# DELTA ELEKTRONIKA BV

## REGULATED POWER SUPPLIES

E 015-20 0-15 V, 0-20 A
E 030-10 0-30 V. 0-10 A
E 060-6 0-60 V, 0-6 A

DESCRIPTION

Each of these 3 power supplies can be used as a constant voltage source with a limited current or as a constant current source with a limited open voltage.
The change of mode occurs sharply at the crossing of the voltage and current setting.
The mode of operation is indicated above the voltage and current meter.
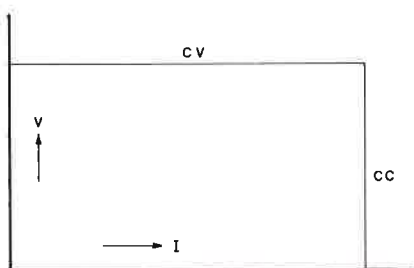
Constant voltage/constant current
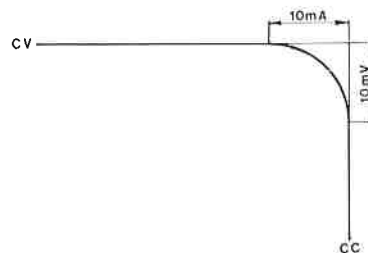
Sharp crossover

A preregulator with silicon controlled rectifiers keeps the rectified voltage in accordance with the output voltage. This results in low dissipation in the power transistors of the series regulator, so that no blower is needed for cooling. The preregulator causes no interference on the mains.

E 015-20 R
When ordering rack mount
version add R. to typenumber

There is no overshoot on the output when the power supply is turned on and off.
The power supply is protected against any overload condition, including sudden and continuous short circuits.

CONSTANT VOLTAGE OPERATION

Voltage control   10-turn potentiometer, range 0-100 %, resolution 0.02 %.

Remote programming   The voltage can be externally programmed by a variable resistor of 0-5 kOhm (0-10 kOhm for E 060-6).
The power supply can also be used as a voltage follower. Source resistance maximum 5 kOhm.
The programming speed is limited by the speed of the preregulator.
At full load the maximum programming speed is 50 V/sec.
(measured with triangular waveform).

Remote sensing   Separate amplifier terminals enable the output voltage to be regulated at a remote load point, using two sensing leads and putting the sense switch on external.
A voltage drop up to 0.5 Volts in each connecting wire can be compensated.

Voltage regulation   1 mV for a + or − 10 % AC line voltage variation.
10 mV for a 100 % load change (2 mV if measured on the sense points).

Temp. coefficient   Less than 5.10^{-5} per $^{\circ}$C.

Long term stability   Unloaded the drift is less than 1.10^{-4} per 8 hours under constant ambient conditions after a warm up time of 20 minutes.
At full load the temperature in the case rises slowly during the first hour, which causes an extra drift of about 1.10^{-3}.

Ripple voltage   0.1 mV r.m.s.

| **Output impedance** | Less than 0.1 Ohm up to 100 kHz load frequency. |

Typical output
impendance versus
frequency.
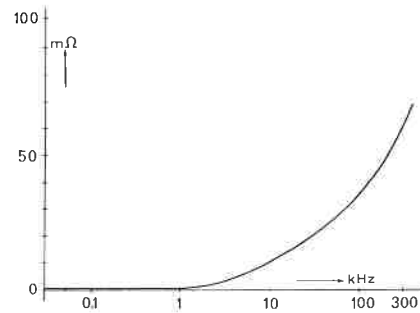
| **Recovery time** | 25 micro seconds for recovery to within 30 mV of steady state voltage after a step load change from 10 % to 100 %. |

CONSTANT CURRENT OPERATION

| **Current control** | Single turn potentiometer, range 0-100 %. Resolution 0.02 %. |

Remote programming

The current can be programmed by an external variable resistor of 0-5000 Ohm. Input on the rear panel.
The output current can also be voltage programmed, input about 0-1 V.

Maximum programming speed	E 015-20	20 A/sec.
(measured with triangular waveform).	E 030-10	10 A/sec.
	E 060-6	6 A/sec.

Current regulation

3 mA for a + or − 10 % AC line voltage variation.
5 mA for a maximum output voltage swing.

| **Temp. coefficient** | Less than 2.10^{-4} per °C. |

Long term stability

At 10 % load the drift is less than 5.10^{-4} per 8 hours under constant ambient conditions, after a warm up time of 20 minutes.
At full load the temperature in the case rises slowly during the first 2 hours, which causes an extra drift of 5.10^{-3}.

| **Ripple current** | 1 mA r.m.s. |

REMAINING SPECIFICATIONS

Input voltage

110-220 V AC 50 Hz standard,
117-234 V AC 50 or 60 Hz also available.

**Parallel and
series connection**

Special design enables parallel and series operation without any precaution. Series connection up to 500 V.

Ambient temperature

Model	E 030-10	E 015-20 and E 060-6
100 % load	0-45 °C	0-35 °C
80 % load	0-50 °C	0-45 °C

| **Output terminals**	On front and rear panel, isolated from the case. Maximum voltage between output terminals and case 500 V.
Cooling	By natural convection. The air must flow freely through the vertically heat sink for effective cooling.
Meters	Voltage and current meter, accuracy 1.5 %.
Finish	Light gray front panel with dark gray case.
Weight and size	20 kg, 418 x 140 x 325 mm (bench model).
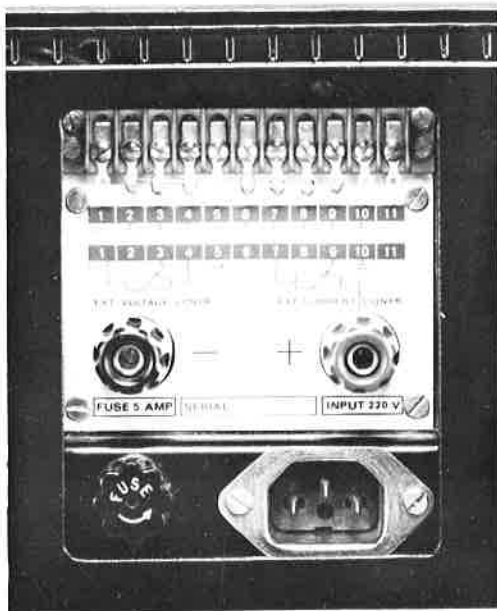
Rear connections for output, sensing, voltage and current programming and AC input.
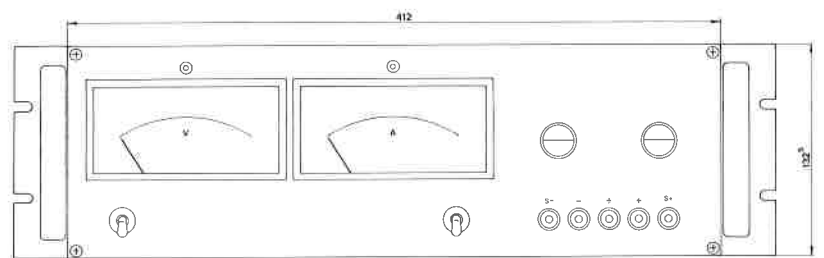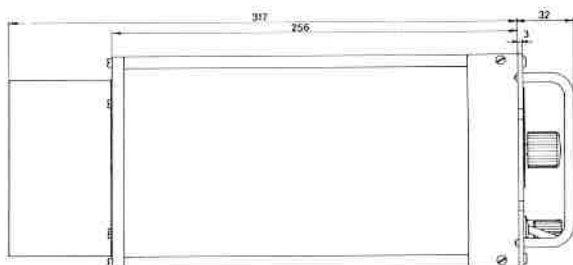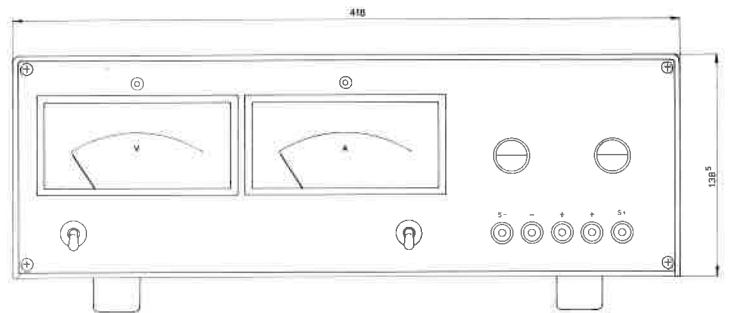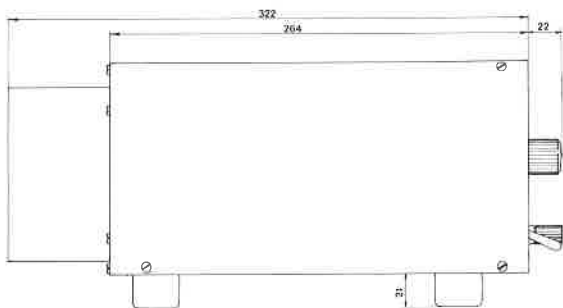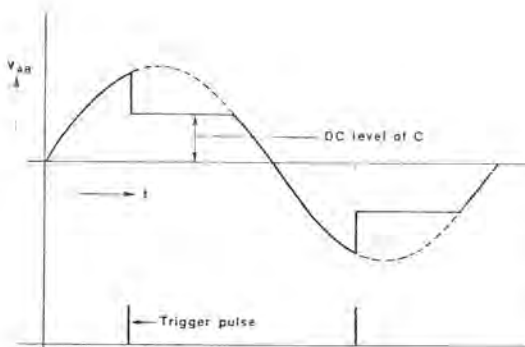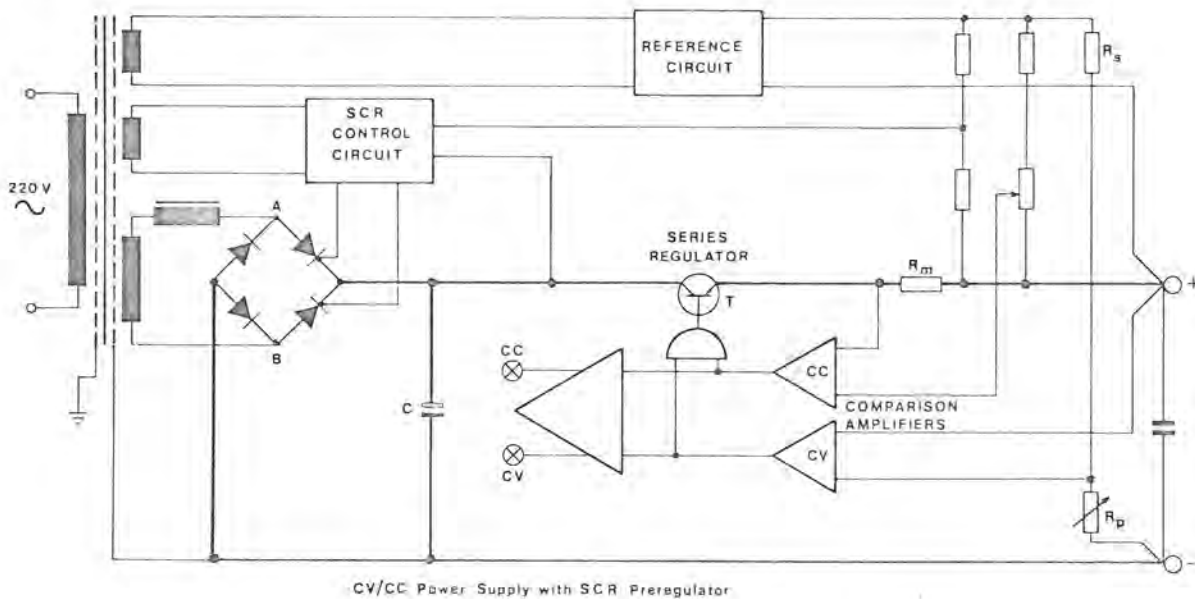
CIRCUIT DESCRIPTION

The regulation can be divided in two parts : A fast regulation with silicon transistors and a slower pre-regulation with silicon controlled rectifiers.

SCR Preregulator

The function of the switching pre-regulator is to keep the heat dissipation in the pass transistor T low.

CV/CC Power Supply with SCR Preregulator

The combined voltage drop across the series regulator and the current monitoring resistor is compared with a part of the reference voltage and the error voltage is converted into a time shift of the firing pulses of the SCR's.
This causes a voltage change across capacitor C in order to keep the voltage across the series regulator constant.
The voltage across the series regulator at maximum output current is about 3 Volts. The choke between the transformer and the rectifier circuit reduces the peak current through the SCR's and also suppresses interference to a very low level.

Constant voltage regulation

A comparison bridge is formed with the resistors R_s, R_p, the reference voltage and the output voltage.
The error voltage is amplified by the CV comparison amplifier and drives the series regulator. At the condition of balance the output voltage is practically proportional to R_p.
As long as the constant voltage regulation is active, the constant current regulation is inoperative.

Constant current regulation

At constant current regulation the voltage drop across R_m, which is proportional to the output current, is compared with a part of the reference voltage. The error voltage is amplified by the CC comparison amplifier and drives the series regulator in such a way that the voltage across R_m is constant which means a constant output current.
As long as the constant current regulation is active, the constant voltage regulation is inoperative. The position of the crossover point of CV and CC regulation depends on the settings of the voltage and current controls.

R (Ohm)	E 015-20	E 030-10	E 060-6	
1 =	560	560	560	5W WW
2 =	1.5 k	1.5 k	1.5 k	0.6 W
3 =	10 k	10 k	10 k	1W
4 =	560	560	560	
5 =	560	820	820	
6 =	33 k	33 k	33 k	
7 =	33 k	33 k	33 k	
8 =	2.2 k	2.2 k	2.2 k	
9 =	270	270	270	
10 =	2.7 k	2.7 k	2.7 k	
11 =	2.2 k	2.2 k	2.2 k	
12 =	6.8 k	15 k	27 k	
13 =	CR	CR	CR	
14 =	1 k	1 k	1 k	
15 =	10	10	10	
16 =	10	10	10	
17 =	27	27	27	
18 =	12 k	10 k	10 k	
19 =	1.5 k	1.5 k	1.5 k	
20 =	1.5 k	1.5 k	1.5 k	
21 =	5 k	5 k	5 k	20 t. potm.
22 =	1 k	1 k	1 k	
23 =	1.8 k	6.8 k	3.9 k	
24 =	—	5.6 k	—	
25 =	CR	CR	CR	
26 =	22 k	22 k	22 k	
27 =	4.7 k	4.7 k	4.7 k	
28 =	2.2 k	2.2 k	2.2 k	
29 =	1 k	1 k	1 k	
30 =	4.7 k	4.7 k	4.7 k	
31 =	12 k	22 k	47 k	
32 =	1 k	1 k	1 k	
33 =	1 k	1 k	1 k	
34 =	680	680	680	
35 =	4.7 k	4.7 k	4.7 k	
36 =	6.8 k	6.8 k	6.8 k	
37 =	CR	CR	CR	
38 =	470	470	470	
39 =	470	470	470	
40 =	680	680	1.5 k	
41 =	1.2 k	1.2 k	330	
42 =	27 k	22 k	22 k	
43 =	12 k	12 k	12 k	
44 =	15 k	15 k	15 k	
45 =	1 k	1 k	1 k	
46 =	2,2 k	2,2 k	2,2 k	
47 =	100	100	100	
48 =	270	270	680	
49 =	100 k	100 k	100 k	
50 =	6.8 k	3.3 k	3.3 k	
51 =	CR	CR	CR	
52 =	CR	CR	CR	
53 =	CR	CR	CR	
54 =	100 k	100 k	100 k	
55 =	330	330	330	1W

				Title: part list
				E015-20 E060-6
				E030-10
Serial no 1953 and up	Jan'78	Vr		Date: Jan'78
Modifications	Date	App.		delta elektronika bv

	E 015-20	E 030-10	E 060-6	
56 =	220	680	1.2 k	9W WW
57 =	220	680	1.2 k	9W WW
58 =	2.7 M	1.8 M	1.2 M	
59 =	CR	CR	CR	
60 =	100	100	100	
61 =	100	100	100	
62 =	10	10	10	
63 =	10	10	10	
64 =	220	680	1.2 k	9W WW
65 =	0.1	0.2	—	50W WW
66 =	1.5 k	1.5 k	1.5 k	
67 =	0.1	0.2	0.18	50W WW
68 =	1.5 k	1.5 k	1.5 k	
69 =	1 k	1 k	1 k	var.
70 =	470	470	470	
71 =	470	470	470	
72 =	15 k	33 k	68 k	
73 =	390 k	270 k	390 k	
74 =	1 k	1 k	1 k	var.
75 =	5 k	5 k	5 k	var. WW
76 =	5 k	5 k	10 k	10 t. potm.
77 =	47	47	47	5W
78 =	47	47	47	5W

C (microfarad)

	E 015-20	E 030-10	E 060-6	
1 =	2.2	2.2	2.2	100 V
2 =	100	100	100	100 V
3 =	1	1	1	250 V
4 =	10	10	10	160 V
5 =	22	22	22	25 V
6 =	0.000047	0.000047	0.000047	400 V
7 =	0.0033	0.0033	0.0033	500 V
8 =	0.22	0.22	0.22	63 V
9 =	10	10	10	40 V
10 =	0.047	0.047	0.047	250 V
11 =	CC	CC	CC	
12 =	0.01	0.01	0.01	250 V
13 =	CC	CC	CC	
14 =	0.01	0.01	0.01	250 V
15 =	47	47	47	63 V
16 =	1000	1000	1000	16 V
17 =	1000	1000	1000	16 V
18 =	1	1	1	250 V
19 =	14000/30 V	5900/75 V	3000/100 V	
20 =	14000/30 V	5900/75 V	3000/100 V	
21 =	14000/30 V	5900/75 V	3000/100 V	
22 =	10	10	10	100 V
23 =	4.7	4.7	4.7	63 V
24 =	4.7	4.7	4.7	63 V
25 =	0.22	0.22	0.22	630 V
26 =	4x220/25 V	4x100/70 V	4x100/70 V	
27 =	0,2 uF X + 2x2500 pFY	0,2 uF X + 2x2500 pFY	0,2 uF X + 2x2500 pFY	250 V

	E 015-20		E 030-10	E 060-6	
D					
1 =	1N4003		1N4003	1N4003	TI
2 =	W 01		W 01	W 01	GI
3 =	1N4003		1N4003	1N4003	TI
4 =	1N4003		1N4003	1N4003	TI
5 =	ZY 12		ZY 12	ZY 12	ITT
6 =	2N6027		2N6027	2N6027	GE
7 =	ZP 6.2		ZP 6.2	ZP 6.2	ITT
8 =	1N4148		1N4148	1N4148	TI
9 =	1N 825		1N 825	1N 825	Micro S.Corp.
10 =	ZP 6.2		ZP 6.2	ZP 6.2	ITT
11 =	1N4148		1N4148	1N4148	TI
12 =	1N4003		1N4003	1N4003	TI
13 =	1N4003		1N4003	1N4003	TI
14 =	1N4003		1N4003	1N4003	TI
15 =	1N4148		1N4148	1N4148	TI
16 =	ZP 6.2		ZP 6.2	ZP 6.2	ITT
17 =	1N4148		1N4148	1N4148	TI
18 =	1N4148		1N4148	1N4148	TI
19 =	1N4148		1N4148	1N4148	TI
20 =	1N4003		1N4003	1N4003	TI
21 =	1N4003		1N4003	1N4003	TI
22 =	VH 148		VH 148	VH 148	VARO
23 =	2N3896		2N3668	2N3660	RCA
24 =	2N3896		2N3668	2N3660	RCA
25 =	40209	RCA	VTD-200/S	VTD-200/S	VARO
26 =	40209	RCA	in 25	in 25	
27 =	60 S 1		60 S 1	60 S 1	Motorola
28 =	40209	RCA	in 25	in 25	
IC					
1 =	SN72709		SN72709	SN72709	TI
2 =	SN72709		SN72709	SN72709	TI
3 =	SN72709		SN72709	SN72709	TI
T					
1 =	2N3053		2N3053	2N3053	RCA
2 =	BC 182		BC 182	BC 182	TI
3 =	2N3053		2N3053	2N3053	RCA
4 =	BC 182		BC 182	BC 182	TI
5 =	BC 182		BC 182	BC 182	TI
6 =	BC 182		BC 182	BC 182	TI
7 =	3x2N3055		2x2N3055	2x2N3442	RCA
8 =	3x2N3055		2x2N3055	2x2N3442	RCA
9 =	2N3055		2N3055	2N3442	RCA
Tr =	T 3010		T 3010	T 606	Delta
L =	S 01520		S03010	S0606	Delta

F = Fuse 5 A delay – 220 V 10 A delay – 117 V 1¼" x ¼"
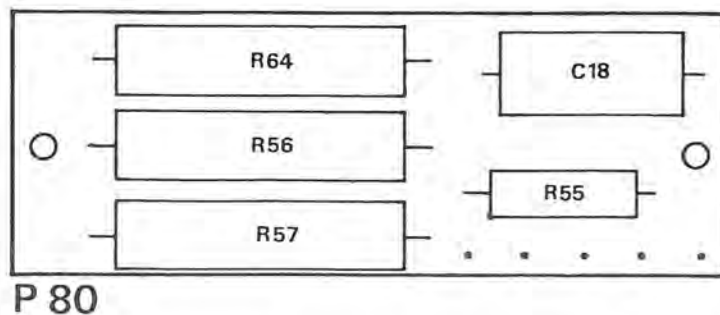WW = Wire wound resistor
All other resistors metalfilm 0,4 W 2%
CR = Calibration resistor
CC = Calibration capacitor

P 78a

R50 R51 R52 R53 R54 R49 D19 R35 D15 D16 R34 R9 T1 R14 C10 R28 R20 R21 C15 C2 R2 R1 R26 R25 T2 R31 R30 D11 R32

D18 D17 C13 T6 T5 C11 C6 R27 R23 R24 D10 R18 R10 R8 C14 C12 T3 C7 R3 R48 R40 R19 D4 D8 D6

IC3 R36 IC2 IC1 R22 D7 D1 C1 D3 R11 R12 R13 R5 T4 C4

R47 D20 D21 R46 R45 R44 R43 R42 R41 R38 R39 R37 R33 R29 D9 C9 C5 D5 C8 R17 B16 R15 C7 R6 C4

D14 D13 D12

D2

2

P 79a

C3 R72 R73 R4 R74 R69 C16 R58 R59 R60 R61 R71 C22 R66 R68 R70 D22 C23 C17 C24

2

P 80

R64 C18 R56 R55 R57
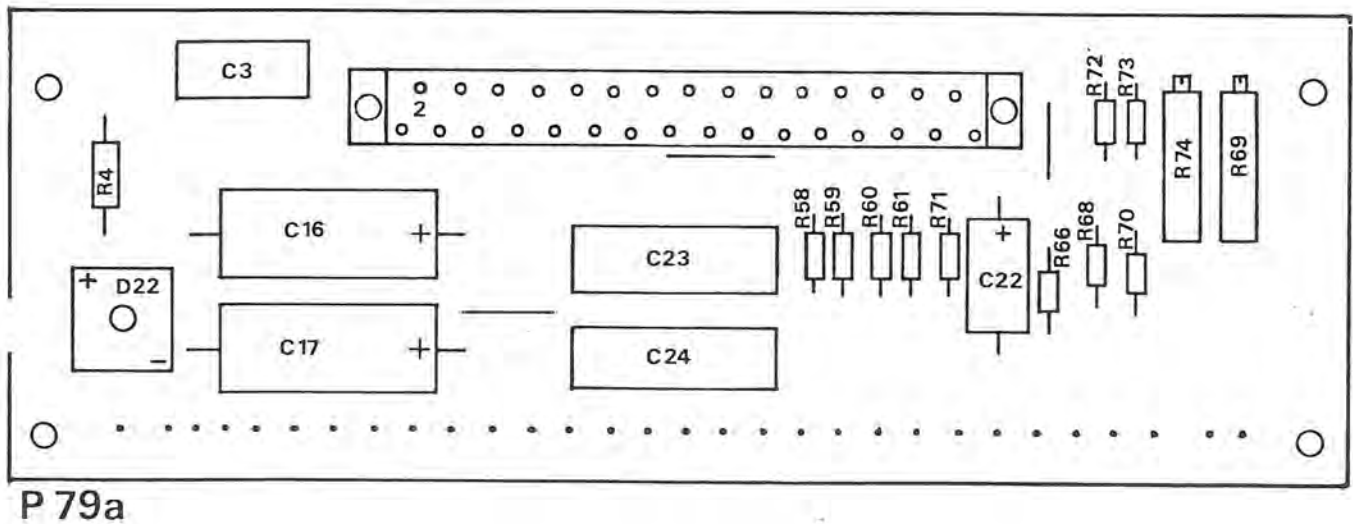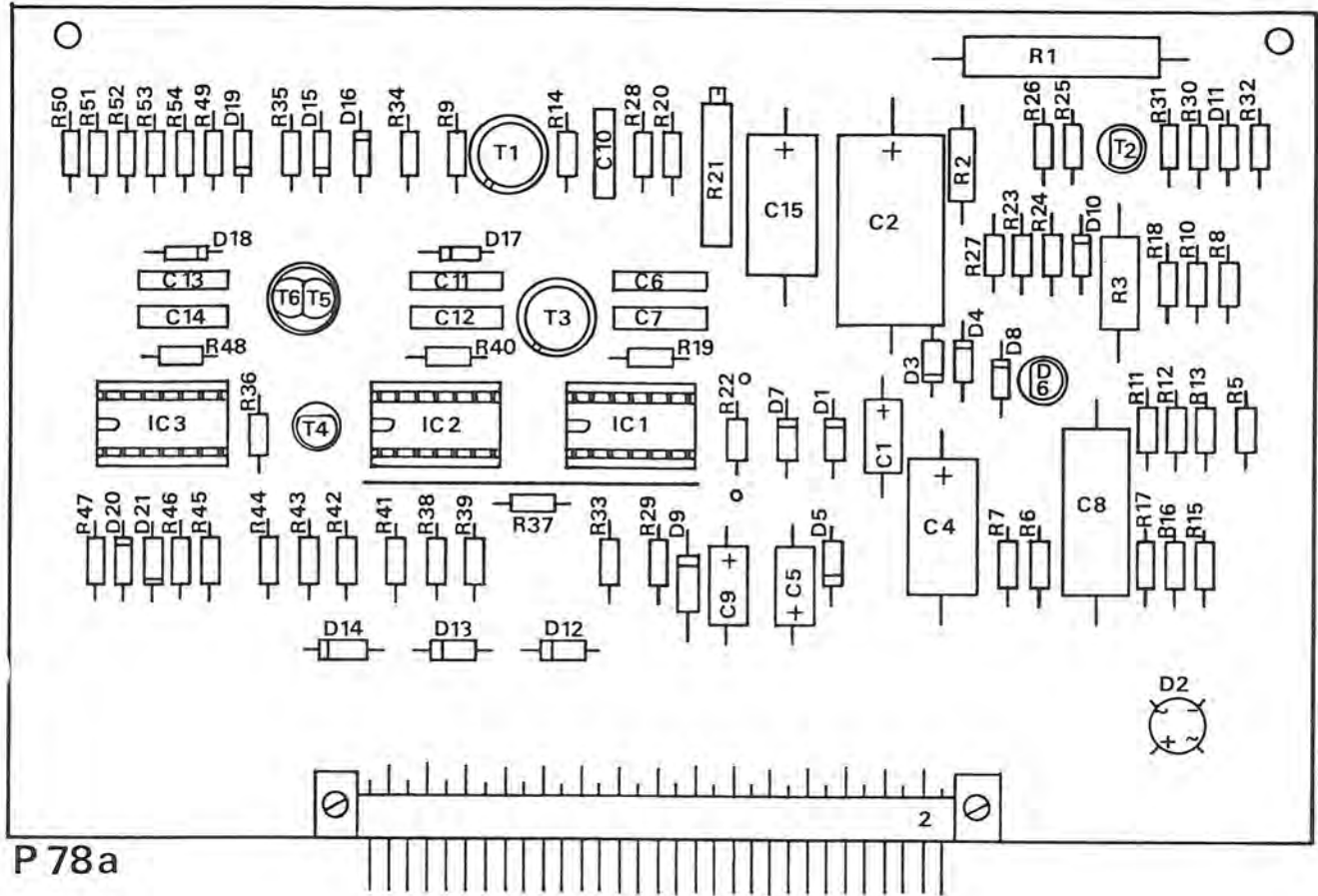
			Title: Printed circuit
			E015 – 20 E60 – 6
			E030 – 10
Serial no 1953 and up	Jan '78	Vr.	Date: Jan '78
Modifications	Date	App.	**delta elektronika bv**

δ

P78a

L1
L2

220V 50Hz
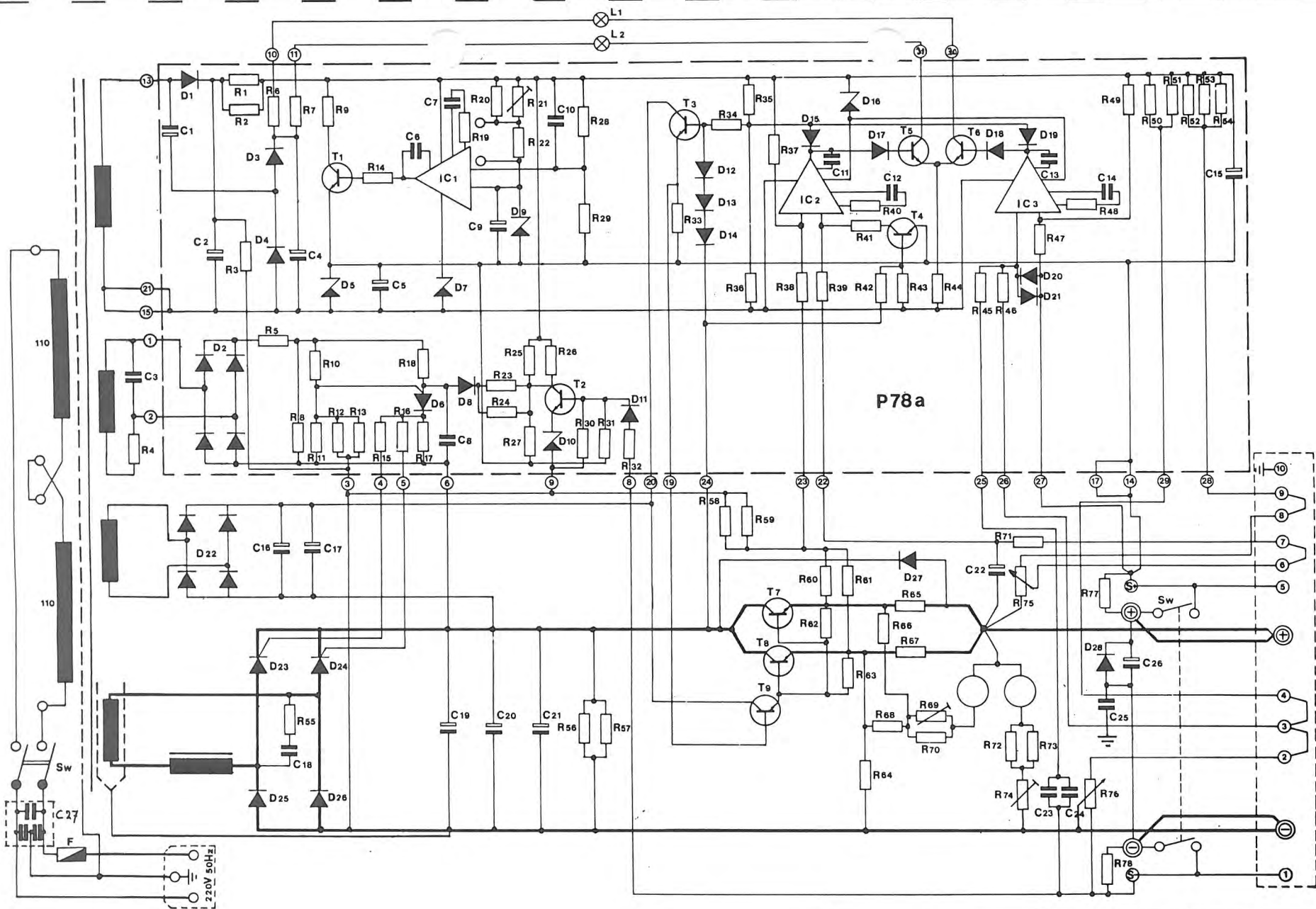
			Title: Wiring diagram
			E 015-20 E 060-6
			E 030-10
Serial no 1953 and up	Jan '78	V.r.	Date: Jan '78
Modifications	Date	App	delta elektronika bv

Rear connections for drive and output

E 015-20, E 030-10, E 060-6

1	2	3	4	5	6	7	8	9	10	11
S −	Int. V. pot.	Voltage op amp	Voltage Ref.	S +	Int.cur pot.	current op amp.	Int..cur pot.	current Ref.	⏚	N.C.

load
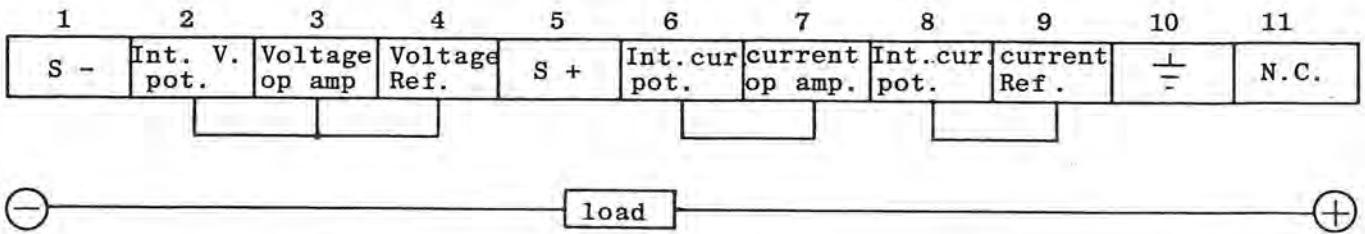
1. Local Control, Local Sensing with front sense switch on "Int." (Constant-Voltage or current)

1	2	3	4	5	6	7	8	9	10	11

twisted shielded pair

load

1000 µF
63 V
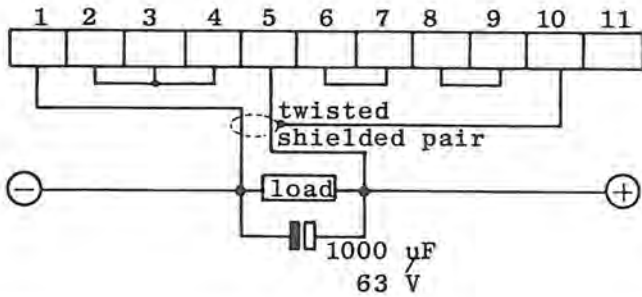
2. Local control, Remote sensing with front sense switch on "Ext."(Constant-Voltage or current)

1	2	3	4	5	6	7	8	9	10	11

twisted shielded pair

Rv

load
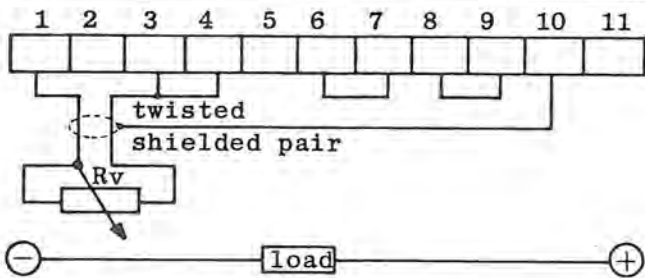
3. Programming (Remote Control) of Constant voltage by Resistance, Local Sensing.

Programming resistor Rv :

E 015-20	Rv = 0-5 kOhm for 0-15 V
E 030-10	Rv = 0-5 kOhm for 0-30 V
E 060-6	Rv = 0-10 kOhm for 0-60 V

1	2	3	4	5	6	7	8	9	10	11

Rc = 0-5 kOhm for zero to full current

twisted shielded pair

RC

load
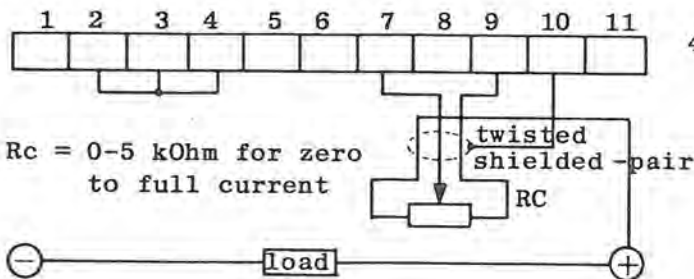
4. Programming (Remote Control) of Constant-current, linear with potentiometer, Local sensing.

1	2	3	4	5	6	7	8	9	10	11

Rc = 0-5 kOhm for zero to full current

twisted shielded pair

RC
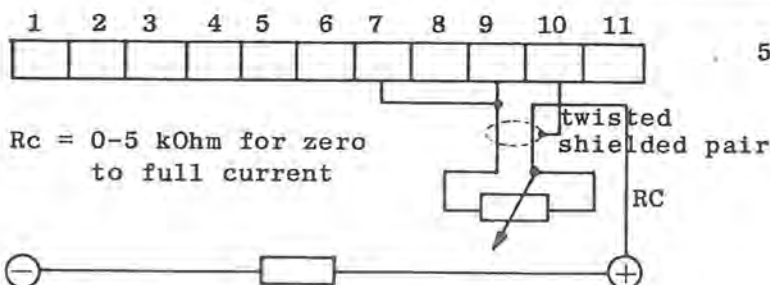
5. Programming (Remote Control) of Constant-current, nonlinear with variable resistor, Local sensing.
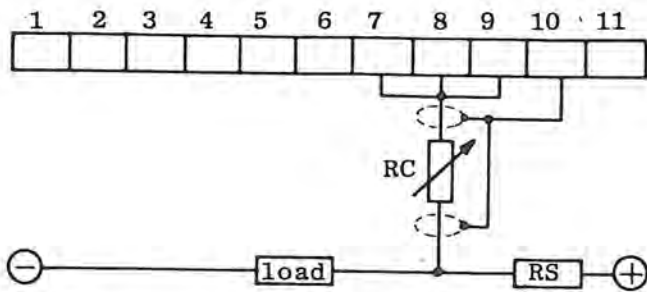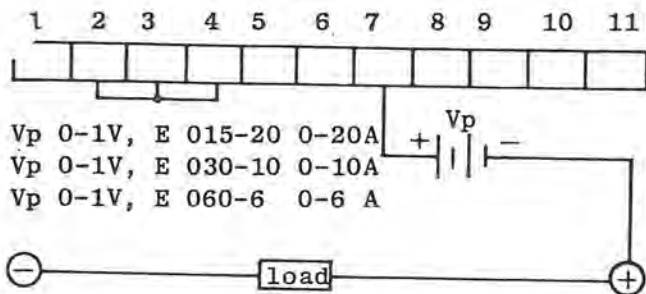
6. Constant-current, External conversion, Remote control, nonlinear with variable resistor, Local sensing.
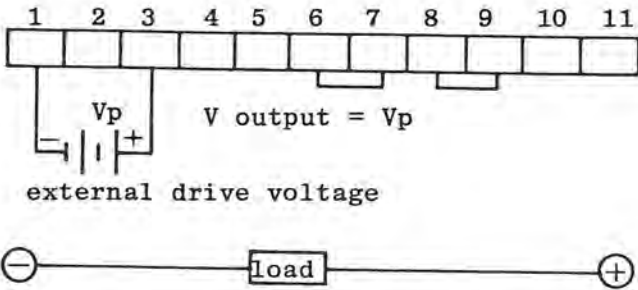
V output = Vp

external drive voltage

7. Voltage programming by voltage, local sensing.

V out : Vp = R_1 : R_2

8. Voltage programming by voltage, local sensing.

Vp 0-1V, E 015-20 0-20A
Vp 0-1V, E 030-10 0-10A
Vp 0-1V, E 060-6 0-6 A
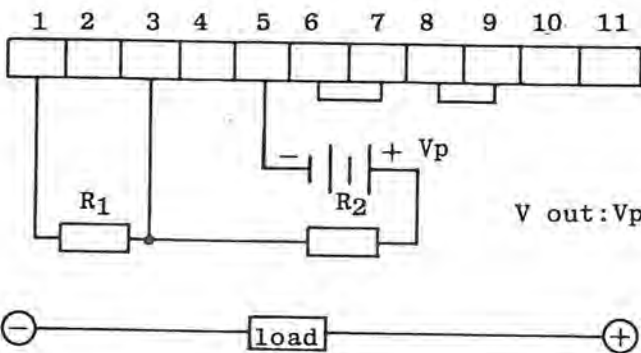
9. Current programming by voltage, local sensing.

$Vp = 1 + \dfrac{R1}{R2}$ Volts
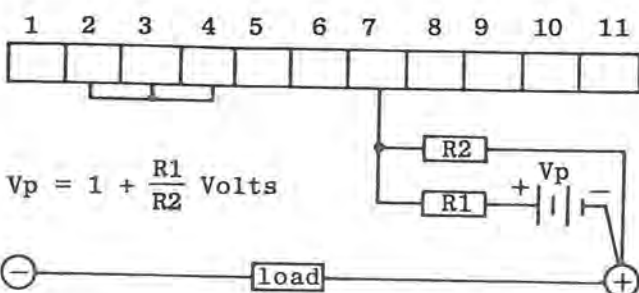
10. Current programming by voltage and devider, local sensing.

0-1 V between 7 and 5 corresponds with zero to full current.

Series connection

Two or more power supplies of the same model can be connected in series without
any precaution by simply connecting the + of the one with the minus of the other
power supply. In this case both voltage knobs have to be used to vary the total
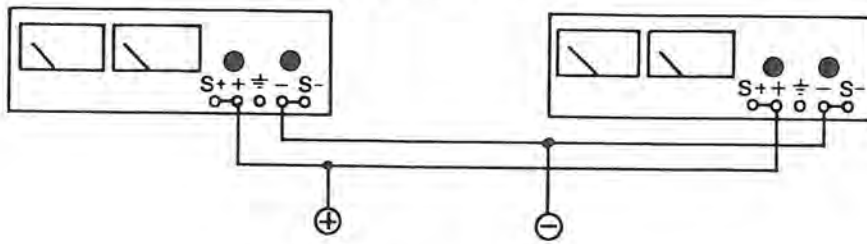voltage.
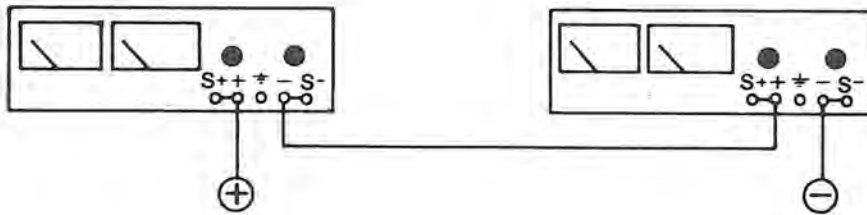
If it is desirable to vary the total voltage with only one knob a special connec-
tion can be made between the rear terminal strips.

$Rc = 5$ k (E 015-20, E 030-10)
   10 k (E 060-6)
   Metal film resistor 1 Watt.
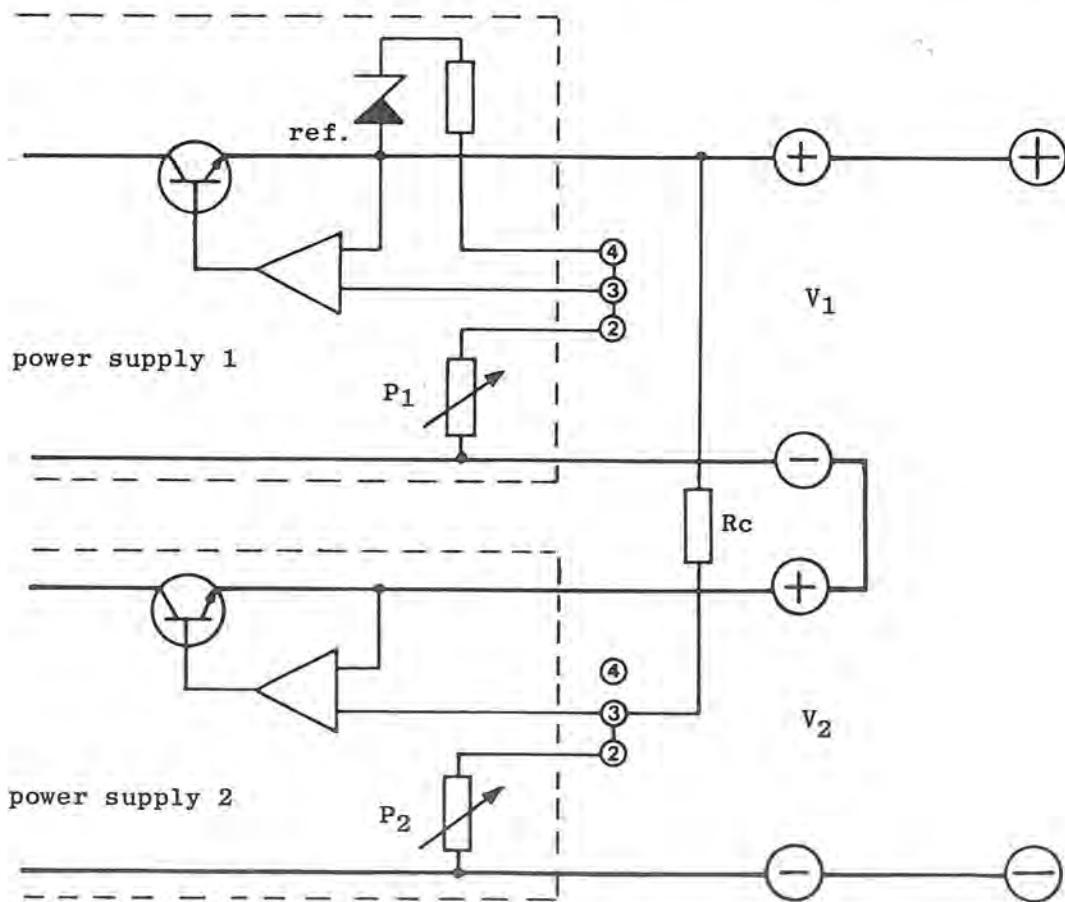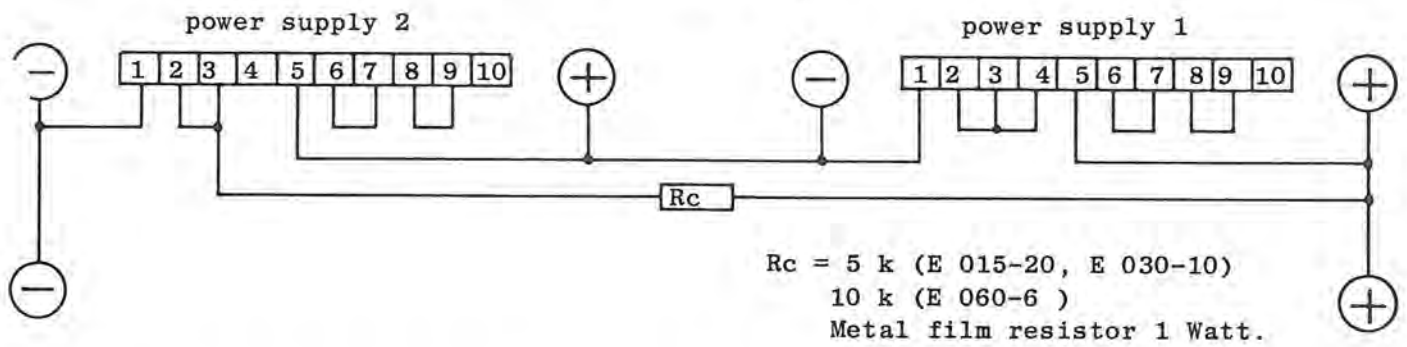
With P_1 (voltage knob of power supply 1) the absolute value of the total output
voltage can be varied and with P_2 the ratio of V_1 and V_2 can be varied.

Parallel connection

Two or more power supplies of the same model can be connected parallel without
any precaution by simply connecting the + terminals and the − terminals. In
that case two voltage knobs and two current knobs have to be used to control the
voltage and current of the parallel connection.

If it is desirable to control the voltage and total current with the knobs of
only one power supply a special connection can be made between the rear terminal
strips.
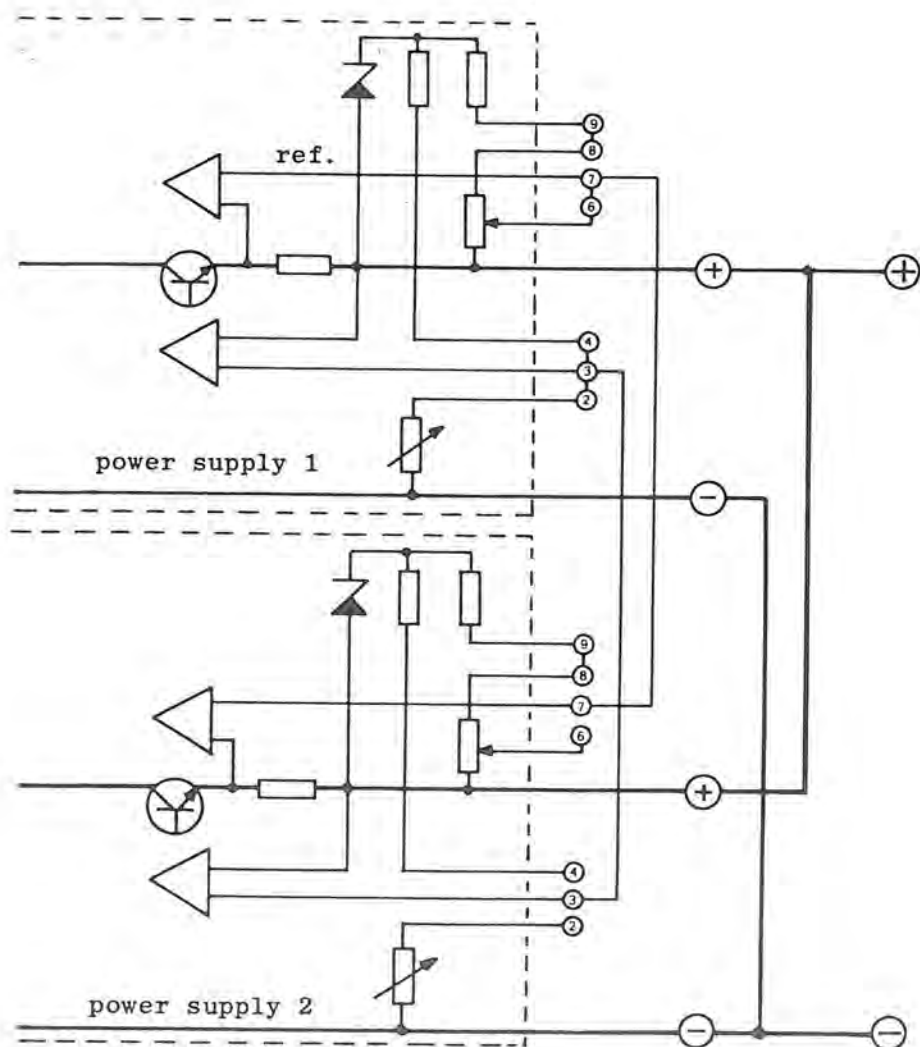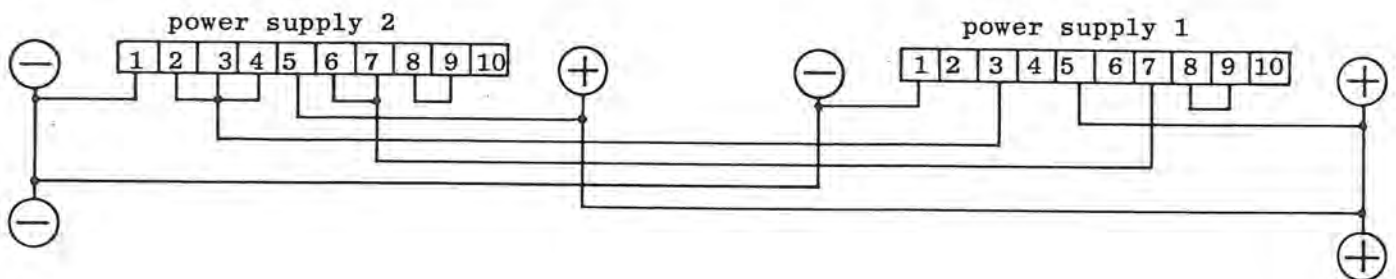
Voltage and current control with the knobs of power supply 1.

USE OF REMOTE SENSING

The output voltage may be regulated at a load point remote from the power supply by means of two extra wires. (fig. A).

S − ◎

− ◎

⏚ ◎   1000 µF ⊣⊢ ▯ R   V = constant
                                                         63 V

+ ◎

S + ◎
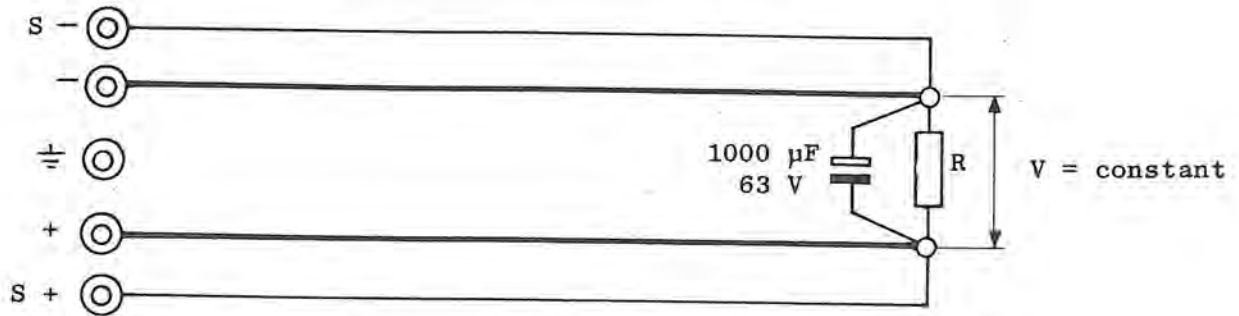
The sense switch must be put on external.

If the terminals at the rear side are used for error sensing, the sense switch must also be put on external.

A voltage drop up to 1,5 Volts in each connecting wire can be compensated.

Depending on the output voltage and current it is often possible to compensate for still larger voltage drops.

Remote sensing does not compensate for the inductance of the load connecting wires.

To establish a low source impedance at the load a capacitor bypass directly at the load terminals is usefull.

ɔ minimize the inductance the sense wires should be twisted together.

The load wires can also be twisted together.

Meter   calibration

On printed board P 79 A are two potentiometers.

R 74 is for calibrating the voltage meter.

R 69 is for calibrating the current meter.