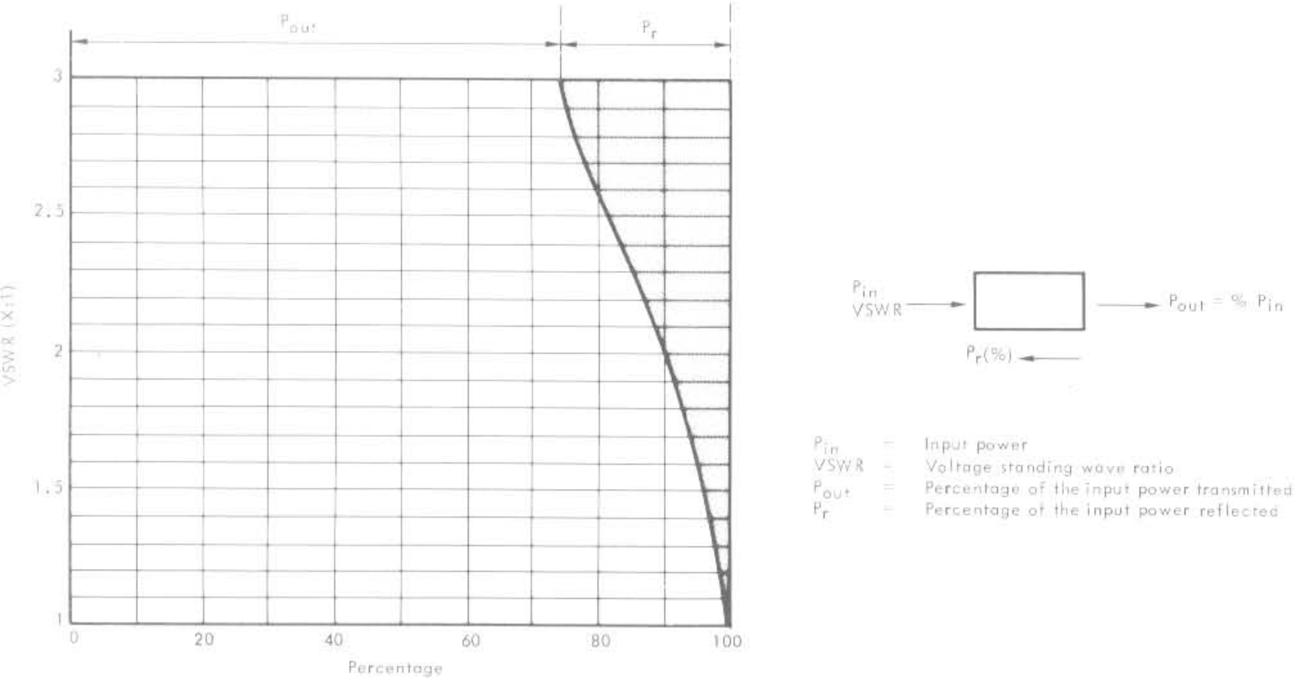


Figure A2 - Percentage of power transmitted and reflected as a function of the mismatch-caused VSWR.

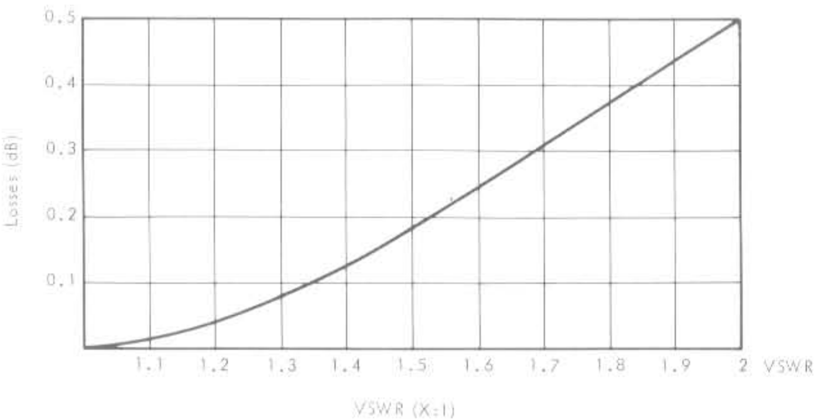


Figure A3 - Detail of Figure A2.

In point of fact, of course, Figures A2 and A3 are applicable not only for the case of an attenuator inserted between the TWTA and the load to improve the matching, but for all the circuitry comprised between the amplifier and the load, even if it consists merely of two RF connectors and a length of transmission line. There is always a certain mismatch present.

PARTS LIST

Symbol	Description	Ref. No./Part No.	French supplier
C1 and C1′	FITCO 1000 μF/25 V Electrochemical capacitors	2222 - 017 - 16102	COGECO
C2	FITCO 15 μF/16 V Electrochemical capacitor	C025	COGECO
C3	0. 47 μF ± 10 %/160 V Metalized Mylar capacitor	IPF 218	LCC
C4	FITCO 4. 7 μF/63 V Electrochemical capacitor	2222 - 015 - 90003	COGECO
C5, C6, C7 and C8	0. 47 μF/2500 V High-voltage capacitors	Type NOR-CF1	SIC-SAFCO
C9	4700 μF/40-48 V Electrochemical capacitor	Type ETF-L	EUROFARAD
C10	2. 2 nF ± 10 %/200 V Ceramic capacitor	DJZ 908-5	LCC
C11	FITCO 100 μF/25 V Electrochemical capacitor	2222 - 016 - 16101	COGECO
C12	0. 1 μF ± 10 %/63 V Metalized Mylar capacitor	IPD 213	LCC
C13	Identical to C10		
C14 - C15	Identical to C3		
C16 - C17	1 nF ± 20 %/200 V Ceramic capacitors	DJZ 905-5	LCC
C18	FITCO 100 μF/63 V Electrochemical capacitor	2222 - 017 - 18101	COGECO
C19 - C20	Eliminated		
C21	10 pF ± 10 %/250 V Tubular ceramic capacitor	CRC 406-10 UK	LCC
C22	100 pF ± 10 %/200 V Ceramic capacitor	DJZ 905-5	LCC
C23	Identical to C12		
C24	Identical to C18		
C25	Eliminated		
C26	Identical to C12		

Symbol	Description	Ref. No./Part No.	French supplier
C27	10 nF ± 10 %/250 V Metalized Mylar capacitor	IPG 213	LCC
C28	47 nF ± 10 %/63 V Metalized Mylar capacitor	IPD 213	LCC
C29	Identical to C12		
C30	1 μF ± 10 %/160 V Metalized Mylar capacitor	IPF 231	LCC
C31	FITCO 22 μF/25 V Electrochemical capacitor	2222 - 015 - 16229	COGECO
C32 to C35	10 nF ± 20 %/2500 V High-voltage capacitors	Type T150/032	LCC
C36	0. 1 μF ± 20 %/3500 V High-voltage capacitor	Type T150/048	LCC
C37	Identical to C30		
C38 - C39	10 nF ± 10 %/400 V Capacitors	C296 TC/A	COGECO
C40	SICAP M 0. 1 μF ± 10 %/630 V Capacitor	Type CF15	SIC-SAFCO
C101	1 nF/3000 V High-voltage capacitor	QCX611	LCC
C102	47 nF ± 20 %/3500 V High voltage capacitor	Type T150/048	LCC
C103	0. 15 μF/1000 V High-voltage capacitor	Type BI73A	EUROFARAD
D1 and D2	Diodes	Type F12	SILEC
D3	General Semiconductor Industries "TRANSZORB" protection diode	1. 5KE8. 2	R.E.A.
D4 to D7	SEMTECH High-voltage diodes	M30	OHMIC
D8 and D9	Diodes	1N1342B	SILEC
D10	Diode	1N4148	SESCOSEM
D11 to D13	Diodes	MC42	SILEC
D14 to D21	Diodes	1N4148	SESCOSEM
D22 to D25	SEMTECH High-voltage diodes	SFM30	OHMIC
DZ1	Zener diode	BZX85C4V7	SESCOSEM
DZ2	Zener diode	1N754A	SILEC
DZ3	Zener diode	BZX55C6V2	SESCOSEM
DZ4 and DZ5	Zener diodes	BZX85C12	SESCOSEM
DZ6	Zener diode	BZX85C18	SESCOSEM
DZ101	Zener diode	1N823	SESCOSEM

Symbol	Description	Ref. No./Part No.	French supplier
F1	CEHESS Fuse holder, equipped with 1A slow-blow fuse	D1 SH No. 23316 D1TD-1	CEHESS
F2	Identical to F1, equipped with 1. 6A slow-blow fuse	D1TD-1. 6	CEHESS
F3	Fuse holder consisting of two type OG 781-01 clips for 5 x 20 fuse, equipped with a fast 1. 25A fuse	D1/1. 25	
I1	Dial lamp, consisting of a socket plus support, Equipped with a 24V/0. 13 A miniature bulb	MFV101	MFOM MAZDA
I2	Identical to I1		
I3	Green indicator lamp, incorporated in S1		COMEPA
I4	Red indicator lamp, incorporated in S3		COMEPA
J1	Female connector	A20F71PO	SOGIE
J2	Male connector	A20M71PO	SOGIE
L1	40 H/30 mA Filtering inductor	SC2Q117E	Mondial Electronique
L101	TRANSCO RF Decoupling inductor	VK200 10/3B	COPRIM
LF1	Schaffner line filter	RN52-1.5/1	R.E.A.
M1	DC milliammeter : plexiglass dial, knife needle, protected by diodes with series and shunt resistors (see R12 and R13) Maximum deflection 30 mA	69M	OMNI-MESURES
M2	DC milliammeter : plexiglass dial, knife needle, max. deflection 3 mA Dial numbers in black (0, 0. 5, 1, 1, 5, 2, 2. 5, 3) with green mark on the 2	69M	OMNI-MESURES
M3	220 V/50 Hz Elapsed-time couhter (capacity 9999)	Standard type CM1000	C.E.M.
Q1	Motorola NPN transistor	2N2405	SCAIB/MOTOROLA
Q2	PNP Transistor	2N2905A	SESCOSEM
Q3	NPN Transistor	181T2	SESCOSEM
Q4 - Q5	Motorola NPN transistors	2N2405	SCAIB
Q6	Thyristor	12T4	SESCOSEM
Q7	Identical to Q3		
Q8	Identical to Q2		
Q9 to Q11	Identical to Q1		
Q12 - Q13	NPN Transistors	2N3054	SESCOSEM
Q14	Identical to Q3		

Symbol	Description	Ref. No./Part No.	French supplier
Q15	NPN Transistor	2N3439	SESCOSEM
Q16	NPN Transistor	BUY49	SGS
Q17	Identical to Q15		
Q18	Identical to Q1		
Q19	Programmable unijunction transistor	TUP2A or TUP4	SILEC
Q20 - Q21	Linear integrated circuits	SFC2301A	SESCOSEM
Q22	ELREMCO Integrated circuit	LR171E	International Semiconductor Corp. (ISC) - France
R1	470 Ω ± 5 %/ 1/2 W Resistor	RBX003	LCC
R2	2. 2 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R3	390 Ω * ± 5 % / 1/2 W Resistor	RBX003	LCC
R4	330 Ω ± 5 % / 1/2 W Resistor	RBX003	LCC
R5	1 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R6	Identical to R1		
R7	2. 7 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R8	BOURNS CERMET 2 kΩ potentiometer	3009-P-1-202	OHMIC
R9	4. 7 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R10	220 Ω ± 5 % / 1/2 W Resistor	RBX003	LCC
R11	Five 470 kΩ ± 10 % / 2 W Resistors (in series)	RM2	OHMIC
R12	5. 6 Ω ± 1 % / 1/2 W Resistor	RCMS05K3	SFERNICE
R13	18 Ω ± 1 % / 1/2 W Resistor	RCMS05K3	SFERNICE
R14	27 Ω ± 10 % / 2 W Resistor	RM2	OHMIC
R15	1 kΩ ± 10 % / 2 W Resistor	RM2	OHMIC
R16	56 Ω ± 10 % / 2 W Resistor	RM2	OHMIC
R17	8. 2 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R18	150 Ω ± 5 % / 1/2 W Resistor	RBX003	LCC
R19	1. 2 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R20	Identical to R10		
R21	390 Ω ± 5 %/1/2 W Resistor	RBX003	LCC
R22	39 Ω ± 5 % / 1/2 W Resistor	RBX003	LCC

(*) Value adjusted during equipment checkout

Symbol	Description	Ref. No./Part No.	French supplier
R23	Identical to R22		
R24	Identical to R5		
R25	BOURNS CERMET 5 kΩ potentiometer	3009-P-1-502	OHMIC
R26	1. 8 Ω ± 5 % / 3 W Wound resistor	RWM4X10	SFERNICE
R27	Identical to R21		
R28	Identical to R7		
R29	3. 3 kΩ ± 10 % / 1 W Resistor	RM1	OHMIC
R30	1. 5 kΩ ± 10 % / 1 W Resistor	RM1	OHMIC
R31	1. 8 kΩ ± 5 % / 1 W Resistor	RM1	OHMIC
R32	4. 7 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R33	1 MΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R34	82 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R35	100 Ω ± 5 % / 1/2 W Resistor	RBX003	LCC
R36	2 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R37	*Ω ± 5 % / 1/2 W Resistor	RBX003	LCC
R38	Identical to R2		
R39	Identical to R19		
R40	Identical to R32		
R41	Identical to R36		
R42	22 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R43	2. 7 kΩ ± 10 % / 1 W Resistor	RM1	OHMIC
R44	3. 3 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R45	1. 5 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R46	10 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R47	Identical to R46		
R48	BOURNS CERMET 10 kΩ potentiometer	3009-P-1-103	OHMIC
R49	18 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R50	12 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R51	Identical to R2		
R52	470 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R53	100 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC

* Value adjusted during equipment checkout.

Symbol	Description	Ref. No./Part No.	French supplier
R54	Identical to R33		
R55	Identical to R35		
R56	180 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R57	27 kΩ ± 10 % / 2 W Resistor	RM2	OHMIC
R58	1. 8 kΩ ± 10 % / 2 W Resistor	RM2	OHMIC
R101 to R111	ROSENTHAL 249 kΩ ± 1 % / 1/2 W Resistors	SMA0411	CEREL
R112	ROSENTHAL 56. 2 kΩ ± 1 % / 1/2 W Resistor	SMA0411	CEREL
R113	Identical to R8		
R114	ROSENTHAL 5. 62 kΩ ± 1 % / 1/2 W Resistor	SMA0411	CEREL
R115	Identical to R2		
R116 to R118	ROSENTHAL 205 kΩ ± 1 % / 1/2 W Resistors	SMA0411	CEREL
R119	ROSENTHAL *Ω ± 1 %/ 1/2 W Resistor	SMA0411	CEREL
R120	250 kΩ Potentiometer, shaft length 32	61-HD-P	DRALOWID
R121	Identical to R119		
R122 to R128	Identical to R101 to R111		
S1	Luminous green rocker switch, equipped with a 24 V lamp (I3)	MLW3022 98024	COMEPA
S2	Rotary switch : 1 wafer ; 1 circuit, 2 directions 60° apart. Contacts non-short circuiting	KR30	R.E.S.
S3	Identical to S1, except (I4)		
T1	127-220 V/50 Hz Line transformer	TC 2V 225E	Mondial Electronique
T2	Miniature transformer, wound on an LCC core	FT10575 T6-FT10	MESUREL
T3	Transformer for high-voltage converter : Magnetic core : LCC broken double-E ferrite with complete housing, including : one case one bracket one spring	TSG231E B42EC 32x13 HAB320PL CAR320 ETR320PL RES300	Mondial Electronique
V1 (B1)	Blower, composed of a 115-230 V/50 Hz motor, rotating clockwise, and of a "delrin" fan	82160S 70-354-052	CROUZET
X 101	Coupler and VSWR detector Frequency of the unit { 4 to 8 GHz 2 to 4 GHz 1 to 2 GHz	 48D20 24D30 12D30	TH-CSF/DTE

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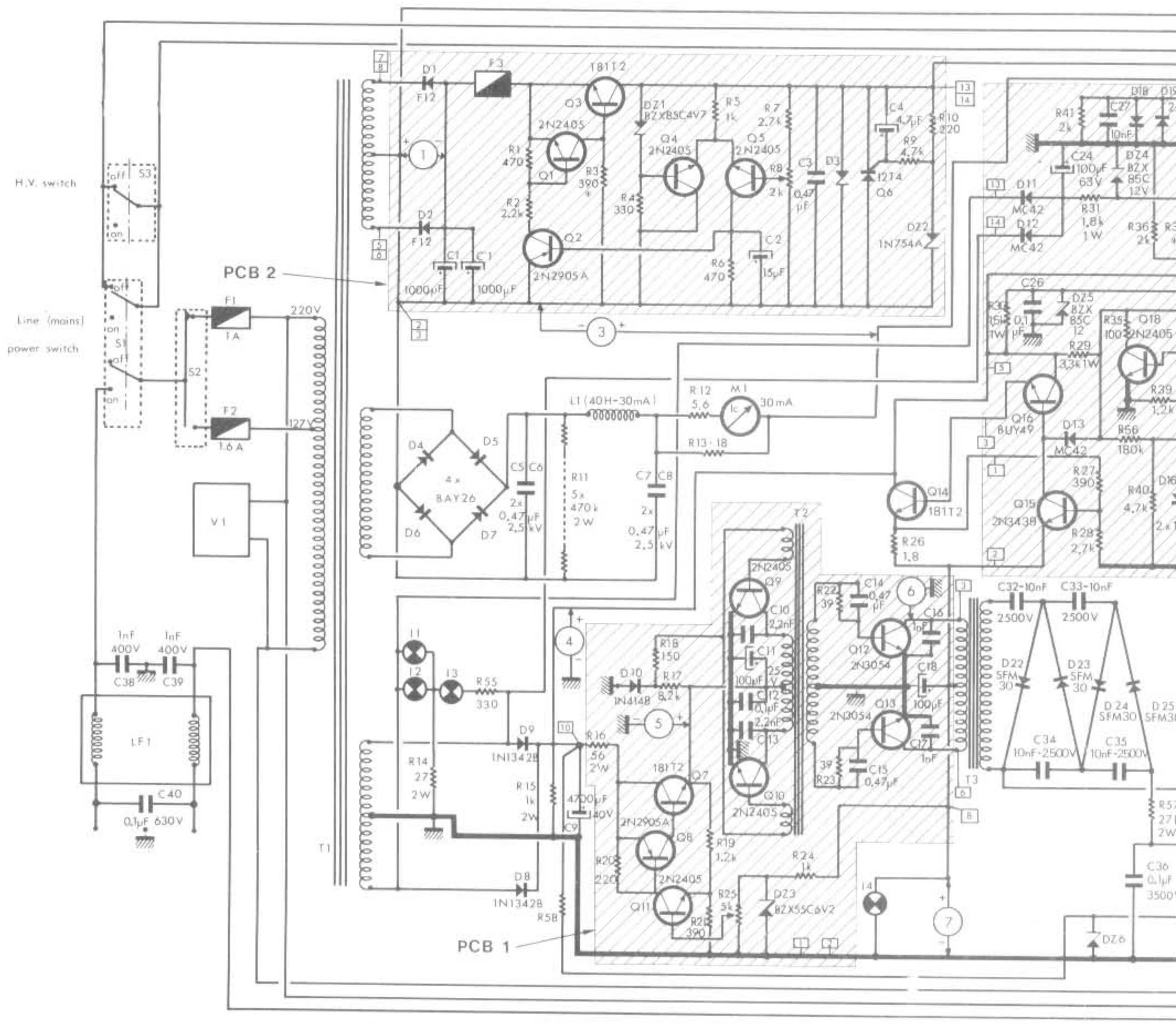
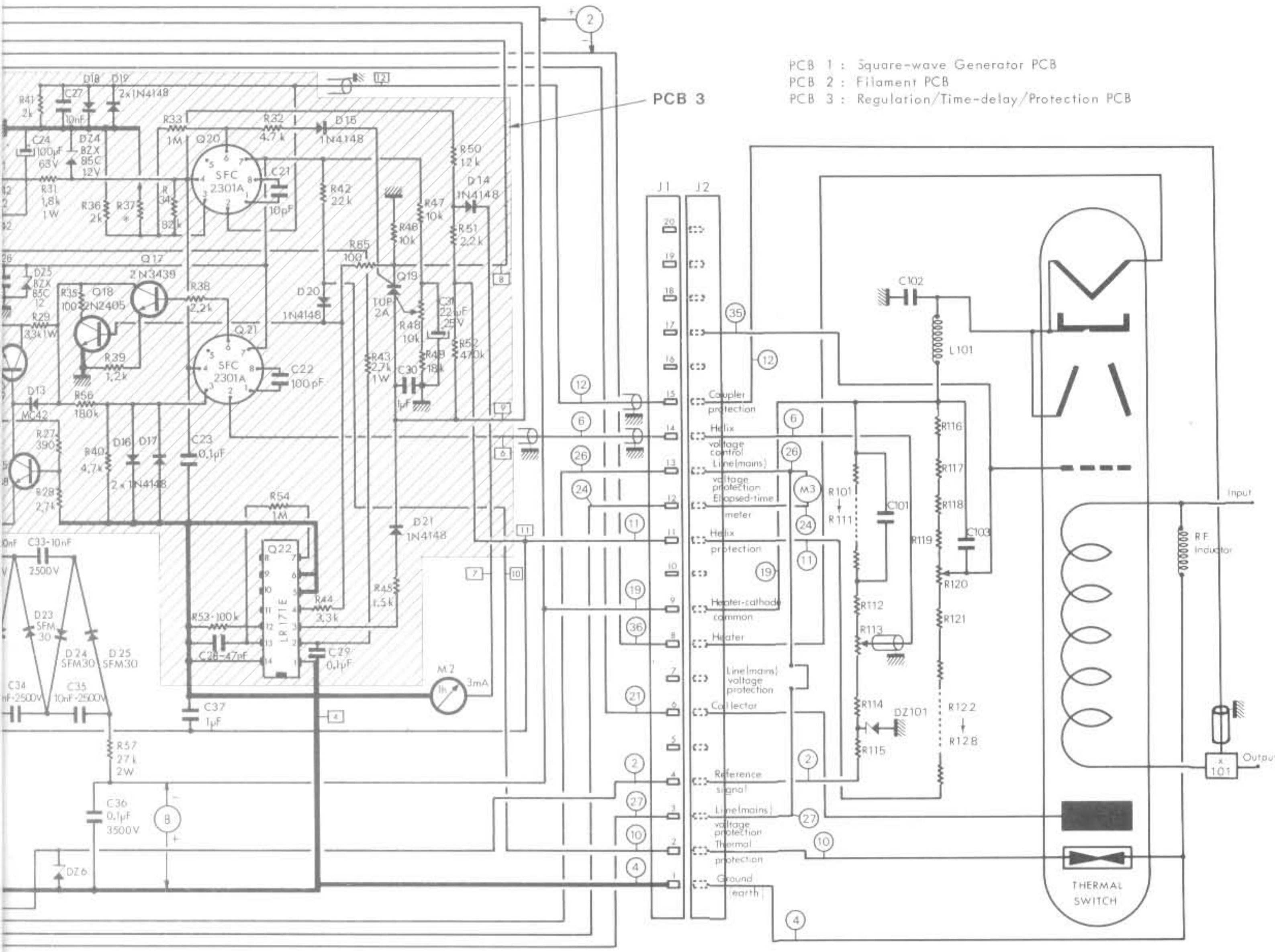
TWT AMPLIFIER AND POW



FIER AND POWER SUPPLY ELECTRICAL DIAGRAM



PARTS LIST
ALT 1410

Symbol	Description	Ref. No./Part No.	French supplier
C1 and C1'	FITCO 1000 µF/25 V Electrochemical capacitors	2222 - 017 - 16102	COGECO
C2	FITCO 15 µF/16 V Electrochemical capacitor	C025	COGECO
C3	0. 47 µF ± 10 %/160 V Metalized Mylar capacitor	IPF 218	LCC
C4	FITCO 4. 7 µF/63 V Electrochemical capacitor	2222 - 015 - 90003	COGECO
C5, C6, C7 and C8	1 µF/1600 V High-voltage capacitors	Type NOR-CF1	SIC-SAFCO
C9	4700 µF/40-48 V Electrochemical capacitor	Type ETF-L	EUROFARAD
C10	2. 2 nF ± 10 %/200 V Ceramic capacitor	DJZ 908-5	LCC
C11	FITCO 100 µF/25 V Electrochemical capacitor	2222 - 016 - 16101	COGECO
C12	0. 1 µF ± 10 %/63 V Metalized Mylar capacitor	IPD 213	LCC
C13	Identical to C10		
C14 - C15	Identical to C3		
C16 - C17	1 nF ± 20 %/200 V Ceramic capacitors	DJZ 905-5	LCC
C18	FITCO 100 µF/63 V Electrochemical capacitor	2222 - 017 - 18101	COGECO
C19 - C20	Eliminated		
C21	10 pF ± 10 %/250 V Tubular ceramic capacitor	CRC 406 10 UK	LCC
C22	100 pF ± 10 %/200 V Ceramic capacitor	DJZ 905-5	LCC
C23	Identical to C12		
C24	Identical to C18		
C25	Eliminated		
C26	Identical to C12		

Symbol	Description	Ref. No./Part No.	French supplier
C27	10 nF ± 10 %/250 V Metalized Mylar capacitor	IPG 213	LCC
C28	47 nF ± 10 %/63 V Metalized Mylar capacitor	IPD 213	LCC
C29	Identical to C12		
C30	1 μF ± 10 %/160 V Metalized Mylar capacitor	IPF 231	LCC
C31	FITCO 22 μF/25 V Electrochemical capacitor	2222 - 015 - 16229	COGECO
C32 to C35	10 nF ± 20 %/1500 V High-voltage capacitors	Type T150/032	LCC
C36	0. 1 μF ± 20 %/2500 V High-voltage capacitor	Type T150/048	LCC
C37	Identical to C30		
C38 - C39	10 nF ± 10 %/400 V Capacitors	C296 TC/A	COGECO
C40	SICAP M 0. 1 μF ± 10 %/630 V Capacitor	Type CF15	SIC-SAFCO
C101	1 nF/3000 V High-voltage capacitor	QCX611	LCC
C102	47 nF ± 20 %/2500 V High voltage capacitor	Type T150/032	LCC
C103	47 nF/1500 V High-voltage capacitor	Type T150/048	LCC
D1 and D2	Diodes	Type F12	SILEC
D3	General Semiconductor Industries "TRANSZORB" protection diode	1. 5KE8. 2	R.E.A.
D4 to D7	SEMTECH High-voltage diodes	M30	OHMIC
D8 and D9	Diodes	1N1342B	SILEC
D10	Diode	1N4148	SESCOSEM
D11 to D13	Diodes	MC42	SILEC
D14 to D21	Diodes	1N4148	SESCOSEM
D22 to D25	SEMTECH High-voltage diodes	SFM30	OHMIC
DZ1	Zener diode	BZX85C4V7	SESCOSEM
DZ2	Zener diode	1N754A	SILEC
DZ3	Zener diode	BZX55C6V2	SESCOSEM
DZ4 and DZ5	Zener diodes	BZX85C12	SESCOSEM
DZ6	Zener diode	BZX85C18	SESCOSEM
DZ101	Zener diode	1N823	SESCOSEM

Symbol	Description	Ref. No./Part No.	French supplier
F1	CEHESS Fuse holder, equipped with 1A slow-blow fuse	D1 SH No. 23316 D1TD-1	CEHESS
F2	Identical to F1, equipped with 1. 6A slow-blow fuse	D1TD-1. 6	CEHESS
F3	Fuse holder consisting of two type OG 781-01 clips for 5 x 20 fuse, equipped with a fast 1. 25A fuse	D1/1. 25	
I1	Dial lamp, consisting of a socket plus support, Equipped with a 24V/0. 13 A miniature bulb	MFV101	MFOM MAZDA
I2	Identical to I1		
I3	Green indicator lamp, incorporated in S1		COMEPA
I4	Red indicator lamp, incorporated in S3		COMEPA
J1	Female connector	A20F71PO	SOGIE
J2	Male connector	A20M71PO	SOGIE
L1	40 H/80 mA Filtering inductor	SE21E	Mondial Electronique
L101	TRANSCO RF Decoupling inductor	VK200 10/3B	COPRIM
LF1	Schaffner line filter	RN52-1.5/1	R.E.A.
M1	DC milliammeter : plexiglass dial, knife needle, protected by diodes with series and shunt resistors (see R12 and R13) Maximum deflection 80 mA	69M	OMNI-MESURES
M2	DC milliammeter : plexiglass dial, knife needle, max. deflection 6 mA Dial numbers in black (0, 0. 5, 1, 1, 5, 2, 2. 5, 3) with green mark on the 2	69M	OMNI-MESURES
M3	220 V/50 Hz Elapsed-time counter (capacity 9999)	Standard type CM1000	C.E.M.
Q1	Motorola NPN transistor	2N2405	SCAIB/MOTOROLA
Q2	PNP Transistor	2N2905A	SESCOSEM
Q3	NPN Transistor	181T2	SESCOSEM
Q4 - Q5	Motorola NPN transistors	2N2405	SCAIB
Q6	Thyristor	12T4	SESCOSEM
Q7	Identical to Q3		
Q8	Identical to Q2		
Q9 to Q11	Identical to Q1		
Q12 - Q13	NPN Transistors	2N3054	SESCOSEM
Q14	Identical to Q3		

Symbol	Description	Ref. No./Part No.	French supplier
Q15	NPN Transistor	2N3439	SESCOSEM
Q16	NPN Transistor	BUY49	SGS
Q17	Identical to Q15		
Q18	Identical to Q1		
Q19	Programmable unijunction transistor	TUP2A or TUP4	SILEC
Q20 - Q21	Linear integrated circuits	SFC2301A	SESCOSEM
Q22	ELREMCO Integrated circuit	LR171E	International Semiconductor Corp. (ISC) - France
R1	470 Ω ± 5 %/ 1/2 W Resistor	RBX003	LCC
R2	2. 2 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R3	390 Ω * ± 5 % / 1/2 W Resistor	RBX003	LCC
R4	330 Ω ± 5 % / 1/2 W Resistor	RBX003	LCC
R5	1 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R6	Identical to R1		
R7	2. 7 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R8	BOURNS CERMET 2 kΩ potentiometer	3009-P-1-202	OHMIC
R9	4. 7 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R10	220 Ω ± 5 % / 1/2 W Resistor	RBX003	LCC
R11	Five 470 kΩ ± 10 % / 2 W Resistor (in series)	RM2	OHMIC
R12	5. 6 Ω ± 1 % / 1/2 W Resistor	RCMS05K3	SFERNICE
R13	18 Ω ± 1 % / 1/2 W Resistor	RCMS05K3	SFERNICE
R14	27 Ω ± 10 % / 2 W Resistor	RM2	OHMIC
R15	1 kΩ ± 10 % / 2 W Resistor	RM2	OHMIC
R16	56 Ω ± 10 % / 2 W Resistor	RM2	OHMIC
R17	8. 2 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R18	150 Ω ± 5 % / 1/2 W Resistor	RBX003	LCC
R19	1. 2 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R20	Identical to R10		
R21	390 Ω ± 5 %/1/2 W Resistor	RBX003	LCC
R22	39 Ω ± 5 % / 1/2 W Resistor	RBX003	LCC

(*) Value adjusted during equipment checkout

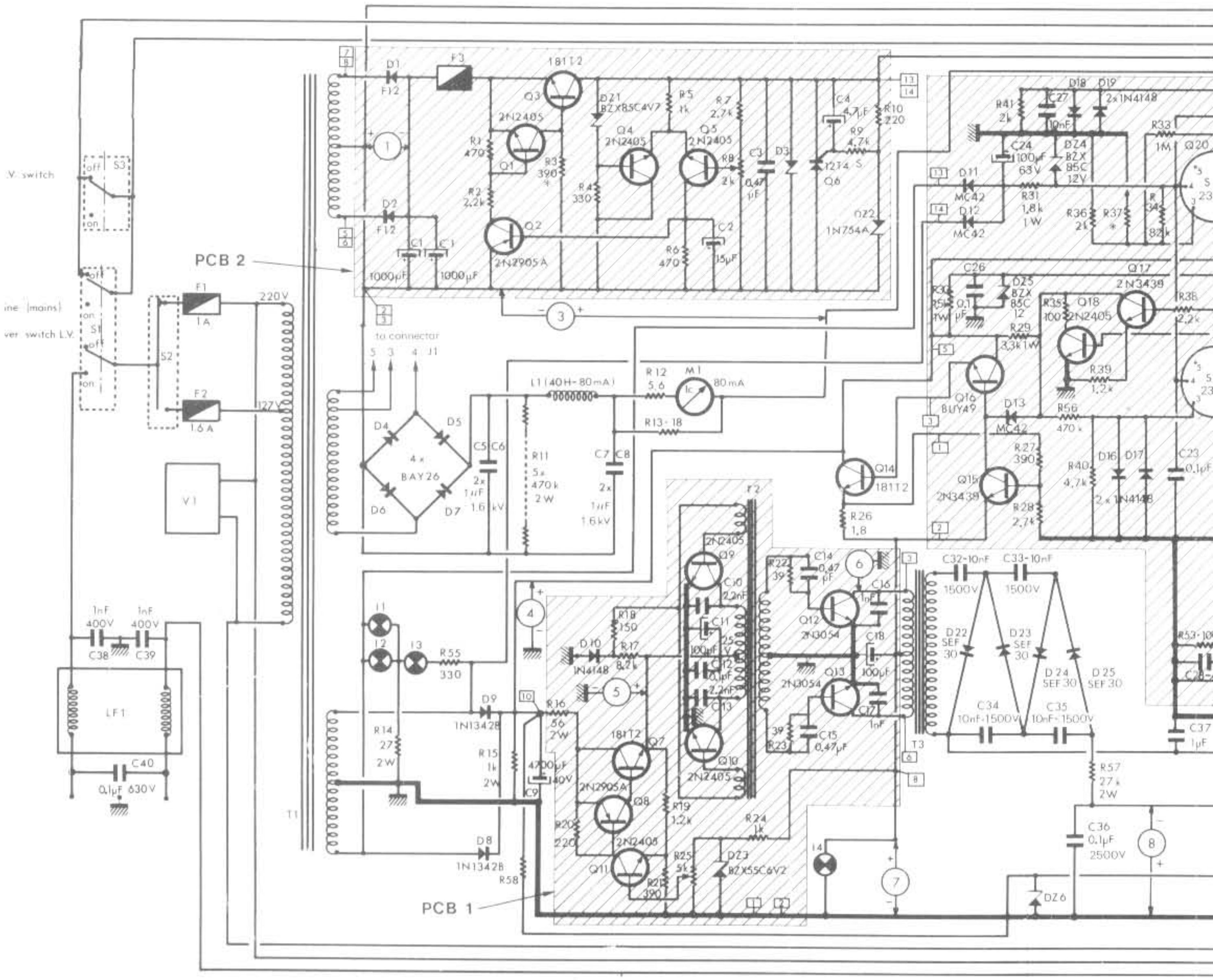
Symbol	Description	Ref. No./Part No.	French supplier
R23	Identical to R22		
R24	Identical to R5		
R25	BOURNS CERMET 5 kΩ potentiometer	3009-P-1-502	OHMIC
R26	1.8 Ω ± 5 % / 3 W Wound resistor	RWM4X10	SFERNICE
R27	Identical to R21		
R28	Identical to R7		
R29	3.3 kΩ ± 10 % / 1 W Resistor	RM1	OHMIC
R30	1.5 kΩ ± 10 % / 1 W Resistor	RM1	OHMIC
R31	1.8 kΩ ± 5 % / 1 W Resistor	RM1	OHMIC
R32	4.7 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R33	1 MΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R34	82 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R35	100 Ω ± 5 % / 1/2 W Resistor	RBX003	LCC
R36	2 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R37	*Ω ± 5 % / 1/2 W Resistor	RBX003	LCC
R38	Identical to R2		
R39	Identical to R19		
R40	Identical to R32		
R41	Identical to R36		
R42	22 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R43	2.7 kΩ ± 10 % / 1 W Resistor	RM1	OHMIC
R44	3.3 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R45	1.5 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R46	10 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R47	Identical to R46		
R48	BOURNS CERMET 10 kΩ potentiometer	3009-P-1-103	OHMIC
R49	18 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R50	12 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R51	Identical to R2		
R52	470 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R53	100 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC

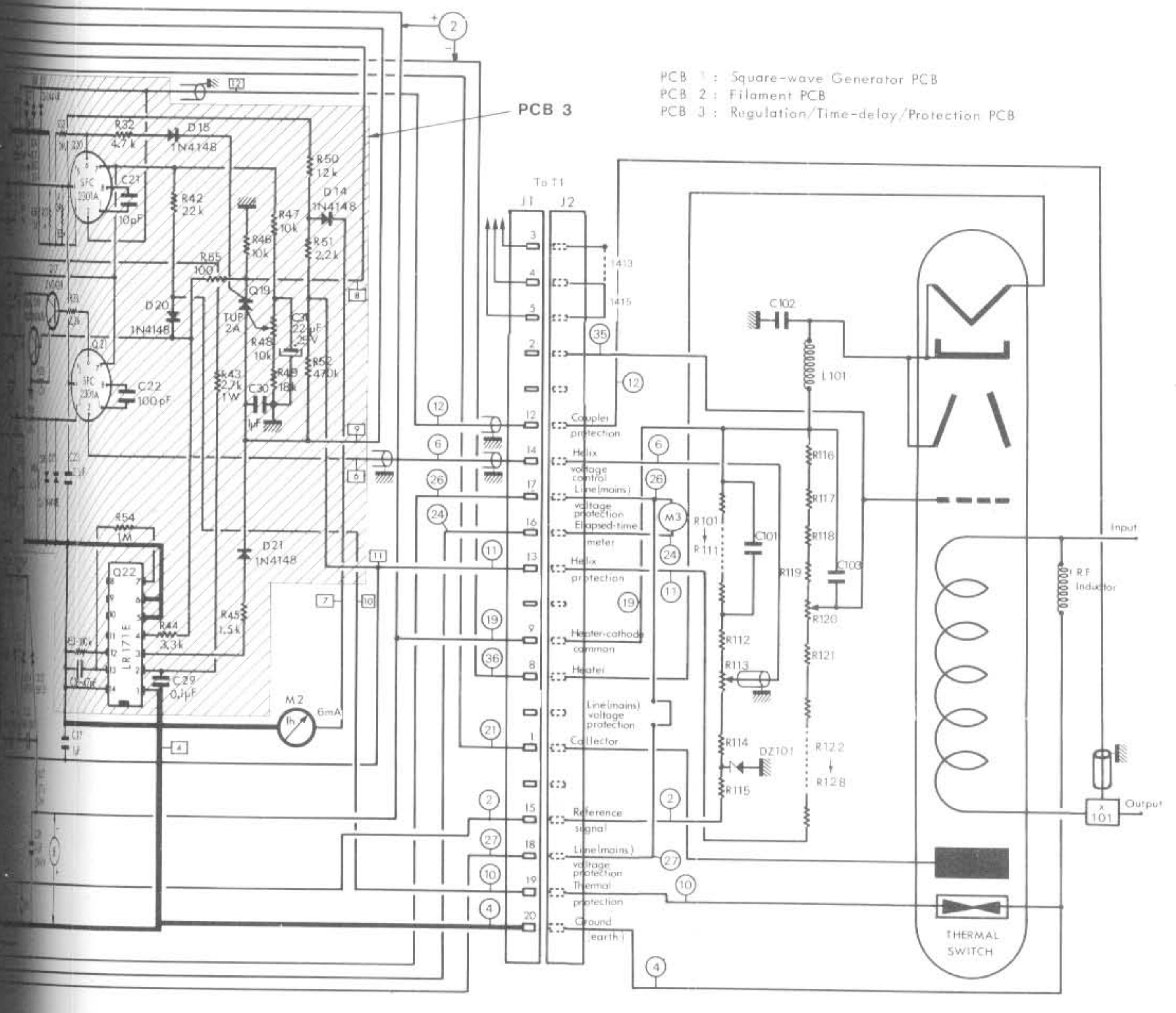
* Value adjusted during equipment checkout.

Symbol	Description	Ref. No./Part No.	French supplier
R54	Identical to R33		
R55	Identical to R35		
R56	180 kΩ ± 5 % / 1/2 W Resistor	RBX003	LCC
R57	27 kΩ ± 10 % / 2 W Resistor	RM2	OHMIC
R58	1. 8 kΩ ± 10 % / 2 W Resistor	RM2	OHMIC
R101 to R111	ROSENTHAL 249 kΩ ± 1 % / 1/2 W Resistors	SMA0411	CEREL
R112	ROSENTHAL 56. 2 kΩ ± 1 % / 1/2 W Resistor	SMA0411	CEREL
R113	Identical to R8		
R114	ROSENTHAL 5. 62 kΩ ± 1 % / 1/2 W Resistor	SMA0411	CEREL
R115	1,5 kΩ ± 5 % / 1/2 W	RBX003	LCC
R116 to R118	ROSENTHAL 205 kΩ ± 1 % / 1/2 W Resistors	SMA0411	CEREL
R119	ROSENTHAL *Ω ± 1 %/ 1/2 W Resistor	SMA0411	CEREL
R120	250 kΩ Potentiometer, shaft length 32	61 HD P	DRALOWID
R121	Identical to R119		
R122 to R128	Identical to R101 to R111		
S1	Luminous green rocker switch, equipped with a 24 V lamp (I3)	MLW3022 98024	COMEPA
S2	Rotary switch : 1 wafer ; 1 circuit, 2 directions 60° apart. Contacts non short circuiting	KR30	R.E.S.
S3	Identical to S1, except lamp 12 V ref. 98012		
T1	127-220 V/50 Hz Line transformer	TC 2V 262E	Mondial Electronique
T2	Miniature transformer, wound on an LCC core	FT10575 T6 FT10	MESUREL
T3	Transformer for high-voltage converter : Magnetic core : LCC broken double-E ferrite with complete housing, including : one case one bracket one spring	TSG231E B42EC 32x13 HAB320PL CAR320 ETR320PL RES300	Mondial Electronique
V1 (B1)	Blower, composed of a 115-230 V/50 Hz motor, rotating clockwise, and of a "delrin" fan	82160S 70-354-052	CROUZET
X 101	Coupler and VSWR detector Frequency of the unit: 4 to 8 GHz 2 to 4 GHz 1 to 2 GHz	 48D20 24D30 12D30	TH-CSF/DTE

THOMSON-CSF

VISION TUBES ELECTRONIQUES




PCB 1 : Square-wave Generator PCB
PCB 2 : Filament PCB
PCB 3 : Regulation/Time-delay/Protection PCB
PCB 3
To T1
J1
J2
Coupler protection
Helix voltage control
Line (mains) voltage protection
Elapsed-time meter
Helix protection
Heater-cathode common
Heater
Line (mains) voltage protection
Collector
Reference signal
Line (mains) voltage protection
Thermal protection
Ground (earth)
Input
Output
RF Inductor
THERMAL SWITCH
M2
6mA
M3
C102
L101
R116
R117
R118
R119
R120
R121
R122 ↓ R128
R101 ↓ R111
C101
C103
R112
R113
R114
R115
DZ101
R32 4,7k
D18 1N4148
R50 12k
D14 1N4148
R42 22k
R47 10k
R46 10k
R51 2,2k
R65 100
Q19 TUP 2A
D20 1N4148
R48 10k
C31 22µF 25V
R52 470k
R43 2,7k 1W
C30 1µF
R49 18k
C21 10pF
C22 100pF
R54 1M
Q22 LR171E
R44 3,3k
D21 1N4148
R45 1,5k
C29 0,1µF