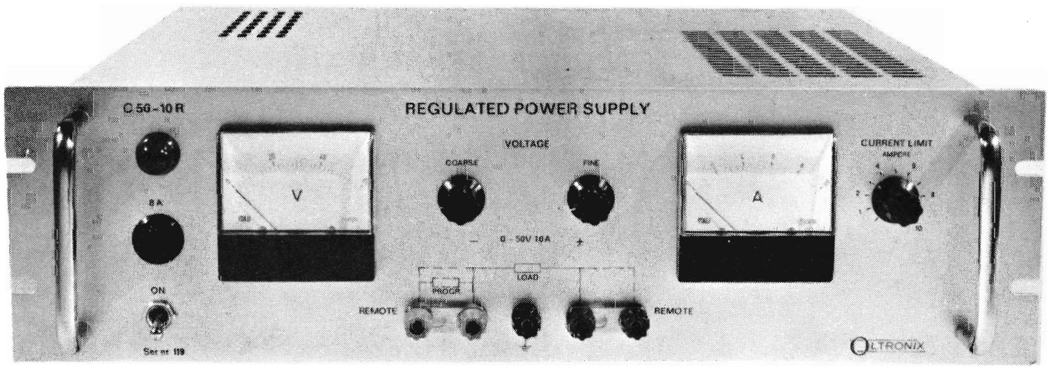
OLTRONIX

INSTRUCTION
MANUAL

REGULATED POWER SUPPLIES



MODELS C50-10R, C32-16R AND C28-20R.

Oltronix C50-10R, C32-16R and C28-20R are a range of transistorized, well regulated, heavy duty power supplies. All the models include circuits for remote programming, remote sensing and modulation.

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SECTION I.

GENERAL DESCRIPTION.

Oltronix C50-10R, C32-16R and C28-20R is a line of low voltage, high power, well regulated DC power supplies. There is no derating in any part of their voltage or current ranges. They are fully protected against overload.

The instrument marking e.g. C28-20R is a code for the performance of the power supply. The first letter shows the approximate stability for ± 10% line voltage variation.

A < 0,01 %
B 0,01 – 0,03 %
C 0,03 – 0,1 %
D > 0,1 %

The next group of figures indicates the maximum output voltage. The figure succeeding the dash shows the maximum output current.

The letter "R" after the code number indicates a rack model.

All the power supplies are equipped with voltmeter and ammeter for simultaneous reading of output voltage and current.

A calibrated current limit control is incorporated. It serves the triple duty to protect the load and the power supply from excessive current and to make it possible to use the power supply as a constant current generator.

Facilities for remote programming, remote sensing and modulation are incorporated. Programming operation gives the possibility to control the output voltage by an external resistor. The remote sensing circuit allows the power supply to regulate the voltage across the load instead of the voltage at the output terminals. This compensates for voltage drops in long load cables. The modulation possibility allows the output voltage to be controlled by an external low power signal.

The terminals needed for operating the power supply are available both from the binding posts on the front panel and through a 5- or 6-prong plug at the rear. Modulation is possible through the rear plug only.

Several units can be connected in series or in parallel if higher voltage or current is needed. Remote programming and remote sensing are still possible.

SECTION II.

SPECIFICATIONS.

	Unit	C50-10R	C32-16R	C28-20R
Output voltage	V	0-50	0-32	0-28
Output current	A	0-10	0-16	0-20
Output voltage at derated current (220 V Line)	V A	50-56 9		28-30 18
Line regulation for 10% line voltage variation	mV	20	10	10
Load regulation for 0-100% load variation	mV	100	100	75
Ripple RMS	mV	1,0	1,0	1,0
Dimensions H W D	mm mm	132 19" 400	132 19" 350	132 19" 400
Weight	Kgs	29	25	29
Calibrated current limit	A	1-10	2-16	2-20
Remote programming		yes	yes	yes
Programming constant	ohms/v	200*	200*	200*
Remote sensing		yes	yes	yes
Modulation		yes	yes	yes
Modulation constant	%/v	20	20	20

Input voltage: 200-240 V 50 Hz

Recovery time: 40 usec

Ambient temp.: 40°C maximum

Output impedance: Less than 20 mohms up to 10 kHz, 50 mohms at 50 kHz and 100 mohms at 300 kHz.

* Other programming constants on request.

SECTION III.

OPERATING INSTRUKTIONS.

1. UNPACKING

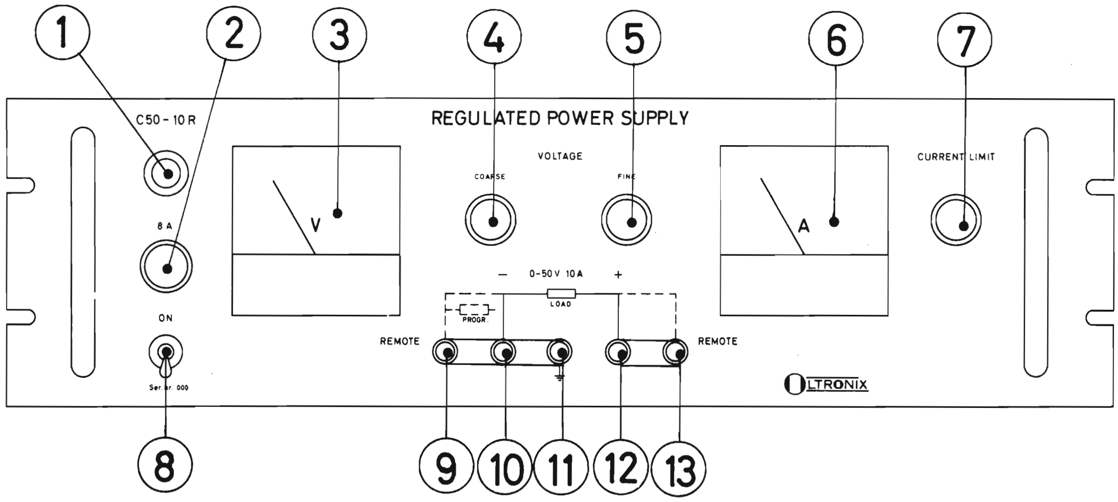
Unpack and inspect the power supply as soon as possible after receipt. Save the packing material, because these may be needed for reshipment in case of shipping damage.

2. INSPECTION

Inspect the power supply for damage such as broken knobs, scratched case etc. Also check that the instrument is working properly by making the "Front panel performance check" in section V:2. Only the "Normal operation" part of it is necessary. If there is any damage fill a claim as soon as possible.

3. PRESENTATION

Fig. III:1 shows the power supply front panel of Oltronix rack model, high current power supplies.



1. Pilot lamp, monitoring AC input power only.
2. AC fuse (8A).
3. Output DC voltmeter.
4. Output voltage coarse control.
5. Output voltage fine control.
6. Output DC ammeter.
7. Output current limit control.
8. Power ON switch (AC power only).
9. Remote sensing "-" and programming terminal.
10. DC power "-" terminal.
11. Power supply ground terminal.
12. DC power "+" terminal.
13. Remote sensing "+" terminal.

Fig. III:1

Front panel models C50-10R, C32-16R and C28-20R.

4. OPERATION

Line

Connect the power supply to a 220 V 50 – 60 Hz line by means of the accompanying three-conductor power cable. The third conductor is the ground contact.

Fuse

The line fuse (8 A) is mounted on the front panel (see fig. III:1 pos. 2). In early power supplies a 1 A fuse protecting the series transistors is mounted inside.

Power

The power supply is switched on with the toggle switch marked "ON".

Normal-Progr.

Check that the NORMAL-PROGR. slide switch at the rear side is in correct position for the actual application. (See paragraph 5 this section.)

Jumpers

See paragraph 5 this section.

Voltage

The desired voltage is set with the voltage controls marked "COARSE" and "FINE". Read the output voltage from the voltmeter on the front panel.

Current

Set the current limit control marked "CURRENT LIMIT" to a value well above the expected peak current, but below the value that can damage the load. Read the output current from the ammeter on the front panel.

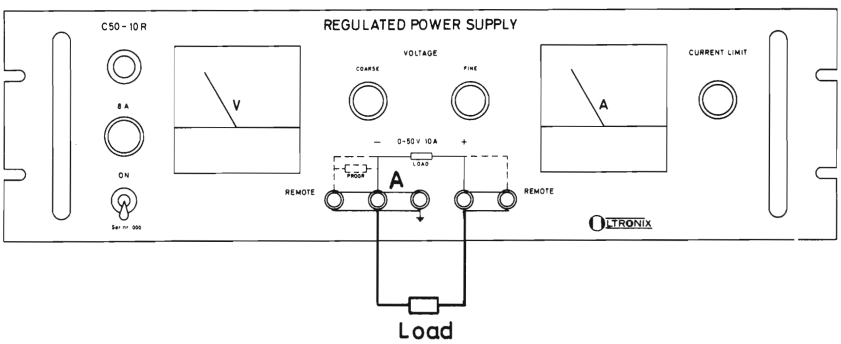
Constant current

Set the output voltage to about 30 % of maximum value. Short the output marked "LOAD" with a piece of wire and set the output current as desired with the "CURRENT LIMIT" control. Disconnect the wire and set output voltage as desired.

This is a low stability (approximately 1 %) method. A better but somewhat more complex one is also possible. It is described in paragraph 5 in this section.

5. APPLICATIONS

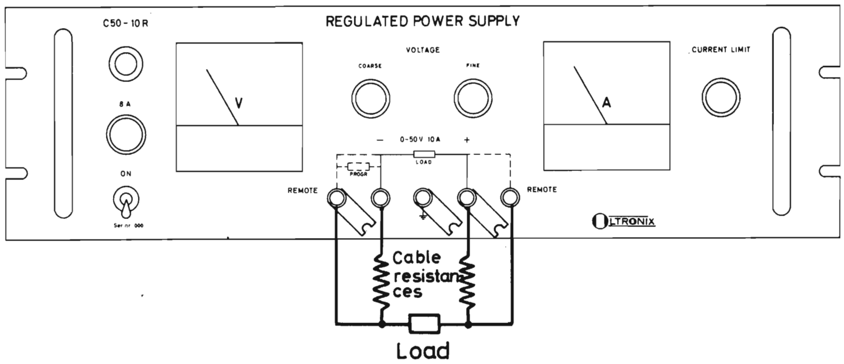
Normal operation



The output may be positive, negative or floating, depending on how the jumper "A" is connected.

The NORMAL-PROGR. switch at the rear shall be in NORMAL position.

Remote sensing



This circuit permits sensing the voltage at the load terminals instead of at the power supply terminals. Regulation loss caused by IR drops in the load leads is thus compensated for.

If possible connect the cable with the lowest expected voltage drop to the "+" side.

If the IR voltage drop in one of the cables is negligible, this side can be connected for normal operation.

When using the remote sensing circuit the following limitations occur:

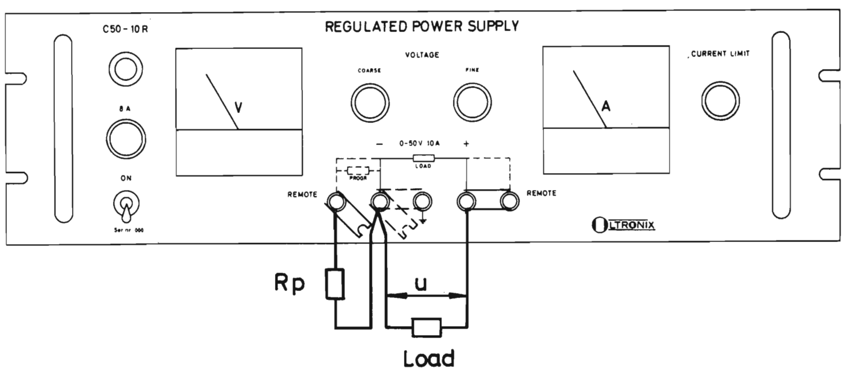
a. The voltage drop in the "+" cable should not exceed 0,65 V (1,2 V upon request). This limitation is caused by the diode D91 which is included as a safety circuit. It protects the load from excessive voltage which might appear at the output terminals if the load or part of it is connected to the remote terminals and a jumper is accidentally removed.

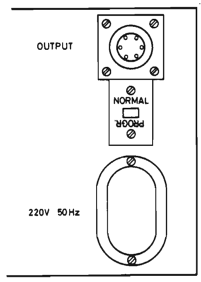
   If it is necessary to have a higher voltage drop in the "+" cable for a special application, D91 can be removed.

b. The maximum voltage at the instrument terminals should not exceed the maximum rating for the actual power supply. This means that the maximum available voltage at the load is the maximum power supply voltage minus the voltage drop in the power cables.

c. The power supply voltmeter indicates the voltage at the instrument terminals (not the voltage at the load).

Programming





When programming connection is used, the output voltage is controlled by an external resistor. The connection procedure is:

a. Switch off the power.

b. Unscrew the "NORMAL-PROGR." plate at the rear of the power supply. Push the slide-switch to the right hand side and fasten the plate again, but now with the "PROGR." side upwards.

c. The output voltage is now controlled by the programming resistor Rp. The relation between Rp and output voltage U is:

$$U = 5 \cdot R_p \quad (R_p \text{ in kohms})$$

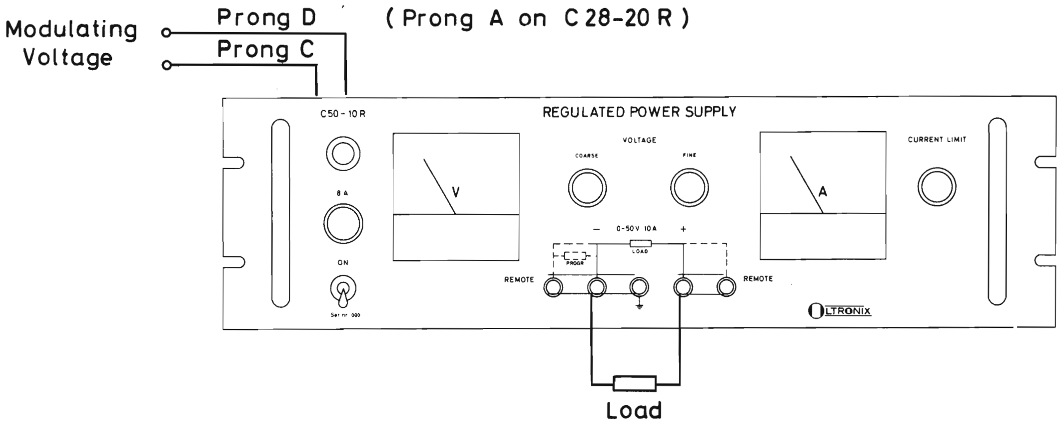
(Other programming constants upon request.)

NB 1 Do not increase R_p above the value corresponding to the maximum rated voltage for the actual power supply, that is:

28 V: 5,6 kohms
32 V: 6,4 kohms
50 V: 10 kohms

NB 2 If the "NORMAL-PROGR." switch is operated with the power supply working, high voltage pulses can appear at the output terminals.

Modulation



The power supply output voltage can be modulated by an external low power signal. This mode of operation is initially intended to give a possibility to add a variable amount of ripple to the output voltage. This is useful for example when a circuit has been developed using a practially ripple free regulated power supply as power source, and is intended to be operated from a simple rectifier. The amount of ripple which the actual circuit stands can easily be examined by varying the ripple modulation amplitude from the laboratory regulated power supply.

When this low amplitude modulation (less than 2V p-p) is used, the upper frequency limit (-3 dB) is approximately 25 Hz with 20–100% load.

Above this frequency limit the amplitude - frequency curve falls about 6 dB/octave. It is however perfectly possible to modulate at several hundred Hz, if the modulating voltage is increased correspondingly. The frequency range is thus enough for most practical ripple tests.

The upper frequency limit can be increased by reducing the capacitor C90.

With C90 completely removed the frequency range is increased to approximately 500 Hz with 50% load current. Other output currents give lower frequency limits. For example 10% and 90% give a frequency of 100–200 Hz. This is caused by the output capacitor. At low output current this capacitor cannot be discharged fast enough, and at high current the current limit function limits the rate of charge. In both cases a sinusoidal wave form will be distored to a saw-tooth function above the frequency limit.

One drawback of removing C90 is that the noise and ripple at the output will increase 5–10 times.

The modulation technique of controlling the power supply also makes it possible to vary the output voltage over the whole output voltage range with a low power signal. The power supply then acts as a DC power amplifier.

When such a high amplitude modulation is used precautions must be taken to assure that modulation frequency is well below the preregulator operation frequency that is 100 Hz. Modulation frequencies near 50 Hz and 100 Hz must be avoided. Recommended frequency range with high modulation amplitude is 0–10 Hz with 20–100% load.

The modulation input has an impedance of 1 kohms.

As the output capacitor is large, and thus takes a high charging current for each modulation cycle, the "CURRENT LIMIT" control must be set well above the maximum expected load current.

When the power supply is used as DC power amplifier it is convenient to regard the output "+" terminal as ground potential because it is common to both input and output. (Prong C is internally connected to "+" side REMOTE terminal.) With this definition the phase angle of the power supply is 180^{o}.

The modulating signal can be applied through prong D (C28-20R Prong A) in the rear input socket only.

The relation between the input voltage E, the output DC voltage UDC, and the output voltage deflection ΔU is:

$$\Delta U = DC \cdot 0,2E$$

Note:

a. The percentage of modulation is independent of the VOLTAGE control setting.

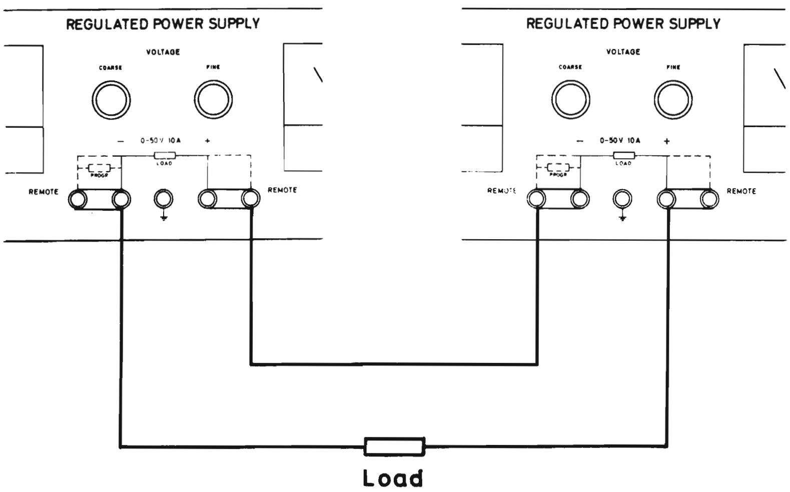
b. UDC is the output DC voltage corresponding to the actual VOLTAGE control setting (not to the modulated output DC voltage).

c. The output voltage cannot be modulated above 100 %, or in other words the output voltage cannot be reversed no matter how high a modulation voltage is applied. Neither should the peak output voltage exceed the maximum nominal value.

d. Avoid modulating voltages giving more than 100 % modulation.

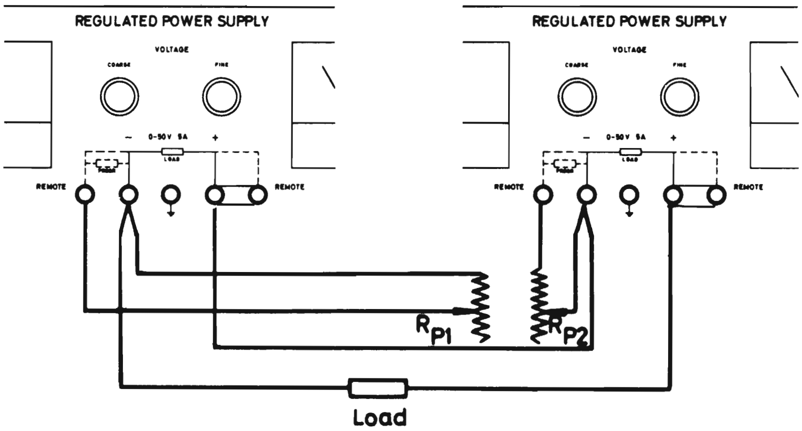
When operating the power supply in the modulation mode, connect the modulating voltage and the load according to the figure. Adjust the VOLTAGE controls for the desired output DC level. Increase the modulation voltage for the desired modulation amplitude.

Serial operation



If a higher output voltage is wanted several units can be connected in series if the maximum voltage to ground does not exceed 500 V. The output can be floating (as shown in the figure), positive or negative. As the current through all units will be identical, a voltage drop may take place, if any current limit is set too low.

Serial operation remote sensing

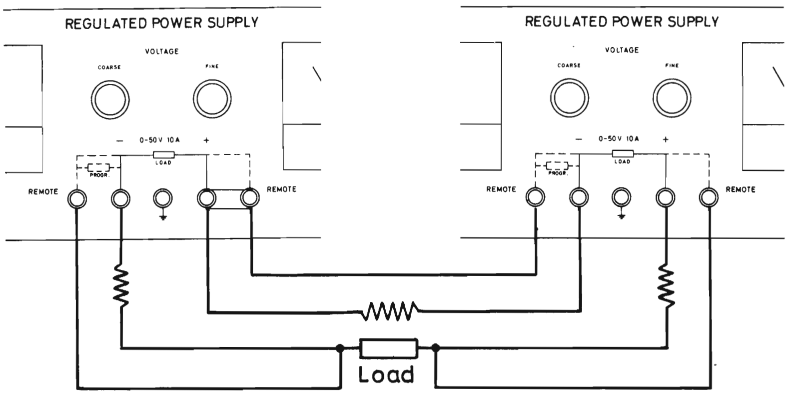


If any power cable is short, so that just a small voltage drop is expected in it, the sensing circuit for this cable can be omitted.

Also refer to paragraph "Remote sensing".

Figure under "Serial operation remote sensing" shall be under "Serial operation, programming" and the contrary.

Serial operation, programming



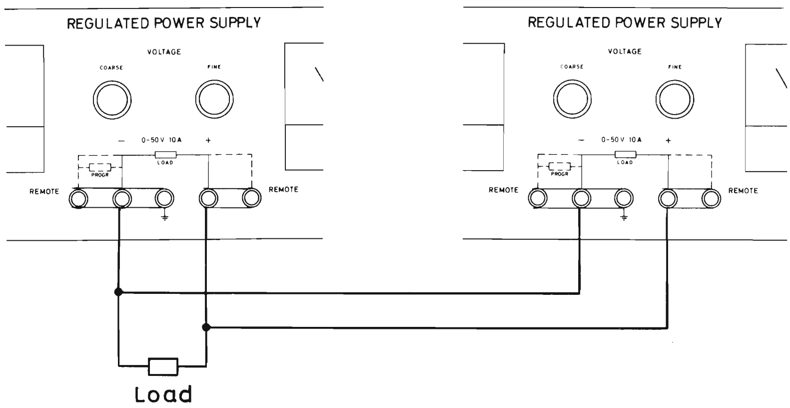
The output voltage is controlled by the resistors R_{P1} and R_{P2}. The relation between R_{P1}, R_{P2} and output voltage U is:

$$U = 5 \cdot (R_{P1} + R_{P2})$$

If the voltage variation range wanted is less than the control range of one of the power supplies one R_P can be omitted and the corresponding power supply arranged for serial operation in the usual way.

Also refer to paragraphs "Programming" and "Serial operation".

Parallel operation



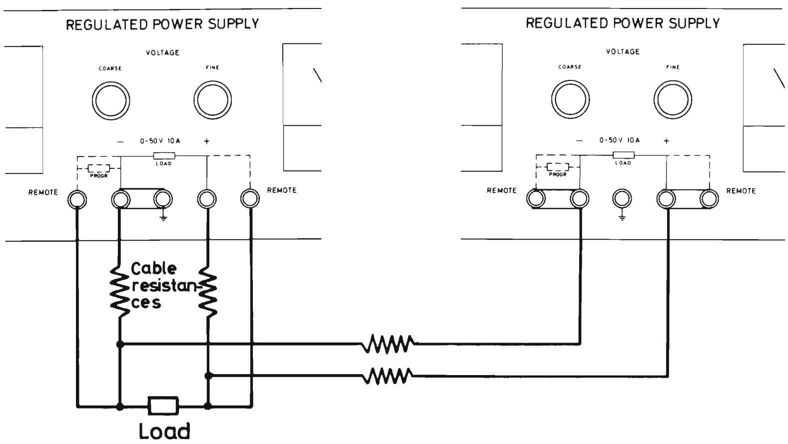
If a higher output current is needed several units can be connected in parallel. One power supply then should be operated as a voltage stabilizer and the remaining units as current stabilizers. The adjustment procedure is:

a. Set the output voltage of the "voltage" unit to the value wanted and to a slightly higher value on the "current" units.

b. Divide the current between the units to about equal by means of the current limit controls of the "current" units.

c. If the voltage decreases when the load is connected correct this by increasing the current limit of the "voltage" unit, and if necessary, also of the current units.

Parallel operation remote sensing

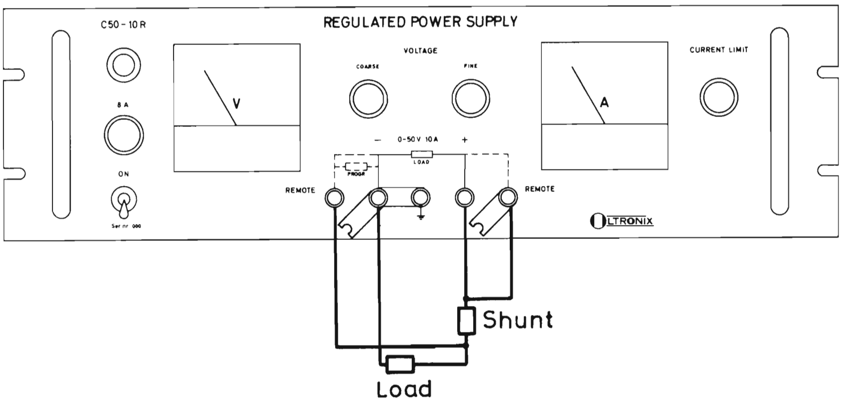


This circuit is similar to the "parallel operation" one which is described above.

The sensing circuit is connected to the "voltage" unit.

Also refer to the paragraph "remote sensing".

Constant current



Recommended resistance of the shunt is about 10% of the load resistance.

NB. The shunt must be in the "+" cable. Start with both the voltage controls set to minimum voltage, and the current limit control to a value well above the current wanted. Increase the voltage until the current reaches the desired value.

If the shunt takes too great part of the available output voltage the shunt resistance can be reduced to about 5% of the load resistance.

The percentage of current stability achieved with this method is of the same order as the percentage of voltage stability at the actual voltage across the shunt.

Other applications

There are lots of further possible uses of the modulation, the remote sensing and the programming circuits and combinations of several power supplies, not mentioned here, which can be used. If you are in doubt about the circuit that solves your problem, please apply to the nearest Oltronix agent.

SECTION IV.

CIRCUIT DESCRIPTION.

1. GENERAL

This chapter describes the electrical operation of the circuits. First the principle operation is described by means of a block diagram. A detailed description of the blocks follows. For these descriptions, please also refer to the complete circuit diagram. (See section VII.)

2. BLOCK DIAGRAM

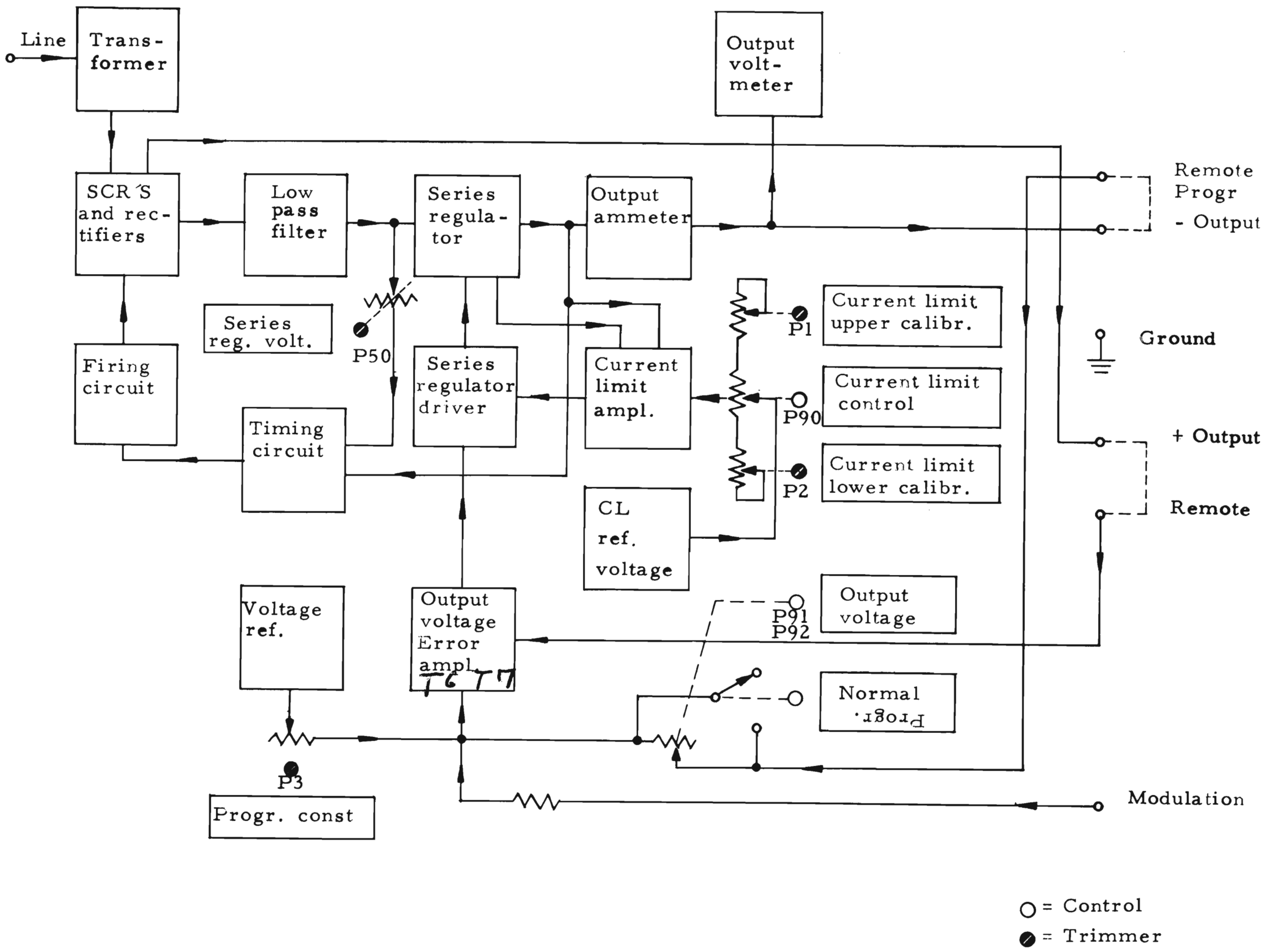


Fig. IV:1

Block diagram C50-10R, C32-16R and C28-20R.

The complete block diagram of the power supply is shown in fig. IV:1. The line delivers power to the "Transformer", where it is transformed to a suitable voltage. In the block "SCR´s and rectifier" it is rectified and then filtered in the "Low pass filter". The DC thus obtained is fed into the "Series regulator". This is the fine regulating device, from which the output power is fed through the "Output ammeter" to the "Output voltmeter", where the output current and voltage are indicated. After the meters the power is accessible through the terminals on the front panel and the 5- or 6-prong plug at the rear.

The output voltage is fed to the "Output Voltage Error Amplifier" (OVEA) through the "Output voltage" potentiometer (NORMAL-PROGR. Switch in "NORMAL" position) where it is divided in a ratio determined by the setting of the potentiometer. This voltage is compared with the "Voltage reference" in "OVEA". If any output voltage error is present, it is amplified here, fed through the "Series Regulator Driver", which is mainly a current amplifier, to the "Series Regulator", which corrects the output voltage.

When the power supply is connected for remote sensing, the "OVEA" senses the voltage at the points where the sensing cables (from the "REMOTE" terminals) are connected, instead of the voltage at the power terminals, marked "+" and "-". In this way long power cables can be used without losing regulation accuracy.

With the power supply operating in the programming mode the "Output voltage" potentiometer is shorted by the "NORMAL-PROGR." switch and replaced by an external resistor between the "REMOTE" and "-" terminals. This resistor works exactly in the same way as the internal "Output voltage" potentiometer.

Modulation is done by superimposing a current proportional to the modulating voltage on the current in the voltage divider from the "-" side "Remote" terminal to the "Voltage reference". The "OVEA" then will change the output voltage in such a way that the sum of the currents in the "Output Voltage" potentiometer, caused by the output voltage and by the modulating voltage, will be constant.

The "Current limit amplifier" senses the voltage caused by the output current in a given resistance and compares it with a variable "CL reference voltage". This voltage is controlled by the "Current limit" potentiometer. If the output current causes a voltage drop that is higher than the "CL reference voltage", the difference is voltage amplified in the "Current limit amplifier" and fed to the "Series regulator driver". Here it is current amplified and the output controls the "Series regulator" in such a way that the output current does not increase further. The "Series regulator" now maintains a constant output current which is essentially independent of the output voltage.

Because of the high power handling capability of these power supplies a pre-regulator has been included, which protects the series regulator from excessive power dissipation.

The pre-regulator consists of two silicon controlled Rectifiers (SCR´s) with associated timing and firing circuits.

The voltage across the series regulator is fed to the "Timing circuit", which gives a firing signal early every half period, if the voltage is low, and late if the voltage is high.

In the "Firing circuit" the firing signal is transformed to a series of pulses that are powerful enough to fire the SCR´s in the pre-regulator.

3. PRE-REGULATOR

The main idea of the pre-regulator is that it limits the power dissipation in the series transistors.

To explain why it is necessary to do so, take this example:

> If the C28-20R were designed in the common way without a pre-regulator the maximum power dissipation in the series transistors would be approximately 750 W with maximum line voltage and minimum output voltage at 20 A load current.
>
> With the pre-regulator the dissipation decreases to approximately 80 W at 20 A load current regardless of the line and output voltages.

The pre-regulator thus reduces the dissipation by about 10 times, which brings the number of series transistors and cooling arrangements within possible limits. Figure IV:2 shows a more detailed block diagram of the pre-regulator. Figure IV:3 shows the wave-forms at important points of the pre-regulator.

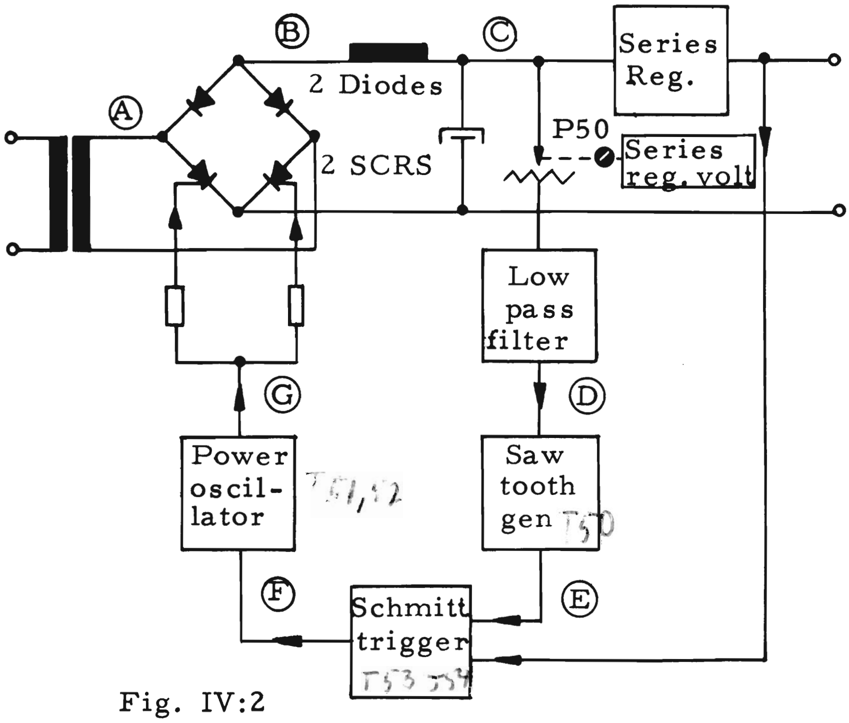


Fig. IV:2

Pre-regulator with SCR's and firing circuits

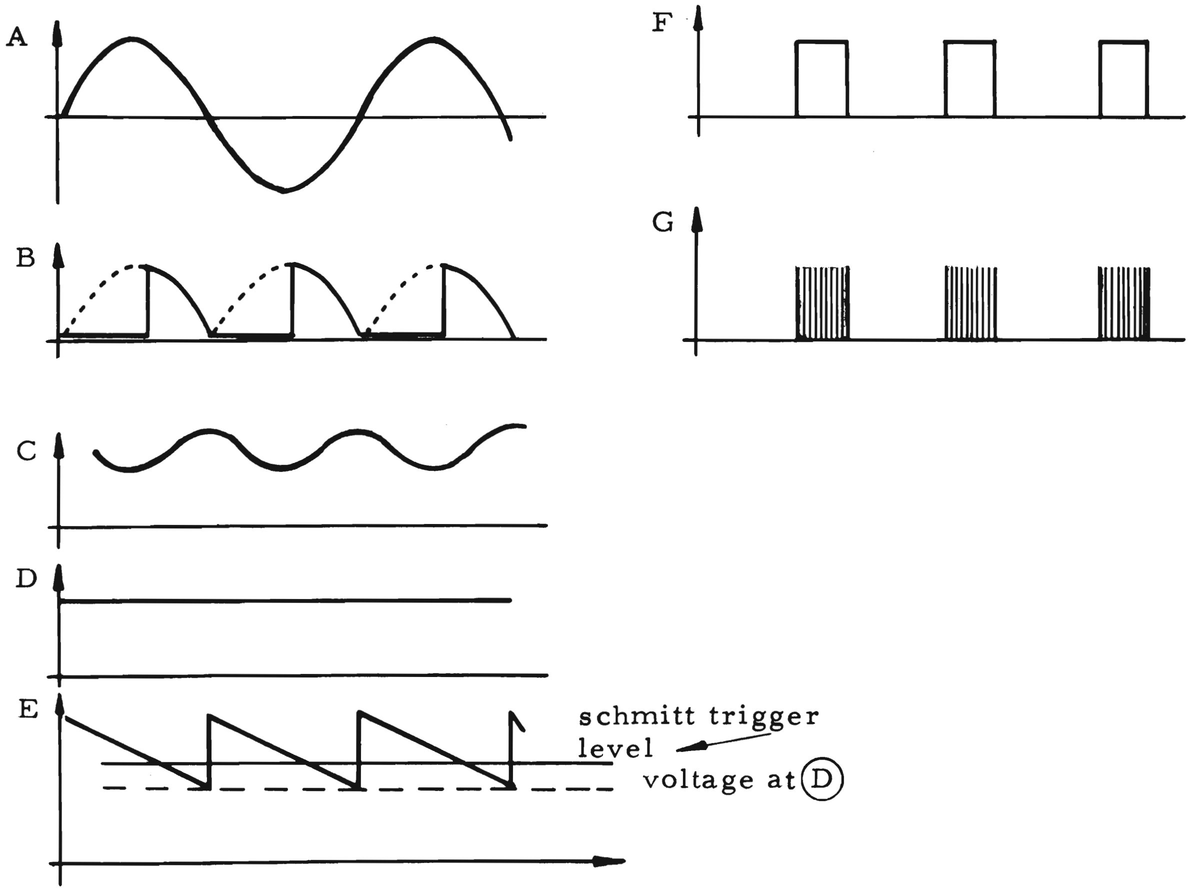


Fig. IV:3

Wave-forms in the pre-regulator

The voltage before the "Series regulator" i.e. at point C in figure IV:2 is fed to a "Low-pass filter" which filters the 100 Hz ripple and limits the high frequency response of the complete pre-regulator system. The latter function is necessary to make the pre-regulator stable. The voltage at point D is superimposed by a saw-tooth wave from the "Saw-tooth generator" which is synchronised to the line frequency in such a way that every half period it produces one tooth which starts when the line voltage passes the zero level. (See fig. IV:3)

As fig. IV:2 shows, a voltage over the series regulator superimposed by the saw-tooth wave is fed into the "Schmitt trigger". When this voltage is above the critical level at the "Schmitt trigger", the output is zero, but when it is below the critical level, the "Schmitt trigger" gives a pulse which starts the "Power oscillator".

The "Power oscillator" is a saturated core, push-pull oscillator working at about 10 kHz. The output from this oscillator is full-wave rectified so that the firing pulses is a train of positive pulses.

All firing pulses are applied to both the SCR´s because of simplicity. This is possible, because the SCR which is not expected to fire is reverse biased and thus is not influenced by unnecessary firing pulses.

If the voltage across the "Series regulator" decreases, figure IV:3 E shows that the trigger level is reached earlier every period and thus the SCR´s are fired earlier. More power is then delivered to the "Series regulator" which resets the voltage across it to the desired value.

P 50 is shown as "Series transistor voltage" trim in figure IV:2 and by means of it this voltage can be controlled.

Referring to the complete circuit diagram in section VII the "Saw-tooth generator" main parts are transistor T 50 the bridge rectifier D50-D53 and the capacitor C53. When the line voltage is not zero transistor T50 is cut off and C53 is charged through resistor R55. This charge function is essentially linear because the end voltage is well below the charging voltage.

When the line voltage passes zero T50 is opened and C53 is discharged through the small resistor R56.

The "Schmitt trigger" consists of transistors T53 and T54. The inputs are at the base and emitter of T54.

Transistors T51 and T52 together with transformer Tr2 forms the "power oscillator". The function of this type of saturated core, push-pull oscillator is well known, so it is not described here in detail.

The reason for using a "Power oscillator" between the "Schmitt trigger" instead of using the output pulse from the "Schmitt trigger" directly is this: When near maximum power is taken from the SCR´s the firing pulse appears very early every half period. The voltage across the SCR´s is then very low which might make the SCR´s refuse to fire. The continuous row of firing pulses from the "Power oscillator" assures that the SCR´s fire as soon as they possibly can after the moment when firing is wanted.

When a low power is taken from the pre-regulator the SCR´s are fired late every period, which means that the power supply consumes a certain amount of reactive power from the line (see figure IV:3B).

Figure IV:4 shows the relationship between the output voltage and the power factor (cos ϕ) of a C50-10R. This relationship is essentially independent of the output current.

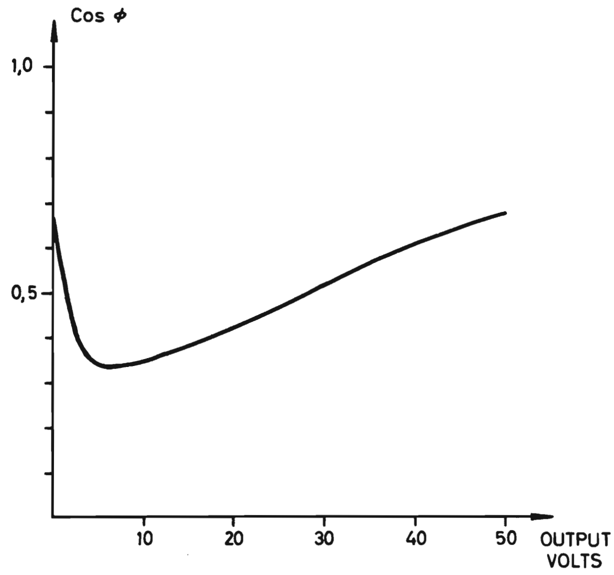


Fig. IV:4

Graph showing the relationship between the power factor (cos ϕ) and the output voltage.

5. SERIES REGULATOR DRIVER AND OVEA

The "Series regulator" is the output voltage (or current) fine regulator. It is driven by the "Output voltage error amplifier" (OVEA) through the "Series regulator driver".

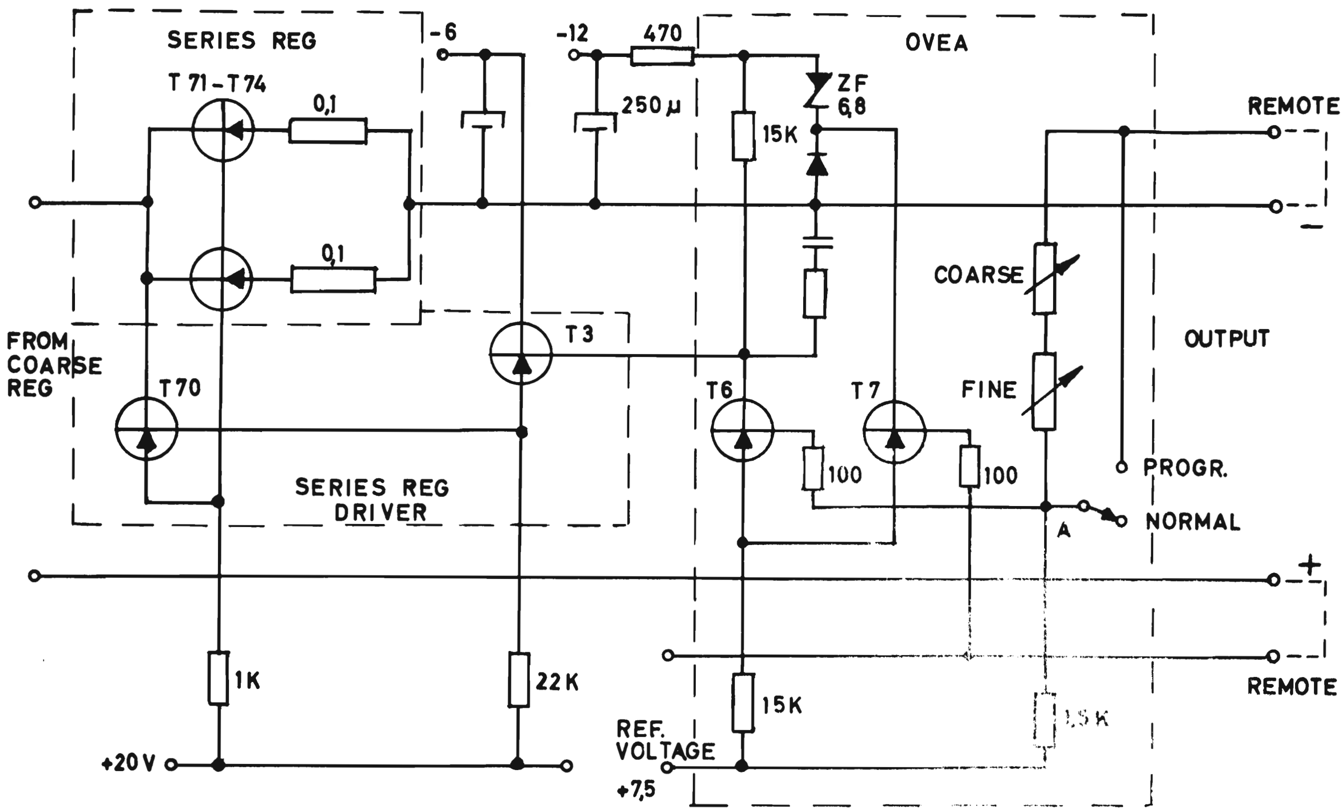


Fig. IV:5

Series regulator with driver and "OVEA". Diagram.

Fig. IV:5 shows the fine regulating circuit connected for normal operation (neither remote sensing nor programming).

The "Series regulator" consists of four parallel connected power transistors T71-T74. (Three in C32-16R, called T71-T73.) To achieve proper current dividing between them they have an emitter resistor each. T71 to T74 are mounted on a fan cooled heat sink. T70 is mounted on an ordinary mat oxidized heat sink.

The "OVEA" is a long-tailed pair T6-T7 because this circuit is simple, has a high voltage amplification and yet introduces a fairly low temperature drift. The RC-circuit in the T6 collector prevents high frequency oscillations.

The output voltage is fed to a voltage divider consisting of the coarse and the fine voltage potentiometers and the 1,5 kohms resistor connected to the "Reference voltage". The voltage at point A depends on both the setting of the output voltage controls, and on the actual output voltage. The long-tailed pair T6-T7 senses the voltage difference between the remote sensing rail (connected to output "+") and point A. This voltage difference should be zero. If not, the difference is voltage amplified in "OVEA", fed into the series regulator driver, consisting of the two current amplifying emitter followers T3 and T70, and finally changes the voltage at the bases of T71 to T74 in such a direction that the output voltage error is cancelled

When the instrument is program controlled, the jumper between "-" and "REMOTE" is disconnected and the "NORMAL-PROGR." switch is switched to the "PROGR." position. This switch overrides the "COARSE" and the "FINE" potentiometers and the output voltage is controlled by the external resistor between the terminals "REMOTE" and "-".

When remote sensing is used both the jumpers between "+" and "REMOTE" and "-" and "REMOTE" are removed and the two "REMOTE" terminals are connected to the points between which the power supply shall maintain a constant voltage. As shown by the diagram the "OVEA" now senses the voltage across these points and keeps it constant in the way described above.

6. CURRENT LIMIT

The current limit circuit is incorporated both to protect the load from excessive current and the instrument itself from destruction if the output is accidentally over-loaded.

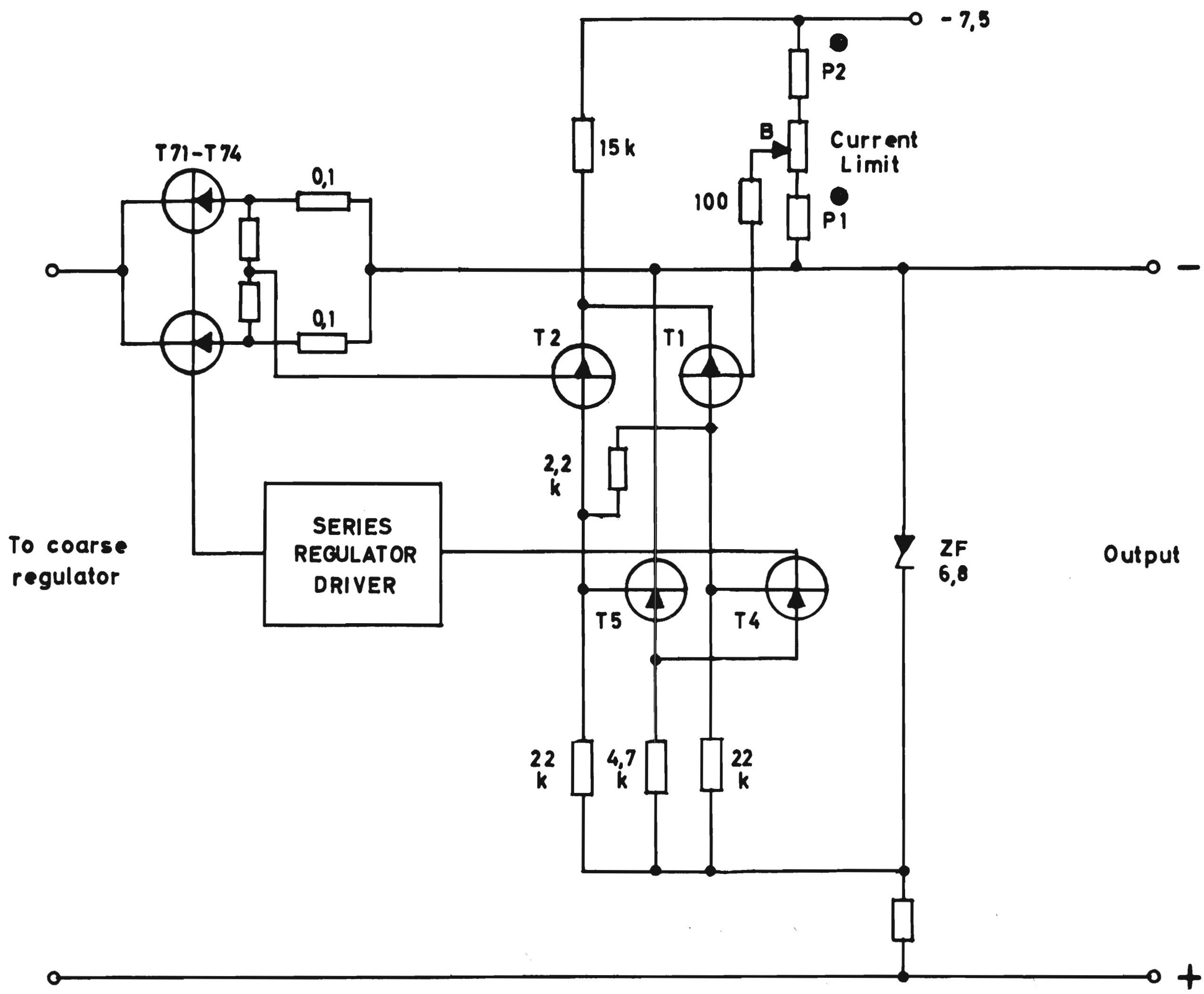


Fig. IV:6

Current limit. Diagram.

The current limit amplifier consists of two cascaded long-tailed pairs T1-T2 and T4-T5. This type of amplifier is used here because of the same reasons as in the "OVEA".

When output current flows, a certain voltage drop appears between the T71-T74 emitters and the junction between P1 and the output "-", mainly because of the 0,1 ohm resistors. This voltage is proportional to the output current. The current limit amplifier senses this voltage and compares it with the voltage at point B. At a low output current the B voltage is higher (more negative) than the voltage at the T71-T74 emitters. T2 is then conducting and T1 cut off, which in turn causes T5 to conduct and T4 to be cut off. In this case the current limit amplifier does not effect the series regulator driver. If the output current increases the voltage at the T71-T74 emitters increases and above a certain output current, this voltage is higher (more negative) than the voltage at B. Now T2 is cut off and T1 is conducting, causing T4 to conduct which in turn cuts the series regulator via the "Series regulator driver", until the output current decreases to a value corresponding to the setting of the "Current limit" control.

7. VOLTAGE REFERENCE

To achieve a high stability voltage reference the following circuit is used.

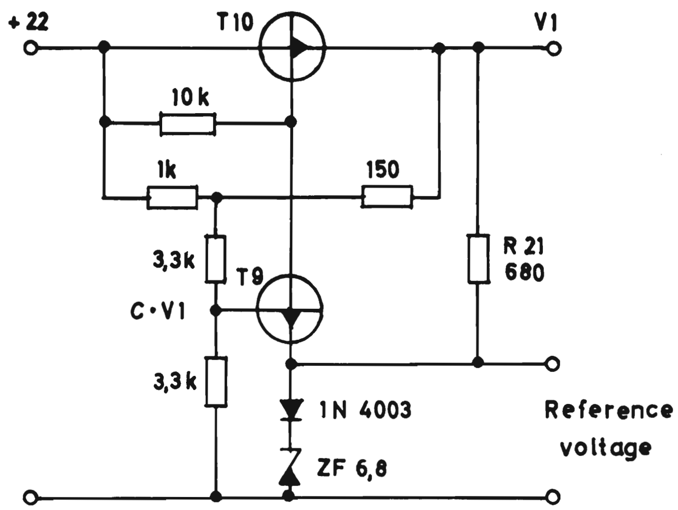


Fig. IV:7

Voltage reference. Diagram.

The reference element in C50-10R, C32-16R and C28-20R is a zener diode ZF 6,8. To get a maximally stable reference voltage from it a two transistor (T9-T10) circuit has been included, which stabilizes the current through the zener diode. This is essential because, even though the dynamic resistance of a zener diode is low, it is not low enough to be neglected when a very high stability reference voltage is needed.

The 1N 4003 silicon diode compensates for the temperature drift in the zener diode.

The T9-T10 stabilizing circuit, is the most common circuit used for voltage stabilizing purposes. The reference voltage is balanced against c · V1 by applying these voltages to the emitter and base of T9 respectively. This voltage can be regarded as an error voltage controlling the DC amplifier T9. The output from this amplifier controls the base of T10 in such a way that V1 is kept constant. From this constant voltage a current is taken to the reference diode via R21. The current through T9 is negligible compared with the current through R21. The current through the zener diode is thus kept almost constant.

8. REMAINING CIRCUITS

The rectifier across the output D90 protects the instrument from reversed polarity voltages. The rectifier D91 and the transistor T8 save the load from the high output voltages otherwise occurring, if the remote terminals are accidentally left open.

The rest of the circuits are straight-forward and need no explanation.

SECTION V.

MAINTENANCE.

1. GENERAL

This section contains information on maintenance and repair of the Oltronix C50-10R, C32-16R and C28-20R range of Regulated Power Supplies.

These Power Supplies are fully equipped with semiconductors and under normal operating conditions require little or no maintenance throughout their lives. Do not troubleshoot this instrument without carefully studying the troubleshooting information given in this manual. Changing an adjustment setting accidentally might involve considerable alignment time. Switch off the instrument when replacing any component.

2. FRONT PANEL PERFORMANCE CHECK

The table below describes a function check which can be performed with the instrument in its cabinet without additional equipment. These tests will establish that the instrument is operating normally. A complete performance test is described in paragraph V:6.

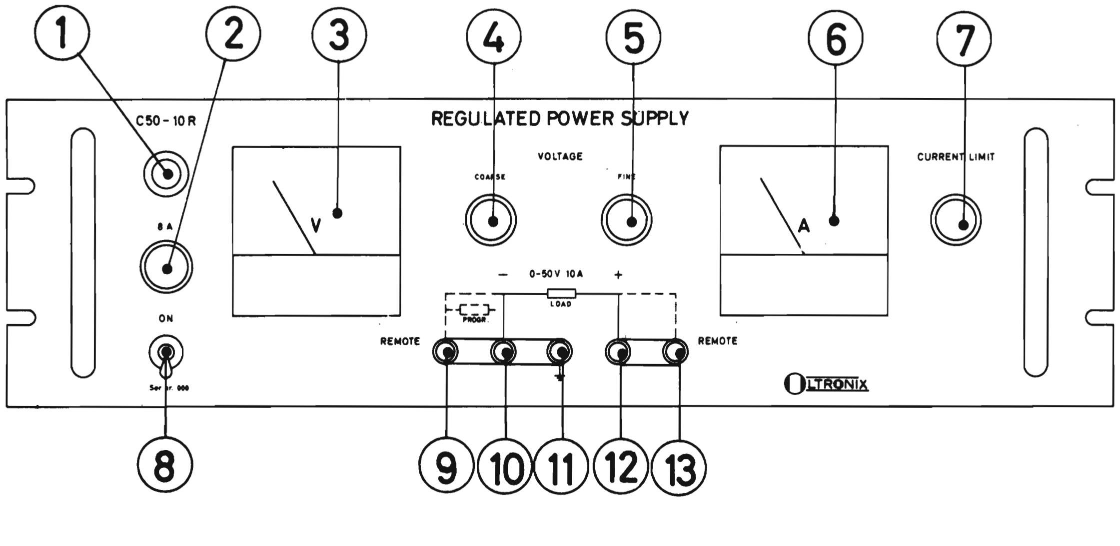


Fig. V:1

Front panel check C50-10R, C32-16R and C28-20R

1. Turn the "Voltage" controls (4, 5) fully CCW and the "Current Limit" (7) fully CW. Jumpers as shown in the figure.
2. Switch on the power supply (8).

<u>Normal operation</u>

3. Increase the output voltage (4, 5) slowly, checking that the voltmeter (3) tracks the voltage control approximately.
4. Decrease the voltage stepwise with the same controls. Check that the faint but audible hiss caused by the firing pulses disappears for a few seconds after every step.
5. Connect an external resistor giving 100% output current to the "+" and "-" terminals (10, 12). Increase the voltage watching both the voltmeter and the ammeter.

6. Turn the "Current Limit" (7) slowly CCW watching that the ammeter tracks the scale of the "Current Limit" control approximately.

Programming

7. Switch off the power supply (8).

8. Slide the "Normal-progr." switch at the rear to "Progr."

9. Disconnect the jumper between (9) and (10) and connect a potentiometer C50-10R: 10 kohms, C32-16R: 6,4 kohms and C28-20R: 5,6 kohms between the same terminals. Switch on the power supply.

10. Increase the potentiometer resistance slowly watching the voltmeter reading to increase from 0% for 0 ohm resistance to 100% for full potentiometer resistance.

Remote sensing

11. Switch off the power supply.

12. Connect the load resistor by means of long power cables according to "III: Operation instruction", "Remote Sensing". Select cables that will give approx. 0,5 V drop each for full output current.

13. Interrupt the load current at the load (with the sensing cable still connected to the power cable) watching the voltmeter for a slight (1 volt) negative voltage jump.

3. CABINET REMOVAL

The cabinet of the rack models is removed as follows.

a. Turn the instrument upside down.

b. Unscrew the four M 4 bolts.

c. Place the power supply upright on front panel handles.

d. Pull the cabinet upwards from the chassis.

e. Take away the bottom panel.

4. VISUAL INSPECTION

The power supply should be inspected once or twice a year for possible circuit defects. These defects may include loose or broken connections, broken PC-circuit, burned components and many others. The cure for most of these faults is obvious but special care must be taken when burned components are observed. This kind of fault often indicates that there is another and perhaps less obvious fault in the instrument. Therefore it is essential to find out what has caused the actual component to overheat before it is replaced.

Also inspect the fan motor for free running. Lubricate the bearings with a few drops of light machine oil.

5. ALIGNMENT PROCEDURE

Figures V:2 to V:4 in this paragraph describe the main part of the alignment procedure. This alignment is completed when the power supply is delivered from the factory. Though it is unlikely that the power supply will fall out of trim when used under normal operating conditions, it is advisable to check alignment once a year to be sure it fullfills the specification.

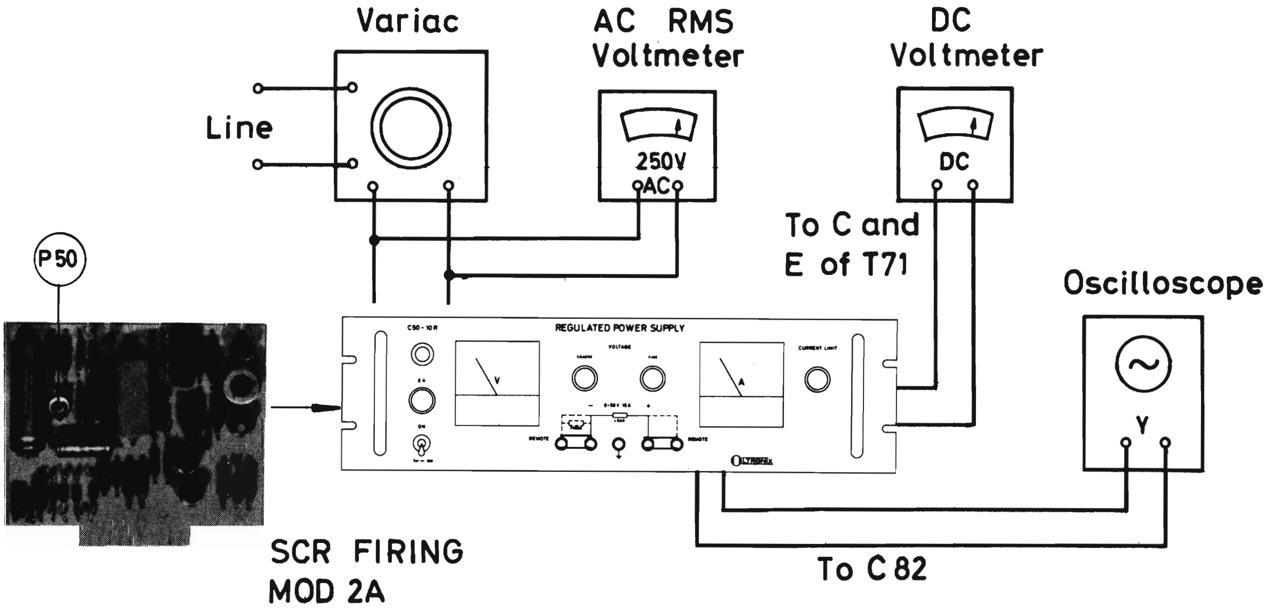
After replacing components it is necessary to check the circuits concerned, especially after transistor replacements. Further information on necessary tests is given in table V:1.

Do not make any adjustment if the test values are within specification.

For "Identification of components" see section V paragraph 8.

Table V:1. Checks after transistor replacements.

Transistor (SCR) replaced	Check	Refer to
T70, T71, T72, T73, T74	Insulation, transistor to chassis	
	Load regulation	Paragraph V:6
T3	Load regulation	Paragraph V:6
T1, T2, T4, T5	Current limit	Figure V:3
T6, T7	Programming	Figure V:4
	Line voltage regulation	Paragraph V:6
	Load regulation	Paragraph V:6
	Ripple	Paragraph V:6
	Long term stability	Paragraph V:7
	NB T6 and T7 must be a pair matched for V_{BE}. If one only needs replacement it is strongly recommended to replace both by a new matched pair. Such a pair can be ordered from the factory.	
T50, T51, T52, T53, T54	Pre-regulator	Figure V:2
T9, T10	Programming	Figure V:4
	Line voltage regulation	Paragraph V:6
D82, D83	Insulation SCR to chassis	
	Pre-regulator	Figure V:2



1. Connect the Power Supply as shown.

2. Connect a DC voltmeter across one of the series transistors.

3. Adjust the variac for 220 V power.

4. Turn the CURRENT LIMIT control fully CW.

5. Switch on the power supply.

6. Adjust the voltage controls for 50 % output voltage (that is 25, 16 or 14V).

7. Connect a load resistor that causes approximately 10 % load current (50, 20 and 14 ohms resp.). The voltage across the series regulator shall be approx. C50-10R: 10 V; C32-16R: 9,0 V and C28-20R: 9,0 V). If the voltage is considerably higher the pre-regulator is not working and the load current MUST NOT be increased further.

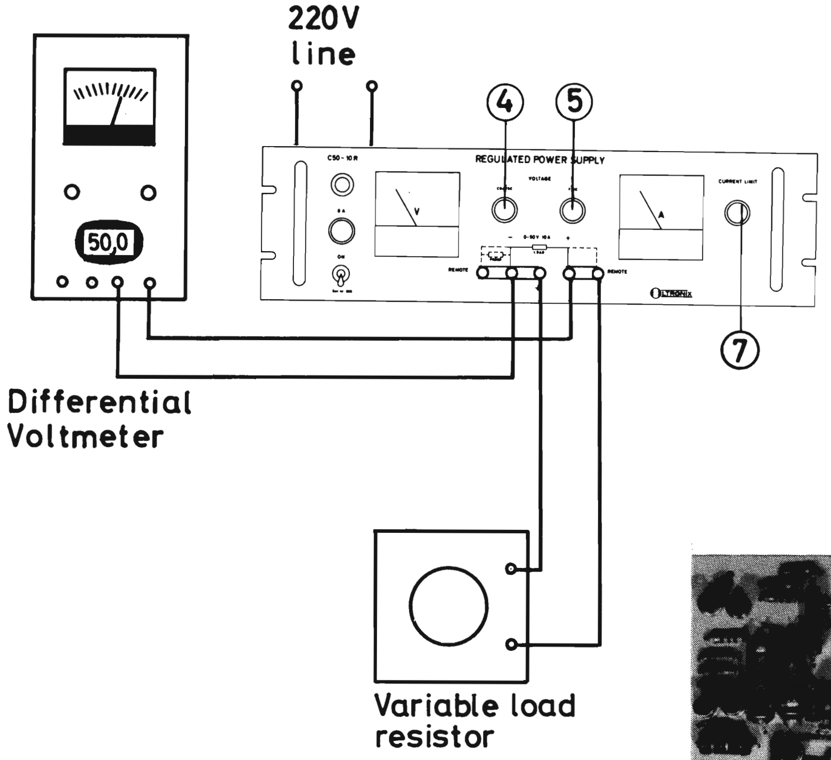
8. Increase the load current to 100 %. Adjust P50 for a voltage over the series transistor of C50-10R: 6,5 V, C32-16R: 4,0 V and C28-20R: 4,0 V.

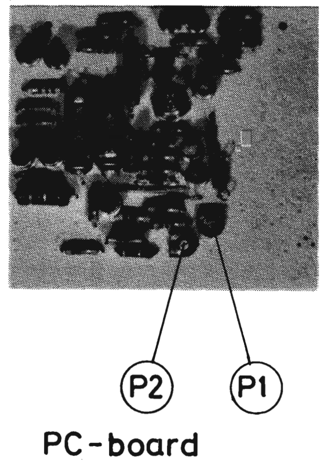
9. Connect an AC oscilloscope across C82. Set the voltage controls at maximum, the current limit at 100 % and connect a variable resistor load. Decrease the load resistance slowly to zero, observing the ripple on the oscilloscope. If the ripple tends to switch over to 50 Hz or 33 Hz, increase the voltage across the series transistors. The following values must not be exceeded at 50 % output voltage and 100 % current. C50-10R: 7,3 V, C32-16R: 4,5 V and C28-20R: 4,5 V.

10. Vary the line voltage from 200-240 V with 50 % output voltage and 100 % load. The voltage across the series transistors must not vary more than ± 0,25 V.

Fig. V:2.

Pre-regulator adjustment. The voltmeters should be of 1 % tolerance or less.





1. Connect the power supply as shown.

2. Set the CURRENT LIMIT control fully CW (7).

3. Set the output voltage (4, 5) to 100% (50, 32 and 28 volts respectively).

4. Adjust the load resistor for 100% output current.

5. Adjust the differential voltmeter for 0 deflection.

6. Set the CURRENT LIMIT control 100%.

7. Adjust P2 for a 5-10 mV deflection on the differential voltmeter.

8. Set the CURRENT LIMIT control to 10%.

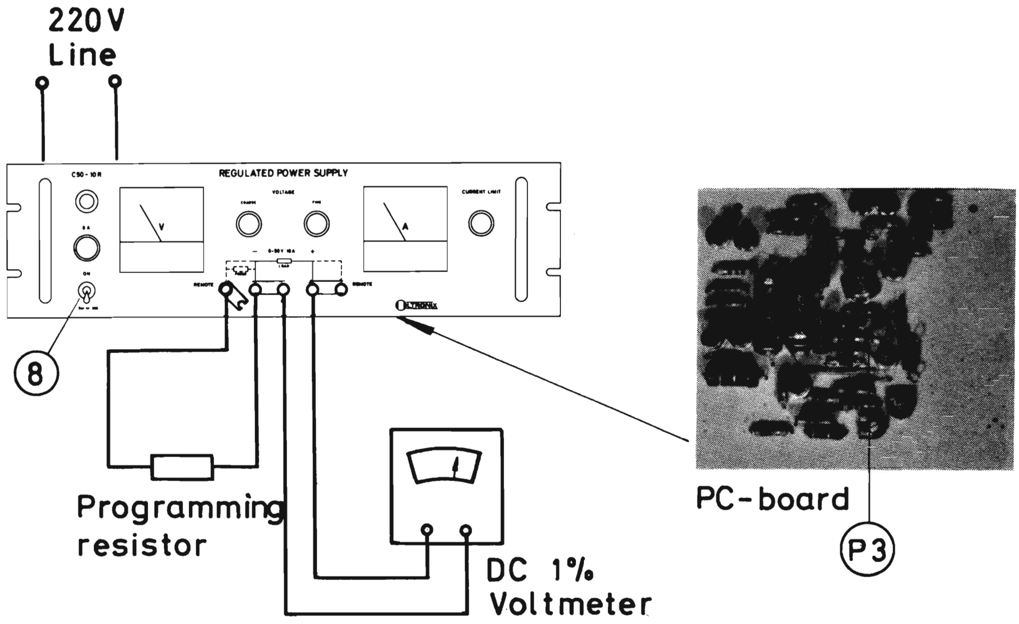
9. Adjust P1 for 10% output current.

10. Repeat numbers 6/, 7/, 8/ and 9/ until the CURRENT LIMIT control is calibrated at both 10% and 100%.

11. If it is not possible to calibrate as described above, replace T1 with T2 and vice versa. If still not possible suspect transistors T1, T2, T4, T5 and -12 V auxiliary power supply.

Fig. V:3

Current limit calibration. The differential voltmeter can be replaced by a digital voltmeter or by an arrangement shown in fig. V:5.



	Programming resistor		Output voltage	
	a	b	a	b
50 V model	1 kohms	10 kohms	5 V	50 V
32 and 28 V models	0,5 kohms	5 kohms	2,5 V	25 V

1. Check that the AC power is switched off (8).

2. Switch the NORMAL-PROGR. slide switch for programming operation. It is placed at the instrument rear.

3. Connect the power supply to the external voltmeter as shown and disconnect the jumper between "-" and minus side REMOTE terminals.

4. Connect the programming resistor "a" (table above) as shown.
   NB. The table above is for power supplies with the standard constant 200 ohms/volt. For other programming constants use the formula: R = Voltage desired x programming constant.

5. Switch ON the power supply.

6. Adjust the output voltage according to the table above with the potentiometer P3.

7. Switch off the power supply.

8. Replace the programming resistor "a" with the "b" one. Switch on the power supply and check the output voltage. It should be as shown in the table above. If it is not, readjust P3 for minimum error at both high and low voltages. If the error is too big replace T6 and T7.

NB. NEVER LEAVE THE PROGRAMMING TERMINALS OPEN WHEN THE POWER SUPPLY IS SWITCHED ON.

Fig. V:4.

Programming constant adjustment.

6. SHORT TERM PERFORMANCE CHECKS

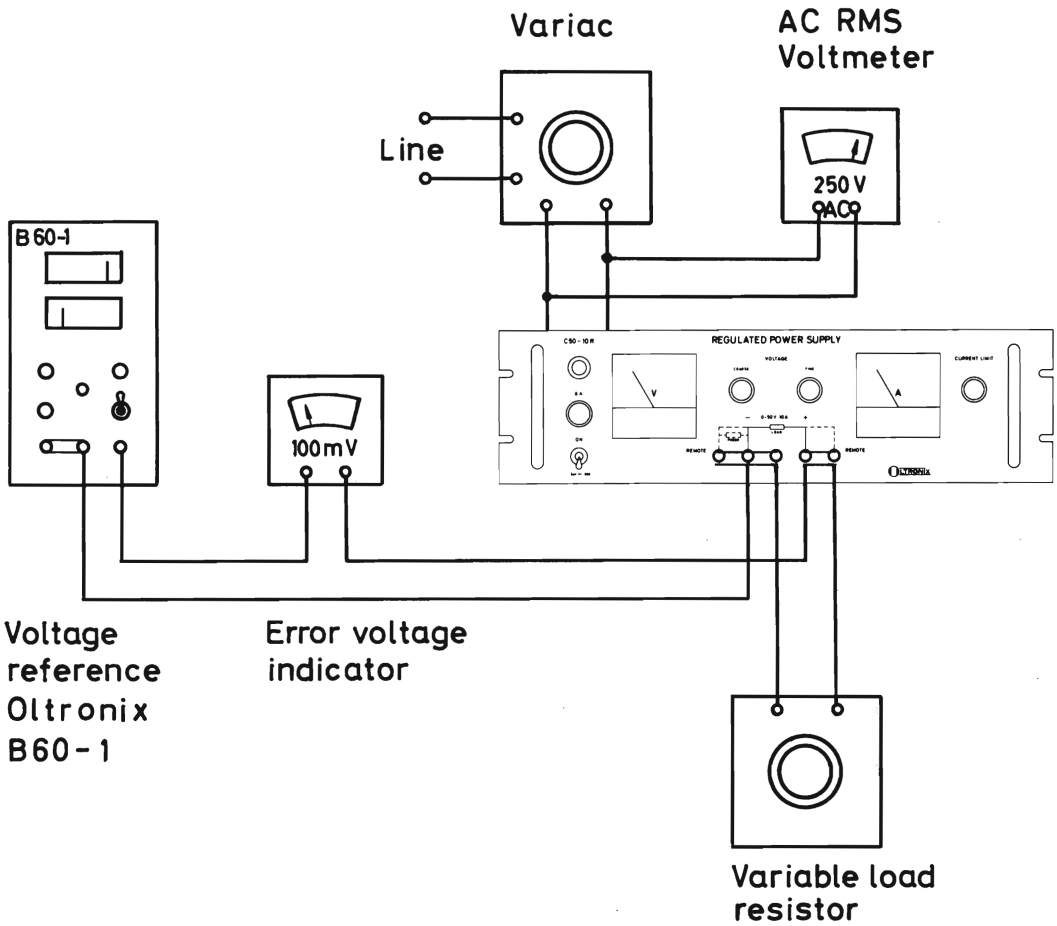


Fig. V:5.

Performance check. The voltage reference power supply and error voltage indicator can be replaced by a differential or a digital voltmeter.

<u>All short term performance checks</u>

a. Connect the power supply as shown.

b. Adjust the variac for 220 V power. Switch on.

c. Adjust the power supply for a 100 % output voltage and the load for 100 % output current.

d. Set the voltage reference for 1/2 scale deflection on the mV-meter.

<u>Line voltage regulation</u>

a. Adjust the variac for 240 V power input. Read the mV-meter deflection.

b. Adjust the variac for 200 V power input. Read the mV-meter deflection.

c. <u>Half</u> the difference between these two readings is the power supply regulation for 10 % line voltage variation.

d. If not within specifications replace transistors T6 and T7 then T9 and T10 then finally the reference diode Z4 (ZF 6, 8). Recheck the regulation after each replacement.

Load regulation

a. Adjust the variac for 220 V power. Read the mV-meter.

b. Disconnect the load. Read the mV-meter.

c. The difference between these two readings is the load regulation.

d. If not within specifications replace T6 and T7. Recheck line and load regulations.

Ripple

a. Connect a load resistor for 100 % output current.

b. Measure the output ripple by means of an AC RMS voltmeter connected across the output.

NB. Always start with the line regulation check, because when it fulfils the specification, the load regulation and the ripple tests seldom cause any trouble.

7. LONG TERM STABILITY CHECK

This test is necessary only when long term stability is really needed.

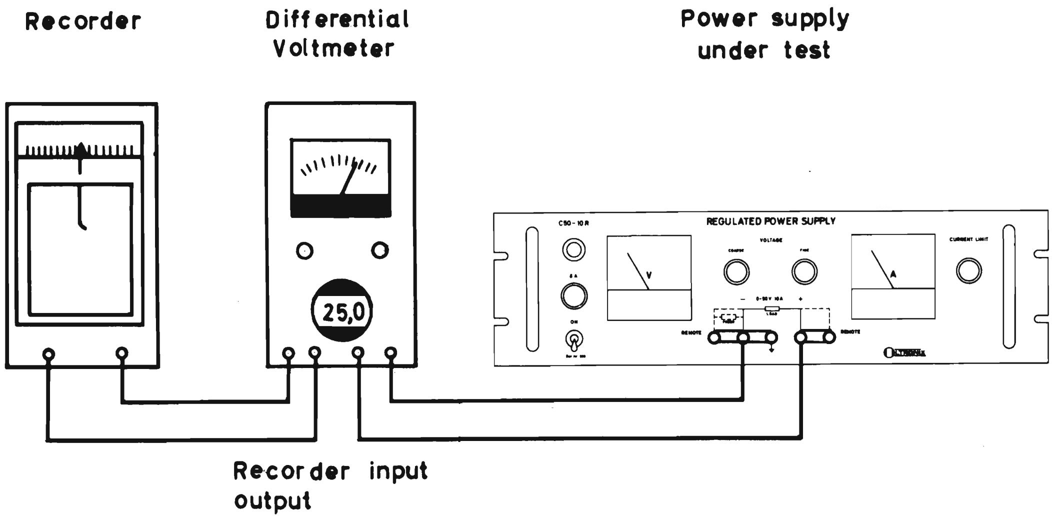


Fig. V:6.

Long term stability check. The differential voltmeter can be replaced by an arrangement similar to the one in fig. V:5.

a. Connect the power supply as shown. Switch on.

b. Adjust the power supply for 25 V on the 32 and 28 V models and for 50 V on the 50 V model.

c. Adjust the differential voltmeter for 1/2 scale deflection on the recorder.

d. Start the recorder and continue the test for a few hours at constant ambient temperature.

e. If the drift is not within specifications replace T6 and T7 then T9 and T10 and finally the reference diode Z4 (ZF 6, 8). Check the long term stability after each replacement until the drift is within specifications.

f. Recheck the short term performance after component replacement.

8. IDENTIFICATION OF COMPONENTS

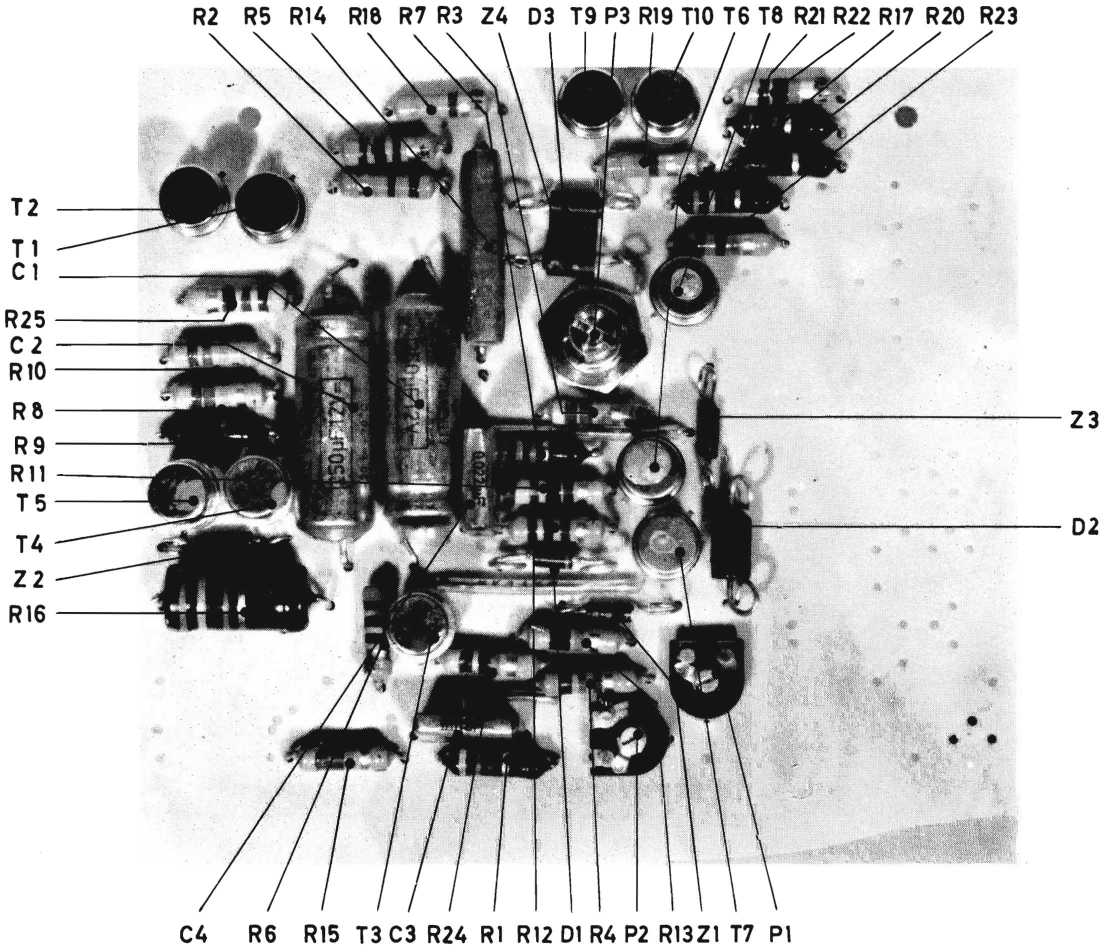
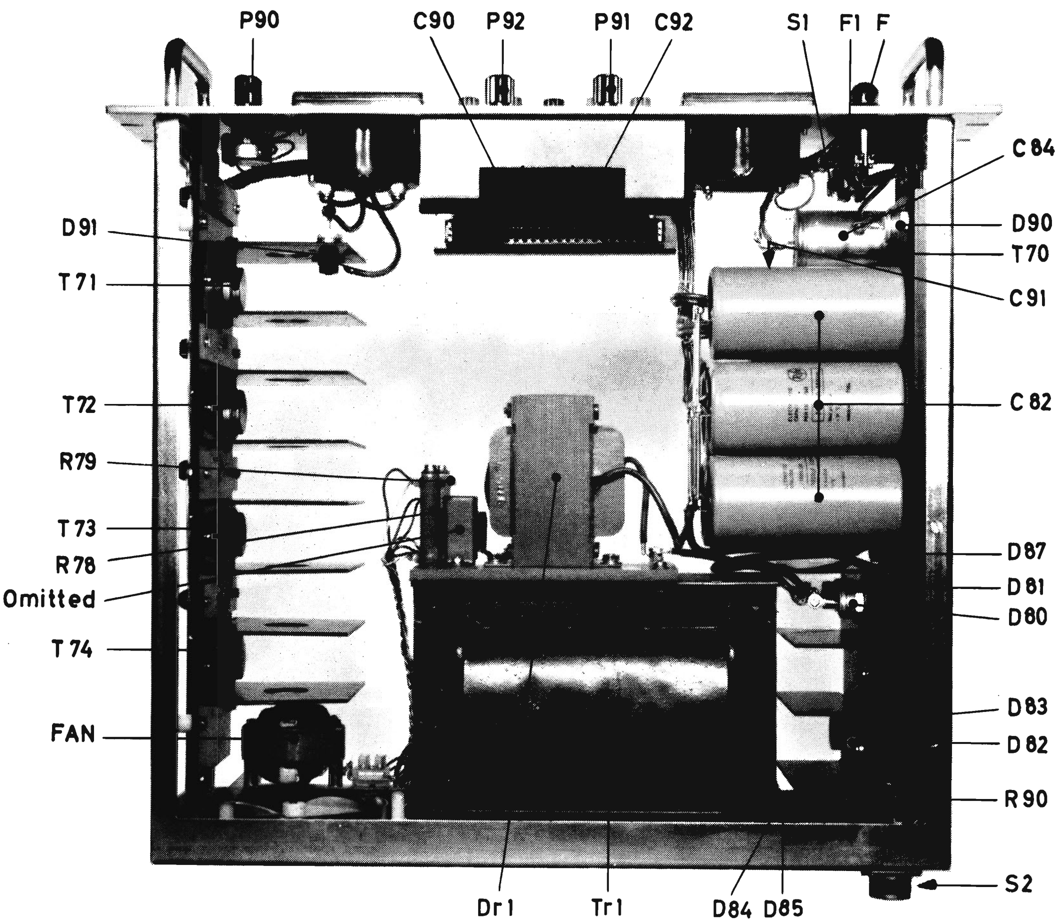
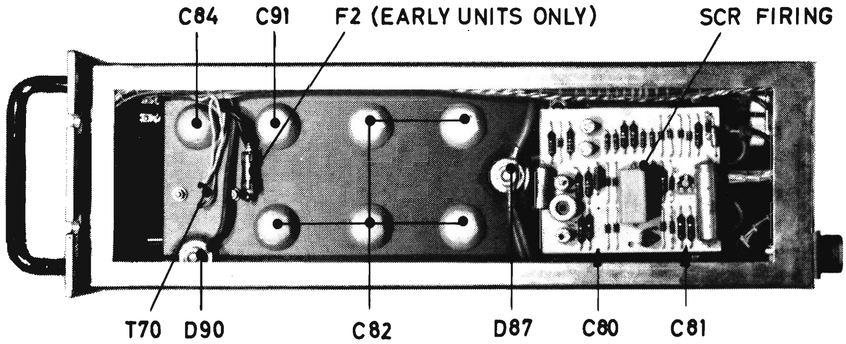


Fig. V:7.

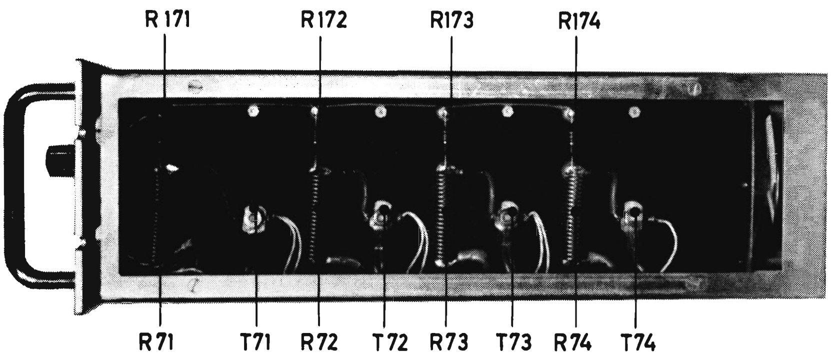
Identification of components. Printed circuit board "C56", all models.



Top view



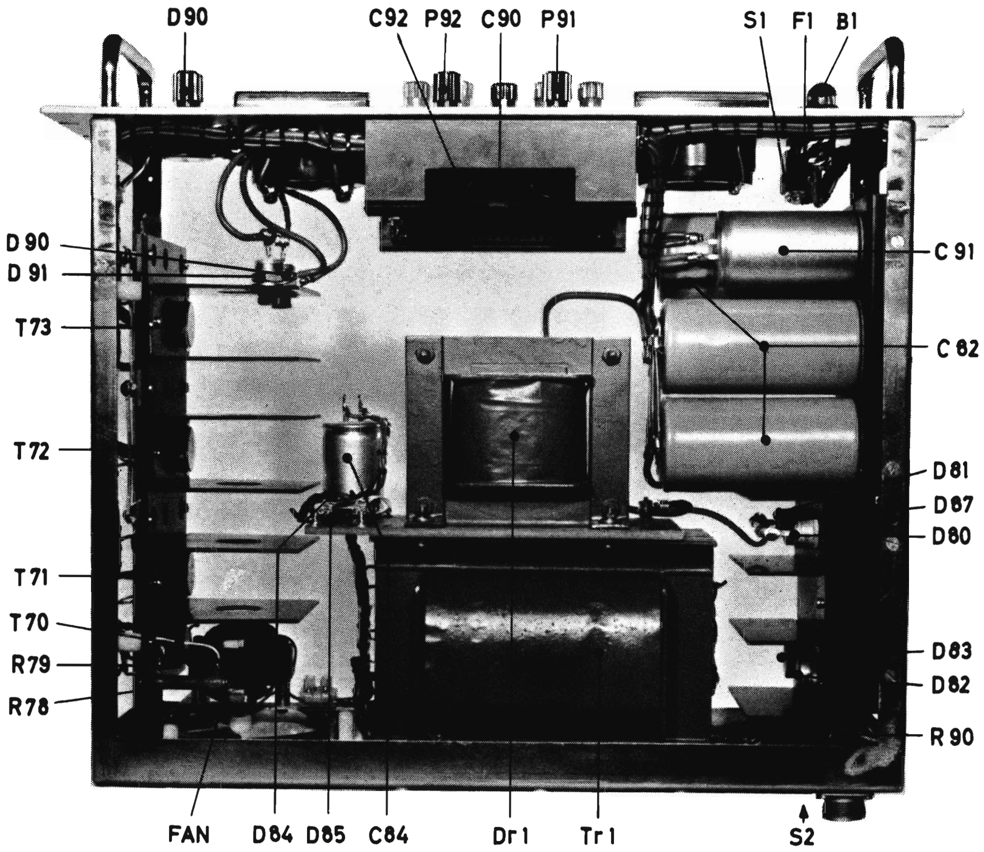
Left hand view



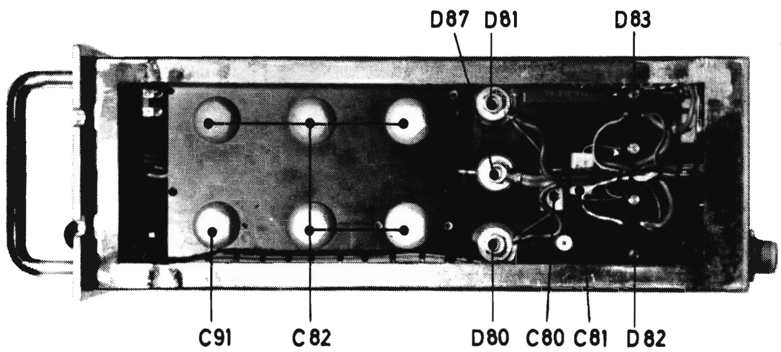
Right hand view

Fig. V:8.

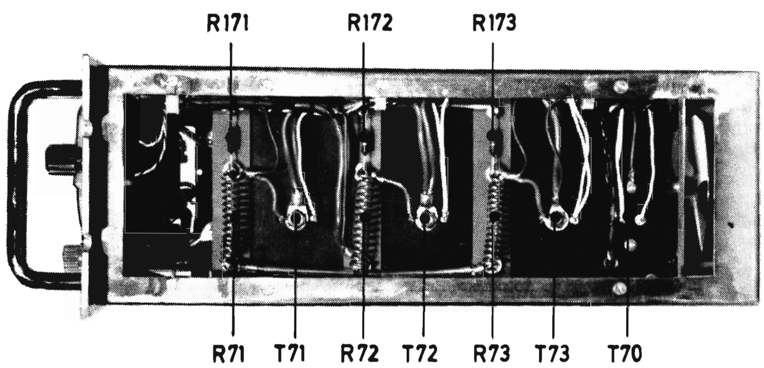
Identification of components. Top, left hand and right hand views of C50-10R and C28-20R.



Top view



Left hand view



Right hand view

Fig. V:9.

Identification of components. Top, left hand and right hand views of C32-16R.

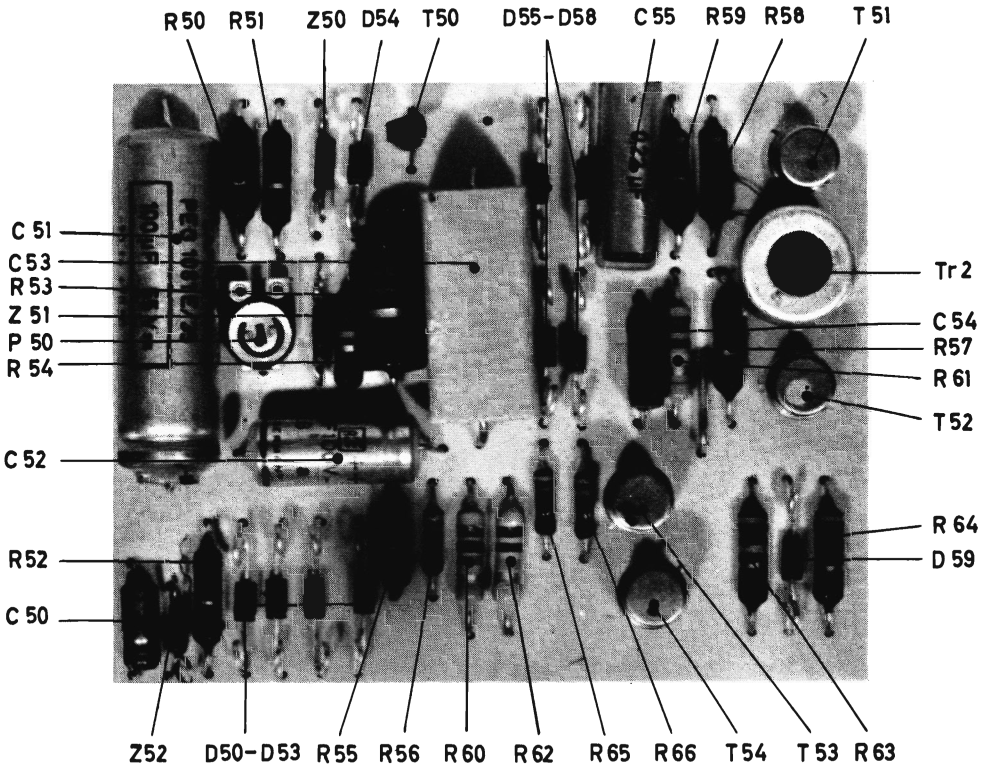


Fig. V:10.

Identification of components. Printed circuit board SCR FIRING MOD 2A.

SECTION VI.

TROUBLESHOOTING.

1. GENERAL

This section provides information about Oltronix Regulated Power Supplies C50-10R, C32-16R and C28-20R that will enable an efficient troubleshooting in event of equipment failure.

Before troubleshooting the power supply study the rest of this instruction manual, especially section IV "CIRCUIT DESCRIPTION", in order to become familiar with the principles of operation.

We have not attempted to give a complete detailed step-by-step instruction for finding the cause of all possible troubles. This guide rather gives a check schedule that leads the fastest way to detect the most probable cause of the actual trouble.

If a burned component is found, special care has to be taken. This kind of fault often indicates that there is another fault in the circuit too. Be sure to find out what has caused the component to burn before it is replaced. Before starting a detailed troubleshooting, make sure that an apparent trouble is actually due to malfunction within the power supply and not due to improper control setting. Operation instructions are given in section III. Do not forget to check that the NORMAL-PROGR. switch at the rear is in correct position.

2. FAULT FINDING

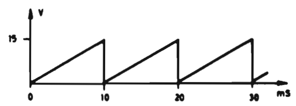
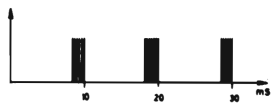
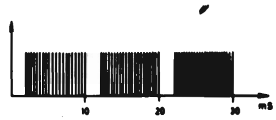
Equipment needed: DC-voltmeter, AC-voltmeter and Oscilloscope.

The test pattern is divided into two tables: Always start with table VI:1 "Action check" and proceed with the tests in numerical order until a faulty reading is detected. The column "Fault location check No" gives a reference number to table VI:2 "Fault location check". The corresponding checks in this table should then be performed. When the table gives a number of components to check, these are mentioned in such an order that the component, which is most likely to be faulty, is mentioned first.

The values indicated in the tables are typical values which vary slightly from instrument to instrument. Some of the readings are also depending on the line voltage. If the line voltage is more than a few percent off its nominal value, use a variac and adjust it for correct voltage.

Oscillations may sometimes appear after a transistor replacement. It is not possible to give a complete instruction on how these should be cured. In general the RC combination R7-C4 is the filter for the voltage stabilizing mode, while C3 is the filter for the current limit mode. If the oscillations cannot be creased by small adjustments on these filters, the power supply should be returned to the Oltronix factory for examination.

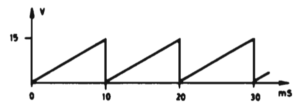
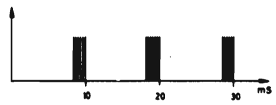
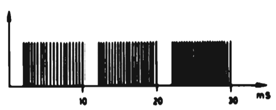
ACTION CHECK C50-10R

Ref. No.	Important control settings	Test equipment and connections	Correct reading	Fault location check No.
0		Line voltage	220V	
I	VOLTAGE 50V CURRENT LIMIT 10A	Output voltmeter	50V	A
	Switch on	DC voltmeter across T71-T74	approx 25V If it is much higher, do not decrease the OUTPUT VOLTAGE control below 50V Continue with II	
II	As in I	DC voltmeter across C51	34V	B
		DC voltmeter T54 emitter to junction R57-R64	.12V	C
		Oscilloscope across C53		D
		Oscilloscope junction R65-R66 to output "+"		E
III	VOLTAGE 25V CURRENT LIMIT 10A Connect load for 10A output current	DC voltmeter collector-emitter T71-T74 (Adjust P50)	Approx 6,5V (5,5 – 7,3V)	F
			Also check that the current limit works	G
IV	As in III	Oscilloscope across C82 Decrease the load resistor steady to zero	Check that the ripple on C84 does not tend to switch over to 50 Hz or 33 Hz	H
V	As in III	As in III. Vary the line voltage from 200 – 240V	Voltage across T71-T74 should not vary more than 0,5V	K
VI	VOLTAGE 50V CURRENT LIMIT 10A Line voltage 200V connect load for 10A current	Oscilloscope junction R65-R66 to output "+"	 Check that a small gap exists in the puls train every 10 mS	L
				cont'd.

ACTION CHECK C50-10R, cont´d

Ref. No.	Important control settings	Test equipment and connections	Correct reading	Fault location check No.
VII	As in VI	As in VI Decrease the line voltage below 200V	Check that the gaps in the puls train disappears	M
VIII	VOLTAGE 2-3V CURRENT LIMIT 10A Short circuit the output	Output ammeter DC voltmeter across R71, R72 R73 and R74	10A Approx. 0,5V The four voltages should not differ more than 25%	N

ACTION CHECK C32-16R

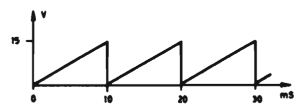
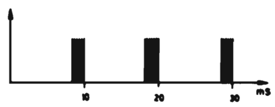
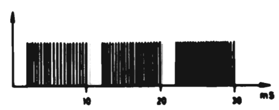
Ref. No.	Important control setting	Test equipment and connections	Correct reading	Fault location check No.
0		Line voltage	220V	
I	VOLTAGE 32V CURRENT LIMIT 16A	Output voltmeter	32V	A
	Switch on	DC voltmeter across T71-T73	approx. 15V If it is much higher, do not decrease the OUTPUT VOLTAGE control below 32V Continue with II	
II	As in I	DC voltmeter across C51	34V	B
		DC voltmeter T54 emitter to junction R57-R64	12V	C
		Oscilloscope across C53		D
		Oscilloscope junction R 65-R66 to output "+"		E
III	VOLTAGE 16V CURRENT LIMIT	DC voltmeter collector-emitter T71-T73. (Adjust P50).	approx. 4,0V (3,5-4,5V)	F
	Connect load for 16A output current		Also check that the current limit works	G
IV	As in III	Oscilloscope across C82 Decrease the load resistor steady to zero	Check that the ripple on C84 does not tend to switch over to 50 Hz or 33 Hz	H
V	As in III	As in III. Vary the line voltage from 200-240V	Voltage across T71-T73 should not vary more than 0,5V	K
VI	VOLTAGE 32V CURRENT LIMIT 16A Line voltage 200V Connect load for 16A current	Oscilloscope junction R65-R66 to output "+"	 Check that a small gap exists in the puls train every 10 mS	L

cont'd

ACTION CHECK C32-16R, cont´d

Ref. No.	Important control setting	Test equipment and connections	Correct reading	Fault location check No.
VII	As in VI	As in VI Decrease the line voltage below 200V	Check that the gaps in the puls train disappears	M
VIII	VOLTAGE 2-3V	Output ammeter	16A	
	CURRENT LIMIT 16A Short circuit the output	DC voltmeter across R71, R72 and R73	Approx. 0,5V The three voltages should not differ more than 25%	N

ACTION CHECK C28-20R

Ref. No.	Important control settings	Test equipment and connections	Correct reading	Fault location check No.
0		Line voltage	220V	
I	VOLTAGE 28V CURRENT LIMIT 20A	Output voltmeter	28V	A
	Switch on	DC voltmeter across T71-T74	approx. 15V If it is much higher, do not decrease the OUTPUT VOLTAGE control below 28V Continue with II	
II	As in I	DC voltmeter across C51	34V	B
		DC voltmeter T54 emitter to junction R57-R64	12V	C
		Oscilloscope across C53		D
		Oscilloscope junction R65-R66 to output "+"		E
III	VOLTAGE 14V CURRENT LIMIT 20A	DC voltmeter collector-emitter T71-T74. (Adjust P50).	approx. 4,0V (3,5-4,5V)	F
	Connect load for 20A output current		Also check that the current limit works	G
IV	As in III	Oscilloscope C82 Decrease the load resistor steady to zero	Check that the ripple on C84 does not tend to switch over to 50 Hz or 33 Hz	H
V	As in III	As in III. Vary the line voltage from 200-240V	Voltage across T71-T74 should not vary more than 0,5V	K
VI	VOLTAGE 28V CURRENT LIMIT 20A	Oscilloscope junction R65-R66 to output "+"		L
	Line voltage 200V Connect load for 20A current		Check that a small gap exists in the puls train every 10 mS	
				cont'd

ACTION CHECK C28-20R, cont´d

Ref. No.	Important control settings	Test equipment and connections	Correct reading	Fault location check No.
VII	As in VI	As in VI Decrease the line voltage below 200V	Check that the gaps in the puls train disappears	M
VIII	VOLTAGE 2-3V	Output ammeter	20A	
	CURRENT LIMIT 20A Short circuit the output	DC voltmeter across R71, R72, R73 and R74	approx. 0,5V The four voltages should not differ more than 25%	N

Table VI:

Fault location check, all models

No.	Symptom	Check	Correct reading	Suspect component
A:1	Output voltmeter reading above 100%	Transistors T71-T74 (T71-T73), T70, T3 and T7 for short circuit		
A:2	Output voltmeter reading low	NORMAL-PROGR. Switch	NORMAL position	
		Jumpers	See section III	
		Fuse F1		
		Transistors T6, T4 and T3		
		Voltage across C82 (voltage given for 0 output voltage)	C50-10R 10V C32-16R 8V C28-20R 8V If correct proceed to A:2b If low, go on to A:2c	
A:2b	As in A:2	Supply voltages across:		
		C1	12V	D84
		C2	6V	D84
		Z1 and D1	7,6V	Z1, D1
		C84	20V	D85
		Z4 and D3	7,6V	T9, T10, Z4, D3
		Z2	6,8V	Z2
A:2c	As in A:2	SCR´S for firing properties	Max. gate current 50mA SCR´s are roughly matched for firing current	D82-D83
B	DC voltmeter reading is low	Diodes D50-D53		D50-D53 C51
C	DC voltmeter reading is low	Prong L on firing card holder		D84
D	No saw-tooth voltage	T50 for short circuit		T50, D50-D53
E	No firing pulses	Short circuit collector to emitter of T53	Still no firing pulses. Continuous firing pulses start	T51, T52 T54, T53
				cont´d

Table VI

Fault location check, all models, cont´d

No.	Symptom	Check	Correct reading	Suspect component
F	Collector-emitter voltage outside specified range	Voltage across Z50 and Z51	6,8V each (12V each in C50-10R)	Z50, Z51, C52
G	Output current more than 110%	Voltage P90 to "+". Turn CURRENT LIMIT over its whole range	0,1 - 0,5V	P90, P1 and P2
		Voltage between bases of T4 and T5	Less than 0,3V	T1, T2 T4 and T5
H	The ripple contains 50 or 33 Hz ripple	Increase the voltage across T71 - T74	C50-10R:5,5-7,3V C32-16R:3,5-4,5V C28-20R:3,5-4,5V	C52
K	V_{CE} varies more than $\pm$ 0,25V	Increase (or decrease) V_{ce}, until correct reading is received	As above	
L	No gaps in the puls train	D80-D81 for high forward voltage drop		D80-D81
M	Puls train does not close	Replace T53 and T54		T53, T54
N	One voltage differs more than 25%	Check corresponding transistor	Voltage and current rating conforms with the actual OLTRONIX classification (eg H100, see Parts List and "Oltronix transistor idenfication code")	T71 - T74

SECTION VII.

PARTS LIST AND CIRCUIT DIAGRAM.

1. GENERAL

Replacement parts are available from the Oltronix factory. All standard parts can also be ordered through most well equipped component distributors.

Note that most transistors have a letter-number combination e.g. H 75 in the spare parts list in addition to the manufacturers number and the circuit reference designator. This combination indicates the quality of the transistor expressed in current amplification and maximum voltage. This description should always accompany the transistor when a replacement is ordered.

For further information on the classification refer to "Oltronix transistor identification code" which is found after the spare parts list.

When a pair of matched transistors is needed add "Matched" to the description. When ordering parts listed below state the following information for each part:

a. Model and serial number of the instrument.
b. Circuit reference designator
c. Type and value

For parts not listed below state:

a. Model and serial number of the instrument
b. Complete description of the part
c. Function and location of the part

2. ABBREVIATIONS

bri	= bridge rectifier	Mul	= Mullard
Car	= carbon	p	= pico or 10^{-12}
Cer	=ceramic	poly	= polystyrene
di	=diode	rec	= rectifier
EMC	= electrolytic, metal case	SCR	= Silicon Controlled Rectifier
F	= farad	Se	= selenium
Ge	= germanium	Si	= silicon
Int	= Intermetall	Sicar	= silicon carbide
k	= kilo or 10^3	SR	= Standard Radio
lin	= linear taper	STC	= Silicon Transistor Corp.
M	= mega or 10^6	TI	= Texas Instruments
Mfr	= manufacturer	Tele	= Telefunken
M & W	= Müller & Weigert	u	= micro or 10^{-6}
MF	= metal foil	V	= volts
Mo	= Motorola	W	= watts
MP	= metalized paper	WW	= wire wound
		Ze	= zener diode

3. SPARE PARTS LISTS

The spare parts list is divided into three parts. The first two cover the printed circuit boards "TYPE C56" and "SCR FIRING MOD 2A" and they are common to all the instruments. In case a value is different between the instruments in these parts it is noted by adding a letter to the circuit reference designator:

C84 a	means	50 V model only
C84 b	means	32 V model only
C84 c	means	28 V model only

The parts list contains:

Circuit reference designator
Parts description
Mfr and Mfr´s reference

a. Printed circuit board type C56

Capacitors

C1	250	uF	12V		EMC		F&T	
C2	250	uF	12V		EMC		F&T	
C3	0,01	uF	400V		MP		Rifa	Miniprint
C4	0,022	uF	400V		MP		Rifa	Miniprint

Diodes

D1	1N4003				Si	di	Mo	
D2ac	1N4003				Si	di	Mo	
D3	1N4003				Si	di	Mo	
Z1	ZF6,8		6,8V		Si	Ze	Int	
Z2	ZF6,8		6,8V		Si	Ze	Int	
Z3ac	ZF3,3		3,3V		Si	Ze	Int	
Z4	ZF6,8		6,8V		Si	Ze	Int	
or	ZF6,2		6,2V		Si	Ze	Int	

Potentiometers

P1	5	kohms	1/4W lin	20%	Car		Tele	GSa887
P2	100	ohms	1/4W lin	20%	Car		Tele	GSa887
P3	500	ohms	2W lin	10%	WW		Clarostat	43

Resistors

All resistors are Beyschlag, 1/3W, 5%, carbon, unless otherwise noted.

R1	470	ohms					
R2	15	kohms					
R3ab	22	kohms					
R3c	15	kohms					
R4	6,8	kohms					
R5	100	ohms					
R6	100	ohms					
R7	680	ohms					
R8	22	kohms					
R9	4,7	kohms					
R10	22	kohms					
R11	100	ohms					
R12	100	ohms					
R13a	10	kohms					
R13c	6,8	kohms					
R14	1,25	kohms	4 W	5%	WW	Vithrom	CZ
R15	22	kohms					
R16	6,8	kohms	1 W	5%	Car	Beyschlag	
R17	1,0	kohms					
R18	3,3	kohms					
R19	3,3	kohms					
R20	150	ohms					
R21	680	ohms					
R22	10	kohms					
R23	15	kohms					
R24	10	kohms					
R25	2,2	kohms					

Transistors

T1	2N 3710		NPN	Si	TI	
or	2N 1304		NPN	Ge	TI	
T2	2N 3710		NPN	Si	TI	
or	2N 1304		NPN	Ge	TI	
T3	ACY 17	H25	PNP	Ge	Mul	
or	2N 3702		PNP	Si	TI	
T4	ACY 17	H25	PNP	Ge	Mul	
or	2N 3702		PNP	Si	TI	
T5	ACY 17	H25	PNP	Ge	Mul	
or	2N 3702		PNP	Si	TI	
T6ab	2S 302	L90	PNP	Si	TI	T6 and T7
or	2N 3702		PNP	Si	TI	are a
T6c	ACY 17	H50	PNP	Ge	Mul	matched
or	2N 3702		PNP	Si	TI	pair
T7ab	2S 302	L90	PNP	Si	TI	
or	2N 3702		PNP	Si	TI	
T7c	ACY 17	H50	PNP	Ge	Mul	
or	2N 3702		PNP	Si	TI	
T8a	2S 302	L90	PNP	Si	TI	
or	2N 3702		PNP	Si	TI	
T8c	ACY 17	H50	PNP	Ge	Mul	
or	2N 3702		PNP	Si	TI	
T9	2N 3710		NPN	Si	TI	
or	2N 1302		NPN	Ge	TI	
T10	2N 3710		NPN	Si	TI	
or	2N 1304		NPN	Ge	TI	

b. Printed circuit board "SCR FIRING MOD 2".

Capacitors

C50	4	uF	40V	EMC	Philips	C426
C51	100	uF	55V	EMC	Rifa	PEG 1081 E/35
C52	10	uF	100V	EMC	ROE	EB
C53	2	uF	160V	MP	Philips	C281 W
C54	100	pF	500V	Mica	El-Menco	
C55	0,22	uF	400	MP	Rifa	Miniprint

Diodes

D50	1N4003		Si	di	Mo
D51	1N4003		Si	di	Mo
D52	1N4003		Si	di	Mo
D53	1N4003		Si	di	Mo
D54	1N4003		Si	di	Mo
D55	1N4003		Si	di	Mo
D56	1N4003		Si	di	Mo
D57	1N4003		Si	di	Mo
D58	1N4003		Si	di	Mo
D59	1N4003		Si	di	Mo
Z50a	ZF12	12V	Si	Ze	Int
Z50bc	ZF6,8	6,8V	Si	Ze	Int
Z51	ZF12	12V	Si	Ze	Int
Z51bc	ZF6,8	6,8V	Si	Ze	Int
Z52	ZF12	12V	Si	Ze	Int

Potentiometer

P50	5	kohms	1/4W lin	20%	Car	Tele	G Sa 887

Resistors

All resistors are Beyschlag 1/3W, 5%, carbon, unless otherwise noted.

R50	1	kohms				
R51	1	kohms				
R52	1,5	kohms				
R53	1,2	kohms				
R54	12	kohms				
R55	12	kohms				
R56	47	ohms	1/8W	5%	Car	Beyschlag
R57	2,2	kohms				
R58	100	ohms				
R59	33	ohms				
R60	10	kohms				
R61	220	kohms				
R62a	100	kohms				
R62b	56	kohms				
R62c	47	kohms				
R63	470	kohms				
R64	4,7	kohms				
R65	47	ohms	1/8W	5%	Car	Beyschlag
R66	47	ohms	1/8W	5%	Car	Beyschlag

Transistors

T50	2N 3710		NPN	Si	TI
or	2N 1304		NPN	Ge	TI
T51	2S 302		PNP	Si	TI
or	ACY 17	L50	PNP	Ge	Mul
or	2N 3702		PNP	Si	TI
T52	2S 302		PNP	Si	TI
or	ACY 17	L50	PNP	Ge	Mul
or	2N 3702		PNP	Si	TI
T53	2S 302		PNP	Si	TI
or	ACY 17	H25	PNP	Ge	Mul
or	2N 3702		PNP	Si	TI
T54	2S 302		PNP	Si	TI
or	ACY 17	H25	PNP	Ge	Mul
or	2N 3702		PNP	Si	TI

Transformer

Tr2	Oscillator	transformer	Oltronix	FT2

c. Special part C50-10R

Bulb

B1	10V	0,2A	Philips	8034D

Capacitors

C80	0,047	uF	400V	MP	Rifa	Miniprint
C81	0,047	uF	400V	MP	Rifa	Miniprint
C82	5x3000	uF	100V	EMC	Rifa	PEH 1391E/245
C84	2000	uF	35V	EMC	Rifa	PEH 1331E/125
C90	1	uF	200V	MP	Rifa	PMD 2002
C91	2000	uF	100V	EMC	Rifa	PEH 1391E/340
C92	0,1	uF	400V	MP	Philips	C281 W

Connector

Output rear	6 prong MS 3102A-14S-6S(C)	Amphenol,	Cannon
Mating plug	6 prong MS 3106B-14S-6S	Amphenol,	Cannon
Cable clamp	MS 3057-6A	Amphenol,	Cannon

Fuses

F1	8A	5 mm	Line	Slo-Blo

Fan

FAN	220V	SR	EM2815/41A

Diodes

D80	1N3209	Si rec	Delco
D81	1N3209	Si rec	Delco
D82	2N2576	SCR	STC
D83	2N2576	SCR	STC
D84	B30C250	Se bri	Siemens
D85	B30C250	Se bri	Siemens
D87	1N3209	Si rec	Delco
D90	1N3209	Si rec	Delco
D91	1N3209	Si rec	Delco

Meters

A	10A	72PL	ammeter	M&W
V	60V	72PL	voltmeter	M&W

Potentiometers

P90	500	ohms	2W	lin	10%	WW	Clarostat	43
P91	11	kohms	3W	lin	10%	WW	Clarostat	58
P92	1	kohms	2W	lin	10%	WW	Clarostat	43

Resistors

R71	0,18	ohms			WW	Oltronix	
R72	0,18	ohms			WW	Oltronix	
R73	0,18	ohms			WW	Oltronix	
R74	0,18	ohms			WW	Oltronix	
R78	2	kohms	12W	5%	WW	Vitrohm	H
R79	1	kohms	12W	5%	WW	Vitrohm	H
R90	1	kohms	1/3W	5%	Car	Beyschlag	
R171	470	ohms	1/3W	5%	Car	Beyschlag	
R172	470	ohms	1/3W	5%	Car	Beyschlag	
R173	470	ohms	1/3W	5%	Car	Beyschlag	
R174	470	ohms	1/3W	5%	Car	Beyschlag	

Switches

S1	DPDT	toggle	switch	6A	Painton	501085
S2	DPDT	slide	switch		Palmblad	T219

Transformer

Tr1	Power	Elab	18398
Dr1	Choke	Elab	17715

Transistors

T70	T13029	H90	PNP	Ge	TI
or	OC26	H90	PNP	Ge	Mul
T71	2N442	H90	PNP	Ge	RCA, Delco
or	2N1100	H90	PNP	Ge	Mul
T72	2N442	H90	PNP	Ge	RCA, Delco
or	2N1100	H90	PNP	Ge	Mul
T73	2N442	H90	PNP	Ge	RCA, Delco
or	2N1100	H90	PNP	Ge	Mul
T74	2N442	H90	PNP	Ge	RCA, Delco
or	2N1100	H90	PNP	Ge	Mul

d. Special part C32-16R

Bulb

B1	10V	0,2A	Philips	8034D

Capacitors

C80	0,047	uF	400V	MP	Rifa	Miniprint
C81	0,047	uF	400V	MP	Rifa	Miniprint
C82	5x5000	uF	70V	EMC	Rifa	PEH 1391E/245
C84	2000	uF	35V	EMC	Rifa	PEH 1331E/125
C90	1	uF	200V	MP	Rifa	PMD 2002
C91	2500	uF	70V	EMC	Rifa	PEH 1331E/240
C92	0,1	uF	400V	MP	Philips	C281 W

Connector

Output rear	6-prong	MS 3102A-14S-6S(C)	Amphenol, Cannon
Mating plug	6-prong	MS 3106B-14S-6P	Amphenol, Cannon
Cable clamp		MS 3057-6A	Amphenol, Cannon

Fan

FAN	220V	SR	EM 2815/41A

Fuses

F1	8A	5 mm	Line	Slo-Blo

Diodes

D80	1N3209	Si	rec	Delco
D81	1N3209	Si	rec	Delco
D82	2N2576	SCR		STC
D83	2N2576	SCR		STC
D84	4x1N4003	Si	di	Mo
D85	4x1N4003	Si	di	Mo
D87	1N3209	Si	rec	Delco
D90	1N3209	Si	rec	Delco
D91	1N3209	Si	rec	Delco

Meters

A	16A	72PL	ammeter	M&W
V	40V	72PL	voltmeter	M&W

Potentiometers

P90	500	ohms	2W	lin	10%	WW	Clarostat	43
P91	6	kohms	3W	lin	10%	WW	Clarostat	58
P92	1	kohms	2W	lin	10%	WW	Clarostat	43

Resistors

R71	0,08	ohms			WW	Oltronix	
R72	0,08	ohms			WW	Oltronix	
R73	0,08	ohms			WW	Oltronix	
R78	2	kohms	4W	5%	jWW	Vithrom	GL
R79	1	kohms	4W	5%	WW	Vithrom	GL
R90	1	kohms	1/3W	5%	Car	Beyschlag	
R171	330	ohms	1/3W	5%	Car	Beyschlag	
R172	330	ohms	1/3W	5%	Car	Beyschlag	
R173	330	ohms	1/3W	5%	Car	Beyschlag	

Switches

S1	DPDT	toggle	switch	6A	Painton	501085
S2	DPDT	slide	switch		Palmblad	T219

Transformer

TR1	Power	Elab	19175
DR1	Choke	Elab	17797

Transistors

T70	T13029	H75	PNP	Ge	TI
or	OC26	H75	PNP	Ge	Mul
T71	2N442	H75	PNP	Ge	RCA, Delco
or	2N1100	H75	PNP	Ge	Mul
T72	2N442	H75	PNP	Ge	RCA, Delco
or	2N1100	H75	PNP	Ge	Mul
T73	2N442	H75	PNP	Ge	RCA, Delco
or	2N1100	H75	PNP	Ge	Mul

e. Special part C28-20R

Bulb

B1	10V	0,2A	Philips	8034D

Capacitors

C80	0,047	uF	400V	MP	Rifa	Miniprint
C81	0,047	uF	400V	MP	Rifa	Miniprint
C82	5x5000	uF	70V	EMC	Rifa	PEH 1391E/245
C84	2000	uF	35V	EMC	Rifa	PEH 1331E/125
C90	1	uF	200V	MP	Rifa	PMD 2002
C91	2000	uF	70V	EMC	Rifa	PEH 1331E/242
C92	0,1	uF	400V	MP	Philips	C281 W

Connector

Output rear	5 prong MS 3102A-18-11S(C)	Amphenol, Cannon
Mating plug	5 prong MS 3106B-18-11P	Amphenol, Cannon
Cable clamp	MS 3057-10A	Amphenol, Cannon

Fan

FAN	220V	SR	EM 2815/41A

Fuses

F1	8A	5 mm	Line	Slo-Blo

Diodes

D80	1N3209	Si rec	Delco
D81	1N3209	Si rec	Delco
D82	2N2575	SCR	STC
D83	2N2575	SCR	STC
D84	B30 C250	Se bri	Siemens
D85	B30 C250	Se bri	Siemens
D87	1N3209	Si rec	Delco
D90	1N3209	Si rec	Delco
D91	1N3209	Si rec	Delco

Meters

A	25A	72PL	Ammeter	M&W
V	30V	72PL	voltmeter	M&W

Potentiometers

P90	500	ohms	2W	lin	10%	WW	Clarostat	43
P91	6	kohms	3W	lin	10%	WW	Clarostat	58
P92	500	ohms	2W	lin	10%	WW	Clarostat	43

Resistors

R71	0,08	ohms			WW	Oltronix	
R72	0,08	ohms			WW	Oltronix	
R73	0,08	ohms			WW	Oltronix	
R74	0,08	ohms			WW	Oltronix	
R78	1	kohms	12W	5%	WW	Vithrom	H
R79	500	ohms	12W	5%	WW	Vithrom	H
R90	1	kohms	1/3W	5%	Car	Beyschlag	
R171	470	ohms	1/3W	5%	Car	Beyschlag	
R172	470	ohms	1/3W	5%	Car	Beyschlag	
R173	470	ohms	1/3W	5%	Car	Beyschlag	
R174	470	ohms	1/3W	5%	Car	Beyschlag	

Switches

S1	DPDT	toggle	switch	6A		Painton	501085
S2	DPDT	slide	switch			Palmblad	T219

Transformer

Tr1	Power	Elab	18831
Dr1	Choke	Elab	17797

Transistors

T70	TI3029	H75	PNP	Ge	TI
or	OC26	H75	PNP	Ge	Mul
T71	2N442	H75	PNP	Ge	RCA, Delco
or	2N1100	H75	PNP	Ge	Mul
T72	2N442	H75	PNP	Ge	RCA, Delco
or	2N1100	H75	PNP	Ge	Mul
T73	2N442	H75	PNP	Ge	RCA, Delco
or	2N1100	H75	PNP	Ge	Mul
T74	2N442	H75	PNP	Ge	RCA, Delco
or	2N1100	H75	PNP	Ge	Mul

Oltronix transistor identification code

To assure that the transistors in the Oltronix power supplies have good enough data for their actual application, all transistors are tested in a Tektronix Curve Tracer before they are mounted in any instrument. Certain transistors e.g. power transistors and transistors for high voltage use pass a more complete test after which a classification mark is applied. This mark is a letter-number combination on the power transistors and a colour dot on the smaller transistors.

The letter indicates high "H" or low "L" current amplification. The number shows the maximum working voltage.

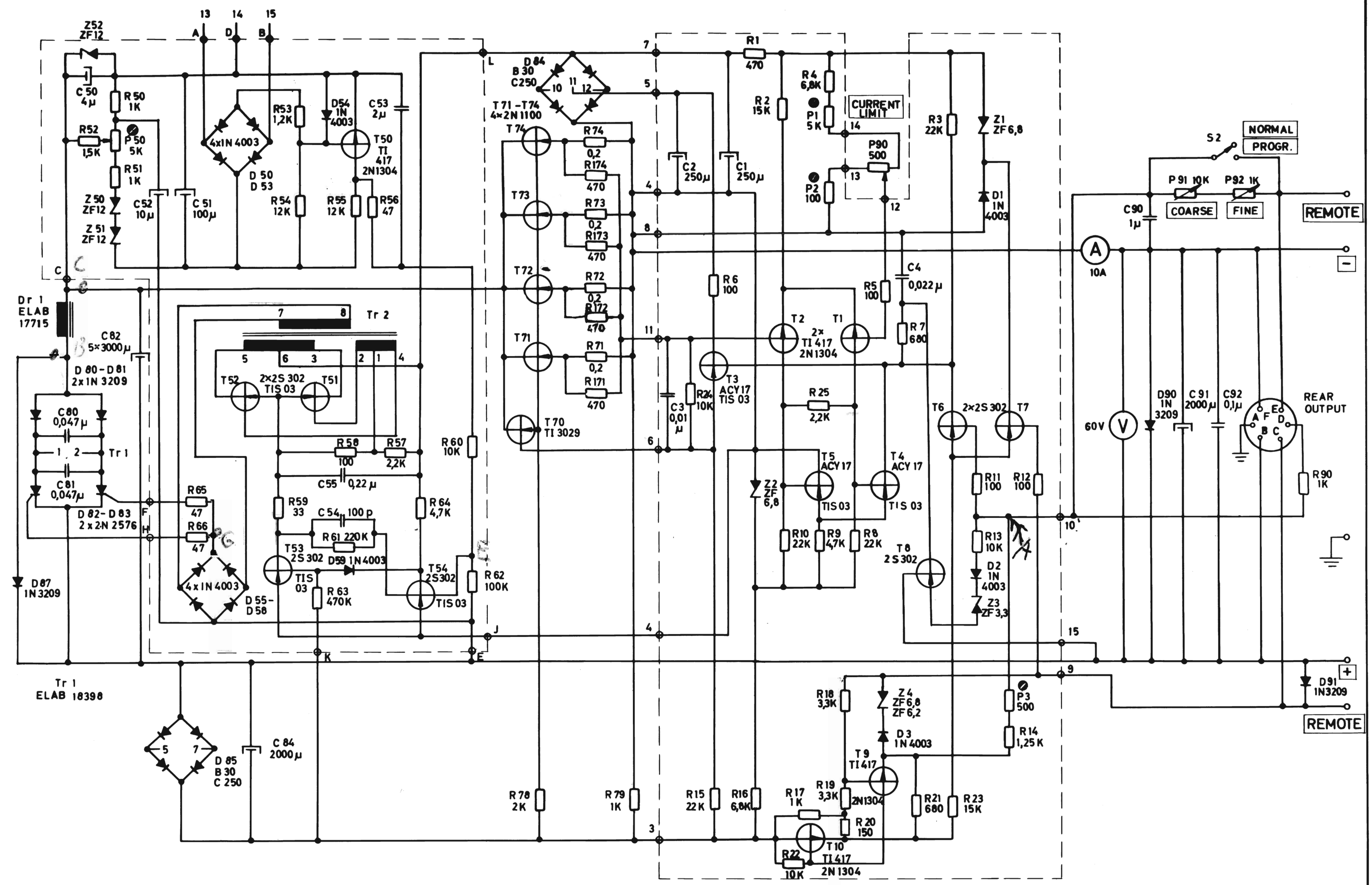
The test conditions are:

Test	Power transistors TO-3 and TO-36	Other transistors TO-5 and similar
Current amplification	I_c=2A V_{CE}=10V High if h_{FE} ≥50 Low if h_{EE} <50	I_c=1mA V_{CE}=10V High if h_{FE} ≥50 Low if h_{FE} <50
	Transistors with extremely high or extremely low h_{FE} are refused.	
Voltage	I_c=400mA R_{BE}=100ohms	I_c=1mA R_{BE}=1,5k

The colour code is:

Class	Colour	Class	Colour
L25	Brown	L100	Silver
H25	Red	H100	Black
L50	Yellow	L125	Silver and brown
H50	Green	H125	Black and red
H65	Blue	L150	Silver and yellow
L75	White	H150	Black and green
H75	Violet	L175	Silver and white
		H175	Black and violet

To get TO-36 power transistors distributed in the voltage and amplification classes in a way suiting our program, transistors of the types 2N442, 2N443, 2N1099 and 2N1100 are used. These transistors come from the same production line, but are classified by the manufacturer. Because of our special requirements these transistors are reclassified at the Oltronix factory. Transistors of different types and from different manufacturers thus can replace each other if they have identical Oltronix classification.



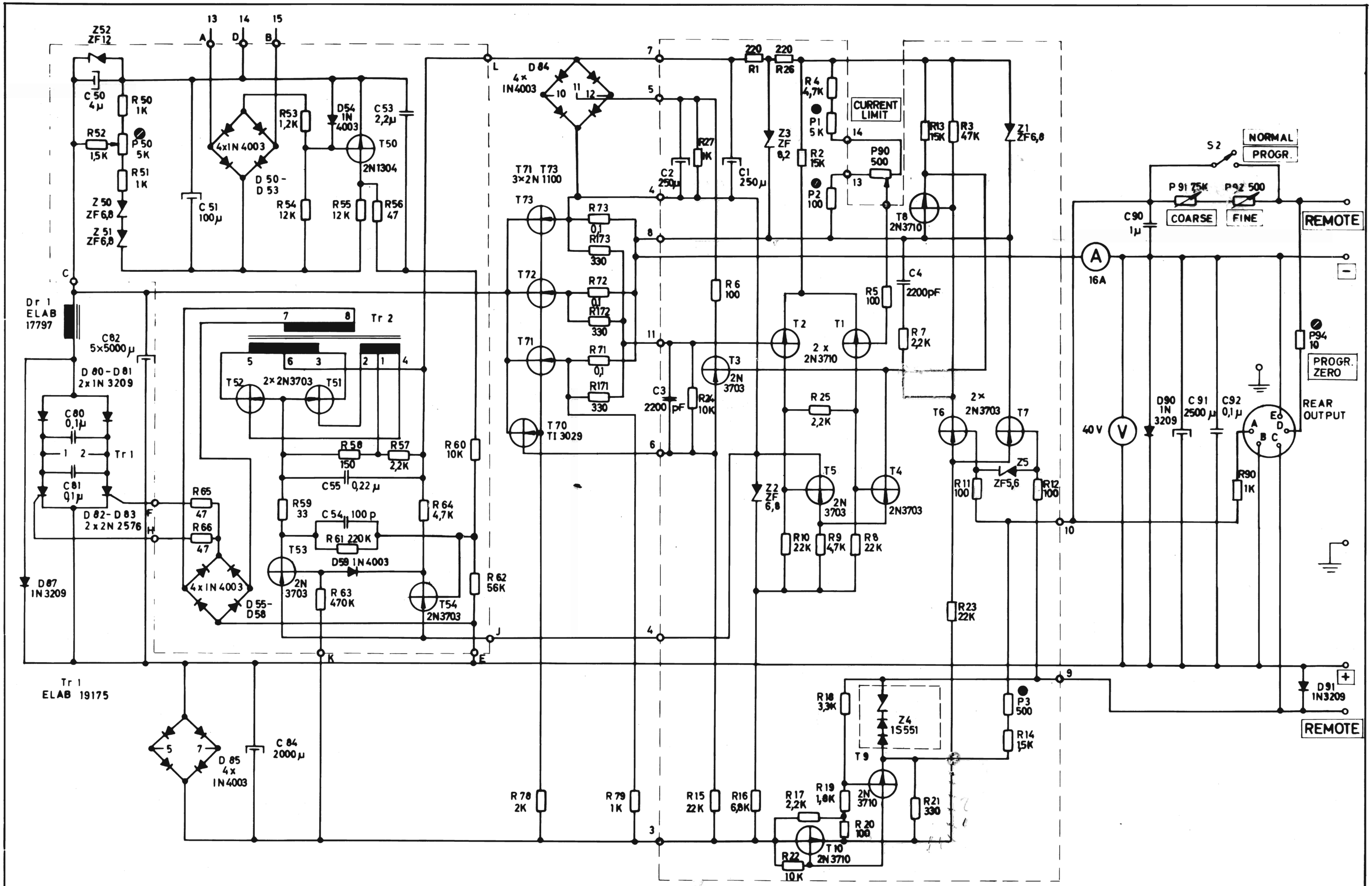
OLTRONIX

REGULATED POWER SUPPLY
C 50-10 R
0-50 V 0-10 A

18.2.65

110-73-1

Rev. 24.3.65



OLTRONIX

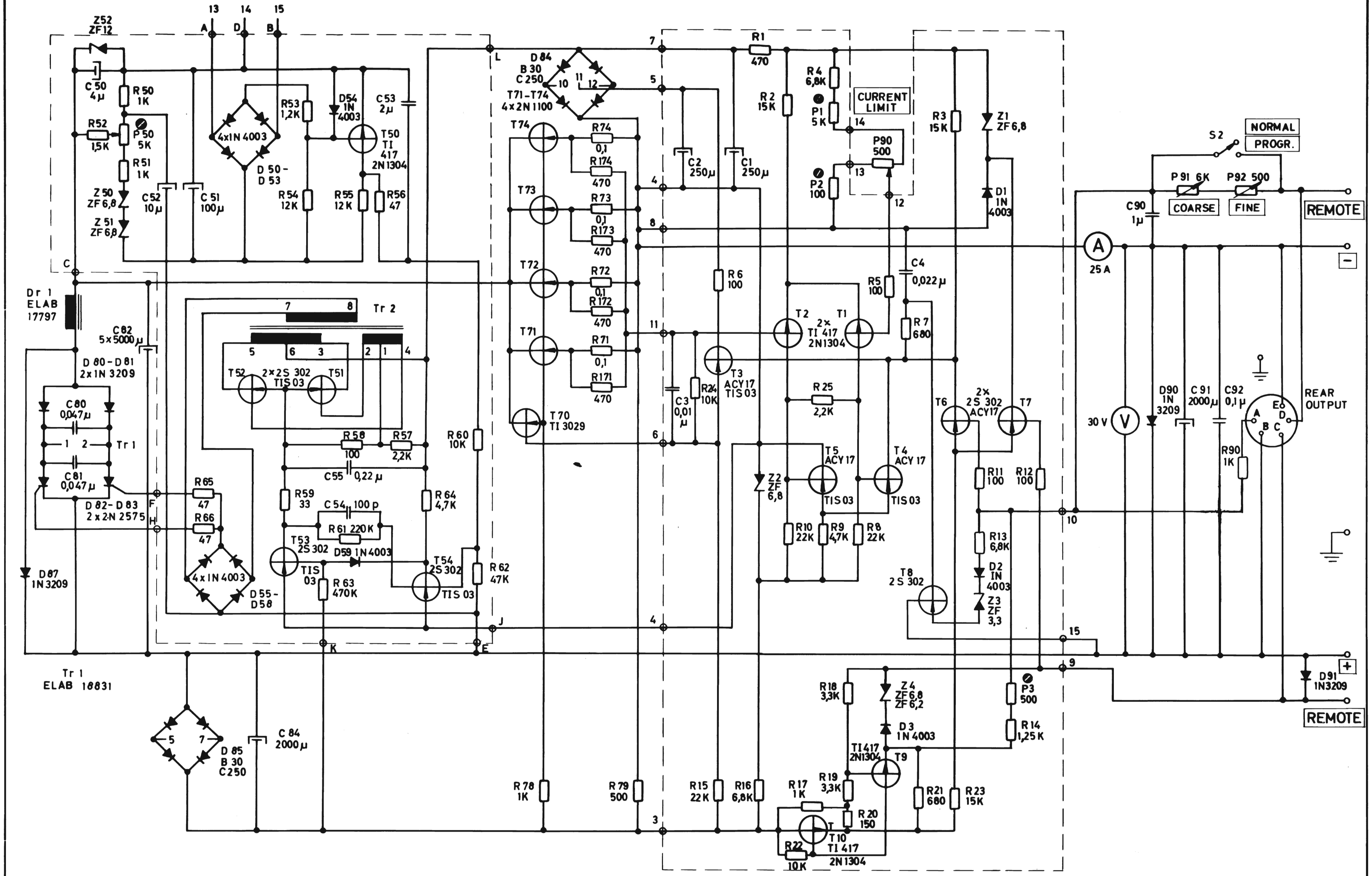
REGULATED POWER SUPPLY

C 32-16R

0-32 V 0-16A Ser. nr. 176 and up

7. 3. 66

117-73-3



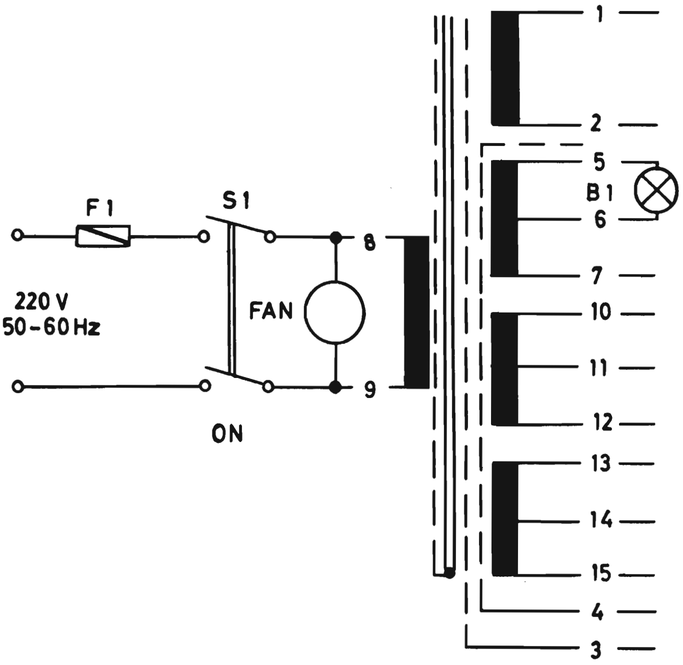
C4 ändras från 0,022 uF till 0,047 uF
C3 ändras från 0,01 uF till 2200 pF

OLTRONIX VÄLLINGBY STOCKHOLM

REGULATED POWER SUPPLY
C 28-20 R
0-28 V 0-20 A

17. 2. 65

111-73-1



Terminal	C 50-10R	C 32-16R	C 28-20R
1	0 V	0 V	0 V
	11 A	18 A	22 A
2	70,5V	52,5 V	43 V
5	0 V	0 V	0 V
6	7 V	7 V	7 V
7	18 V	18 V	18 V
10	5 V	5 V	5 V
11	0 V	0 V	0 V
12	5V	5 V	5V
13	25 V	25 V	25V
14	0 V	0 V	0 V
15	25 V	25 V	25 V
4	+	+	+
3	+	+	+

Elab 18398 in C 50-10R
Elab 19175 in C 32-16R
Elab 18831 in C 28-20R

SVENSKA AB OLTRONIX VÄLLINGBY STOCKHOLM

TRANSFORMER CONNECTION
TYPES C 50-10R, C 32-16R,
C 28-20R

4. 3. 65

110-74-2