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This paper summarizes the system layout, electrical configurations, and component values of the dipole-power supply, and the quadrupole power supply, including the quad-trim supply. Also the current and voltage ratings of the bus bars are included.

DIPOLE POWER SUPPLY

The physical size and cost of the magnet power supplies is governed by the product of the maximum voltage and the rms current. A tabulation of the important parameters used in sizing the dipole power supply is given in Table I. The calculated values are for 1.5 GEV protons and Heavy Ions, as listed in the preliminary Design Manual.

It is proposed that a common power supply be employed for the proton and heavy ion cycles. Since the rms currents are almost in the ratio of 2:1, the supply can be built in two half-sections, which can be series connected for proton operation and parallel connected for the heavy ion cycle. The maximum voltage for the proton cycle is three times that for the heavy ion cycle. Obviously the supplies will be under utilized in the heavy ion cycle by a factor of 2/3; and fully utilized in the proton cycle. This arrangement is economically efficient, as compared to two independent, fully utilized power supplies.

The basic dipole excitation consists of 5-1000 volt supplies sequentially switched on, each half section consist of 5 modules. In total this arrangement will require 10 modules, each rated 800 KVA. A system layout with ratings of major components is given in Figure 1.

As an alternative solution to the series-parallel connection of the power supply, it is proposed that the full magnet inductance of the dipole string be divided into two identical inductances. For the proton cycle the half-inductors are connected in parallel; for the heavy ion cycle, in series. This allows the same power supply to be employed for both cycles. A physical representation and the equivalent circuit of the scheme is given in Figures 2 and 3. In total this arrangement will require 5 modules, each rated 1600 kVA.

Each of the 36 dipoles consists of four pancake type coils. For this scheme each dipole has two pancake type coils wired in series and in turn wired in series with two coils from each of the remaining 35 dipoles. The magnetic coupling coefficient between each of the four coils in a dipole is nearly unity. Therefore, the currents will divide equally between the two parallel branches of the coils.

This scheme is analogous to multi-rating a power transformer, in which the primary, secondary, or both are wound in two identical sections. The two halves are connected in series or in parallel with voltage ratings of V or V/2 and current ratings of I or 2I, respectively.

The major advantages for the second scheme are:

1. Reduction of peak voltage from 2500 volts to 1250 volts for the bus bar, cooling water and magnet windings.
2. Reduction of the number of power supply modules and controls from 10 to 5.

QUADRUPOLE POWER SUPPLY

A tabulation of the pertinent parameters used in sizing the quadruple power supply is given in Table II, and a tabulation of the quadrupole trim (tune) is given in Table III. The system layout is given in Figure 4. Since the quadrupole system requires a second (trim) power supply, it was decided to switch the supplies and have a fixed coil arrangement. In total this arrangement requires four modules each rated 360 kVA and two modules each rated 80 kVA.

The 48 quadrupole magnets are divided into 24 horizontal and 24 vertical quads and wired as to form a hair-pin loop around the ring. The loop is tapped and excited by the quad-trim power supply, such that the horizontal and vertical coils respond in a push-pull or balanced mode. The main power supply excites the two groups in a common or single-ended mode. The trim power supply is bidirectional and can unbalance the loop current symmetrically ± 10%. The trim power supply must always supply a positive voltage, varying between .45 and .55 of the main power supply voltage. The trim supply must function both as a rectifier and as an inverter. This supply can be constructed from two full-wave bridges, poled in opposite directions connected in parallel, and excited from a common transformer, as shown in the schematic of Figure 5.

	Cycle	V_{max} (volts)	I_{max} (amp)	I_{rms} (amp)	Peak Power V_{max} I_{max} (MW)	Power Supply Rating V_{max} I_{rms} (MVA)
Calculated	Proton	4669	2220	1550	10.37	7.
	Heavy Ion	1425	5200	3200	7.41	4.56
Design Value	Proton	5000	2600	1600	13.	8.
	Heavy Ion	2500	5200	3200	13.	8.

TABLE I

PARAMETERS FOR DIPOLE
POWER SUPPLY

	Cycle	V_{max} (volts)	I_{max} (amp)	I_{rms} (amp)	Peak Power V_{max} I_{max} (MW)	Power Supply Rating V_{max} I_{rms} (MVA)
Calculated	Proton	787.	2220	1600	1.75	1.18
	Heavy Ion	425	5200	3200	2.2	1.36
Design Value	Proton	900	2600	1600	2.34	1.44
	Heavy Ion	450	5200	3200	2.34	1.44

TABLE II

PARAMETERS FOR QUADRUPOLE
POWER SUPPLY

	Cycle	V_{max} (volts)	I_{max} (amp)	I_{rms} (amp)	Peak Power V_{max} I_{max} (KW)	Power Supply Rating V_{max} I_{rms} (KVA)
Calculated	Proton	432	444	320	192	138
	Heavy Ion	234	1040	640	244	150
Design Value	Proton	500	520	320	260	160
	Heavy Ion	250	1040	640	260	160

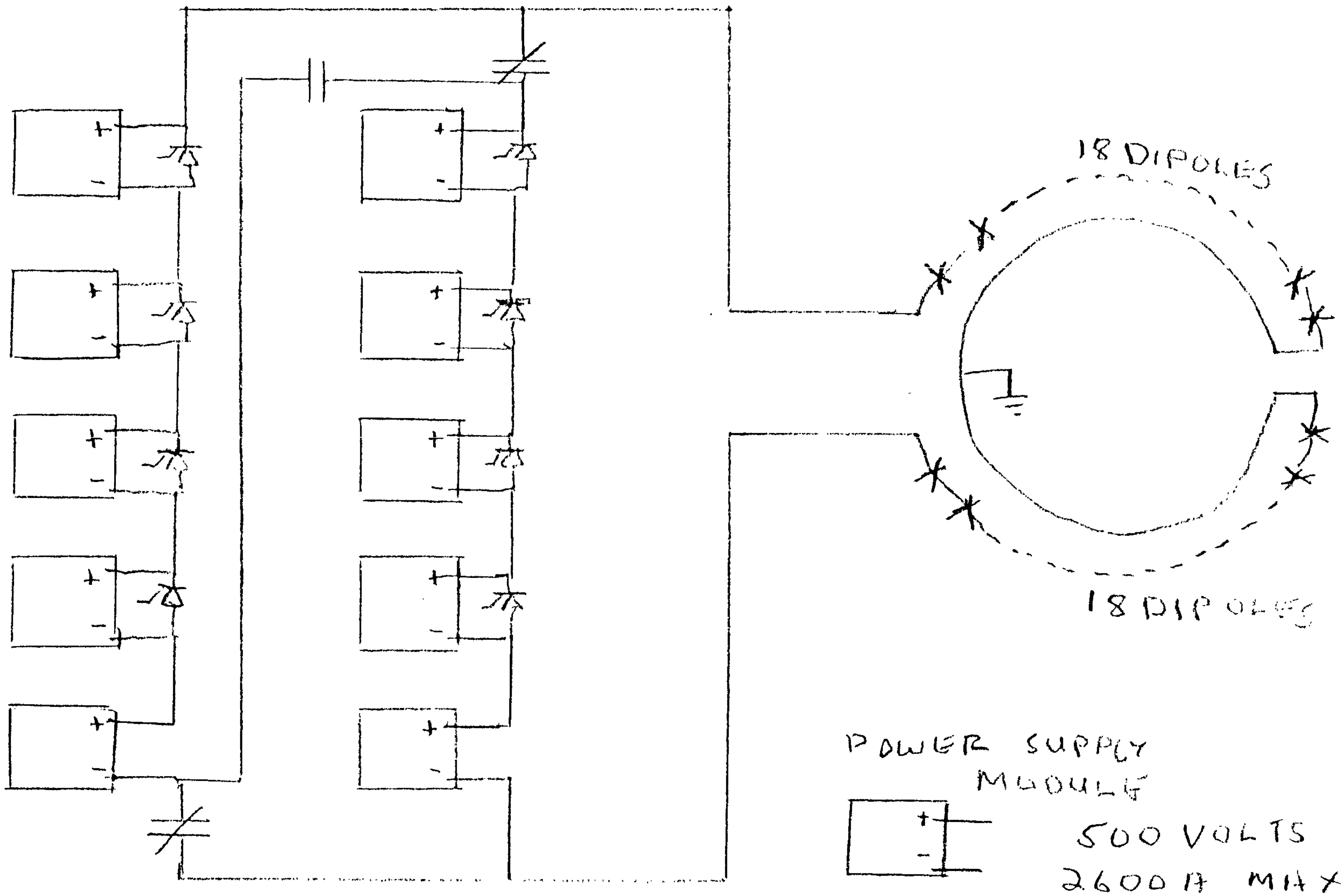
TABLE III

PARAMETERS FOR QUADRUPOLE TRIM POWER SUPPLY

RATINGS:

BUS BAR 3200A (rms)

V_{PEAK} = 2500 VOLTS



500 VOLTS
2600 A MAX
1600 A (rms)
800KVA

FIG 1

SYSTEM LAYOUT
POWER SUPPLY SWITCHING

FIG 2.

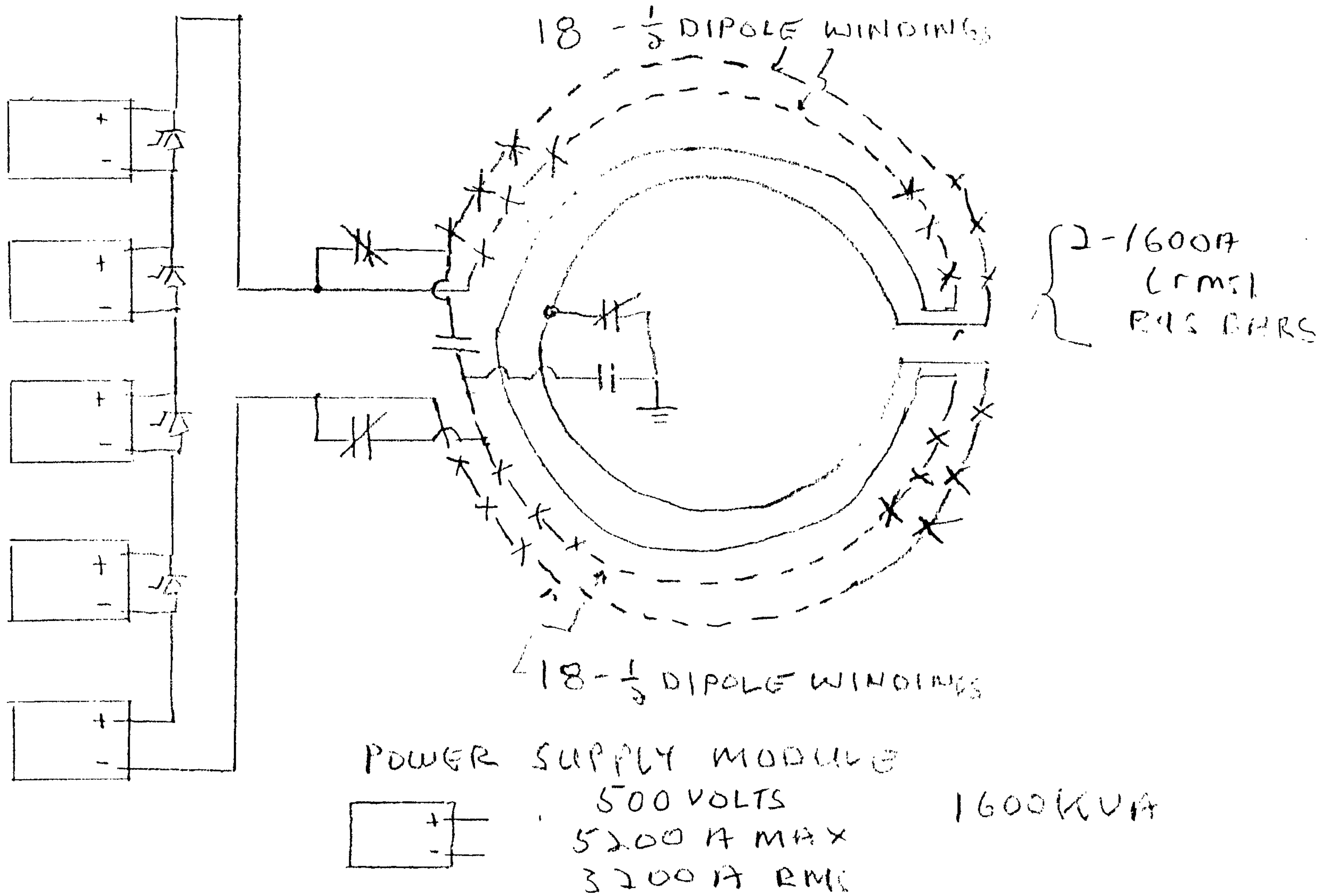
SYSTEM LAYOUT

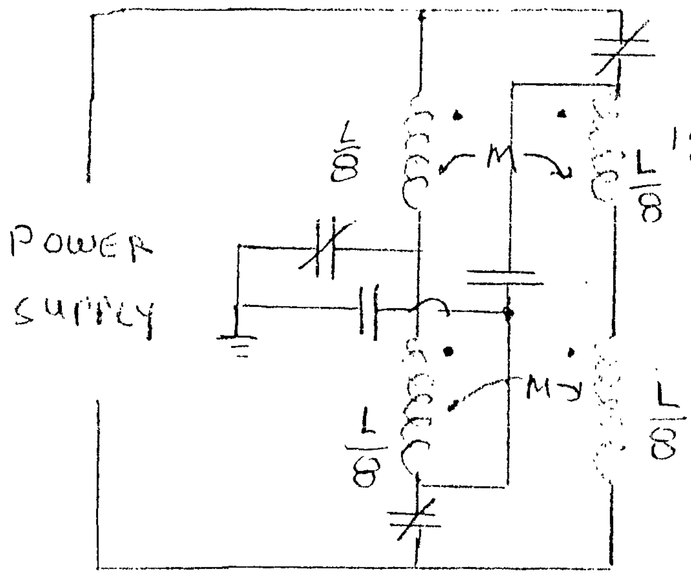
MAGNET COIL SWITCHING

RATINGS

BUS BAR 3200A (rms)

VPEAK = 1250 VOLTS





18 - $\frac{L}{2}$ DIPOLE WINDINGS

COEFFICIENT OF COUPLING CLOSE TO UNITY

$M \cong \frac{L}{8}$

L is the inductance of the full dipole string, series aiding

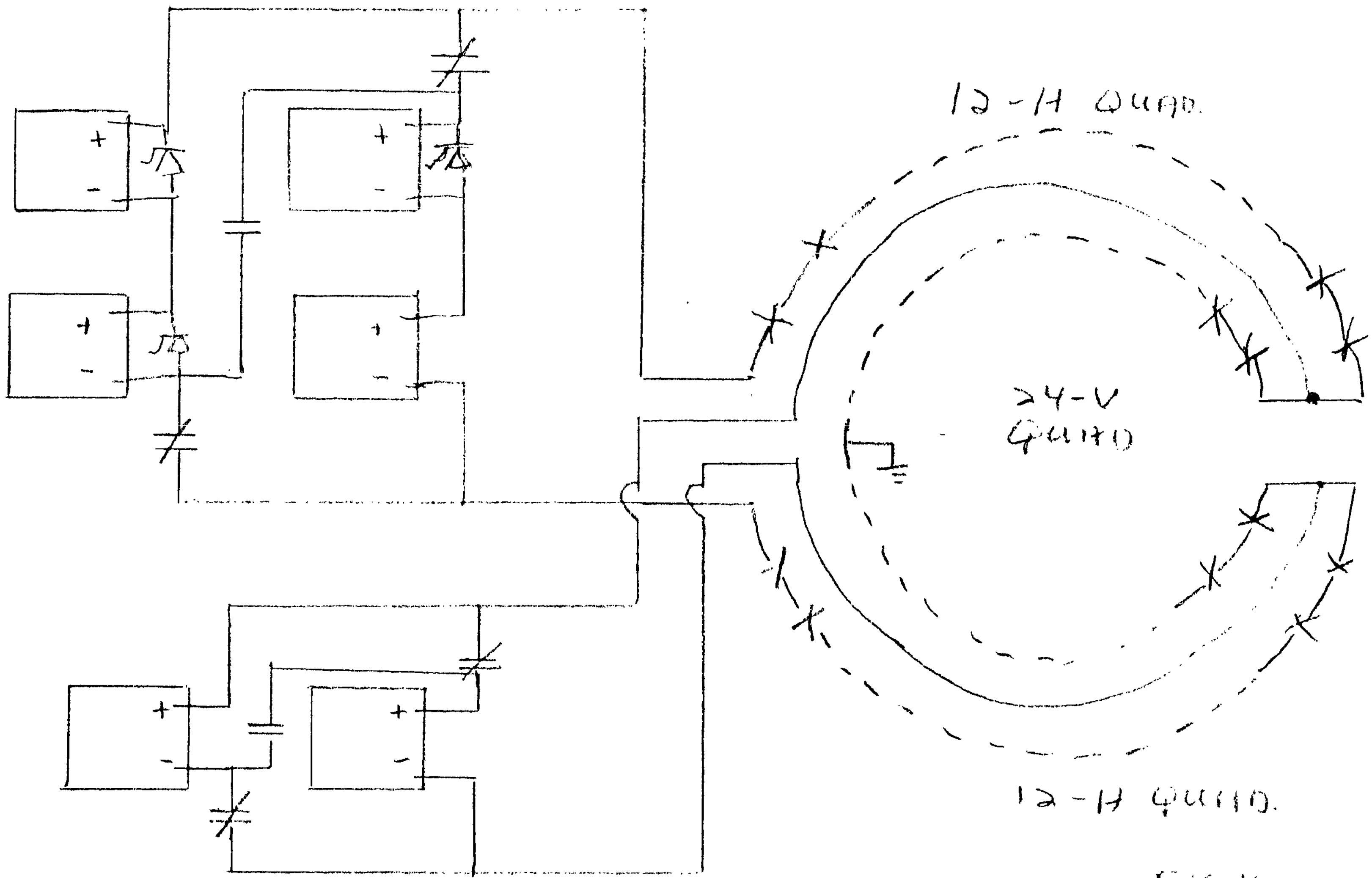
FIG 3

EQUIVALENT CIRCUIT

MAGNET COIL SWITCHING

MAIN QUAD MODULE
225 VOLTS
2600 A MAX
1600 A RMS
360 KVA

RATINGS.
MAIN BUS I ... 3200 A (RMS)
PEAK VOLTAGE 450 VOLTS
TRIM BUS CURR 640 A (RMS)



QUAD-TRIM MODULE
250 VOLTS
520 A MAX
320 A RMS
80 KVA

FIG 4
SYSTEM LAYOUT
QUADRUPOLE
POWER SUPPLY

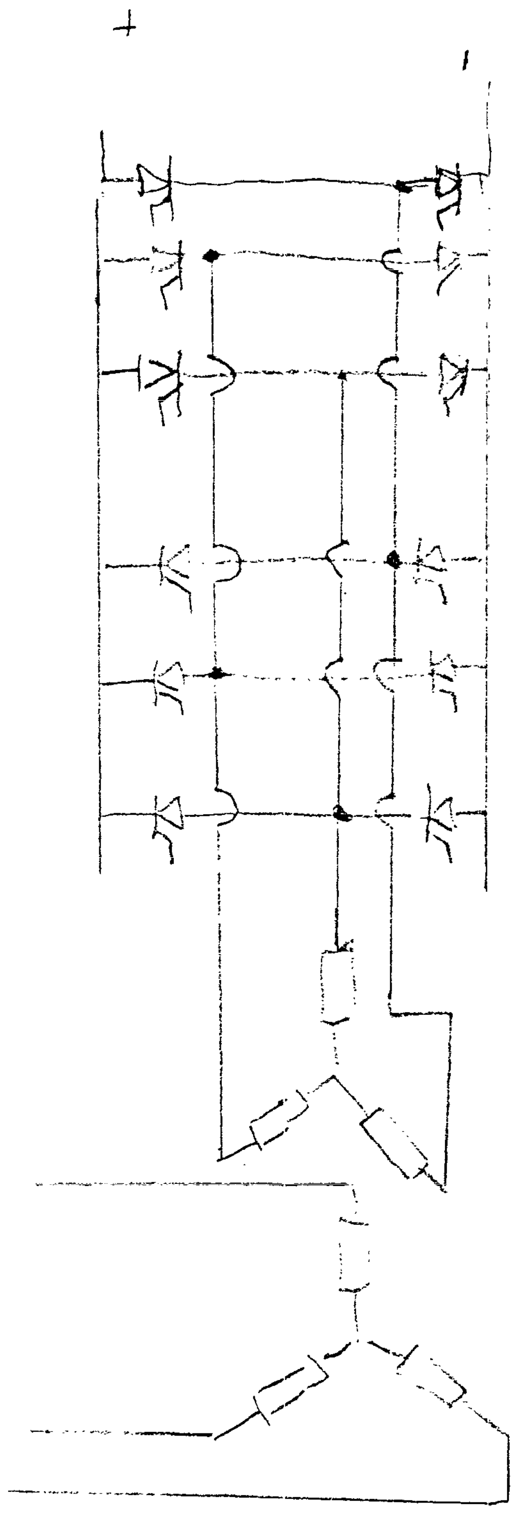


FIG 5
SCHEMATIC OF
QUAD-TRIM
POWER SUPPLY