Quick-Selection Chart
For Rectifier Tubes and Circuits

This Note presents a chart designed to facilitate selection of a combination of a rectifier circuit and an RCA mercury-vapor rectifier-tube type for any application requiring dc voltage up to 21 kilovolts and direct current up to 60 amperes. It also contains a table of the electrical quantities involved in the design of rectifier-type dc power supplies, and gives the values of these quantities for the rectifier circuits shown in the chart.

The chart, shown on page 4, and the table, shown on page 6, are based on five types of rectifier circuits. The circuits shown in Figs. 2, 3, 5, and 6, and the values of the electrical quantities for these circuits, are reproduced from the data sheets entitled "CIRCUITS FOR HOT-CATHODE MERCURY-VAPOR AND GAS RECTIFIER TUBES" in the TRANSMITTING TUBE SECTION of the RCA TUBE HANDBOOK HB-3. The figure numbers for these circuits are the same as those used in the HB-3. The circuit shown in Fig. 9, and the values of the electrical quantities for this circuit, were prepared especially for this Note. The chart is divided into voltage-current areas, each of which is labelled with the figure number of the rectifier circuit and the type designation of the rectifier tube which will usually provide, most economically, the combinations of voltages and currents within the limits of the area.

Use of Chart

To use the chart, simply determine the maximum dc output voltage and current required, locate the area in which the coordinates of these values intersect, and note the indicated rectifier circuit and tube type. For example, if the dc requirements before filtering are 3000 volts and 2 amperes, the indicated source is a full-wave, single-phase rectifier circuit (Fig. 2) using a pair of type 8008 or 872-A rectifier tubes. If the required voltage is between 10,500 and 14,000 volts, and the required current between 15 and 30 amperes, the indicated source is the series three-phase rectifier circuit shown in Fig. 6, using six type 857-B rectifier tubes. For applications requiring between 9600 and 14,000 volts,

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at currents between 7.5 and 15 amperes, the indicated source is the series-parallel, three-phase circuit (Fig.9), using twelve type 6894 or 6895 rectifier tubes.

Use of the Table of Electrical Quantities

As an example of the use of the Table of Electrical Quantities, assume that the required dc output voltage before filtering is 2560 volts, and the required dc output current is 0.4 ampere. The recommended source for these requirements is a full-wave, single-phase circuit (Fig.2) using two Type 866-A's. The RMS voltage E which must be delivered by each half of the plate-transformer secondary winding is

$$E = 1.11 \times E_{av} = 1.11 \times 2560$$
$$= 2842 \text{ volts RMS}$$

The peak inverse voltage E_{bmi} at the anodes of the 866-A's is

$$E_{bmi} = 2.83 \times E = 2.83 \times 2842,$$
$$\text{or } 3.14 \times E_{av} = 3.14 \times 2560$$
$$= 8040 \text{ volts approx.}$$

The peak dc output voltage E_m of the rectifier is

$$E_m = 1.57 \times E_{av} = 1.57 \times 2560$$
$$= 4019 \text{ volts approx.}$$

The amount of ripple voltage E_r in the output of the rectifier is

$$E_r = 0.472 \times E_{av} = 0.472 \times 2560$$
$$= 1208 \text{ volts approx.}$$

The RMS anode current I_p of each rectifier tube is

$$I_p = 0.785 \times I_{av} = 0.785 \times 0.4$$
$$= 0.314 \text{ ampere RMS}$$

The average anode current handled by each rectifier tube (I_b) is, of course, one-half the average output current of the rectifier, or 0.2 ampere.

The peak anode current in each rectifier tube (I_{pm}), and the volt-amperes in the transformer secondary (P_{as}), transformer primary (P_{ap}), and line (P_{al}), depend upon the character of the rectifier load circuit. For a resistive load--that is, where no filter capacitor or filter choke is used -

$$I_{pm} = 3.14 \times I_b = 3.14 \times 0.2$$
$$= 0.628 \text{ ampere,}$$
$$P_{as} = 1.74 \times (E_{av} \times I_{av}) = 1.74 \times 1024$$
$$= 1782 \text{ volt-amperes,}$$
$$P_{ap} = 1.23 \times (E_{av} \times I_{av}) = 1.23 \times 1024$$
$$= 1259 \text{ volt-amperes, and}$$
$$P_{al} = 1.23 \times (E_{av} \times I_{av})$$
$$= 1259 \text{ volt-amperes}$$

For an inductive load--that is, where a large input filter choke is used--

$$I_{pm} = I_{av}$$
$$= 0.4 \text{ ampere},$$
$$P_{as} = 1.57 \times (E_{av} \times I_{av})$$
$$= 1.57 \times 1024$$
$$= 1608 \text{ volt-amperes},$$
$$P_{ap} = 1.11 \times (E_{av} \times I_{av})$$
$$= 1.11 \times 1024$$
$$= 1137 \text{ volt-amperes, and}$$
$$P_{al} = 1.11 \times (E_{av} \times I_{av})$$
$$= 1137 \text{ volt-amperes}$$

The preceding calculations do not take into account the voltage drops in the rectifier tubes and in the secondary windings of the plate-supply transformer. For most accurate results, both of these voltage drops should be added to E_{av} wherever this term is used.

RCA thyratron type 5563-A has the same electrical ratings as mercury-vapor rectifier types 6894 and 6895, and may be used in place of these types in applications requiring the use of grid-controlled rectifier tubes.

Systems Analysis

The chart is also useful in systems analysis where the desired output power is known and the most economical voltage and current values are to be determined. In such cases the choice is immediately narrowed to those areas intersected by the diagonal line corresponding to the desired output-power level. In general, the tube-and-circuit combination for the area where this intersection occurs closest to the upper-right hand corner will be most economical. However, all nearly equal choices made on this basis should be investigated more closely. For example, if the desired power output is 100 kilowatts, a parallel three-phase circuit (Fig.5) using type 6894 or 6895 rectifier tubes and delivering 14 to 19 kilovolts, or a series three-phase circuit (Fig.6) also using type 6894 or 6895 rectifier tubes and delivering 7 to 9.5 kilovolts, are about equally advantageous. Operation in the ranges below 7 kilovolts, between 9.5 and 14 kilovolts, and above 19 kilovolts is relatively expensive.

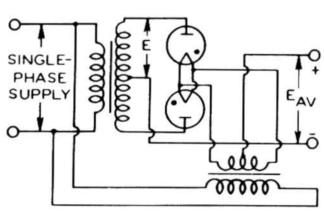


Fig.2 - Full-Wave Single-Phase.

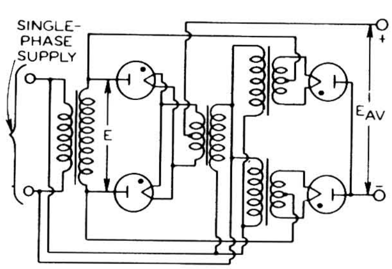
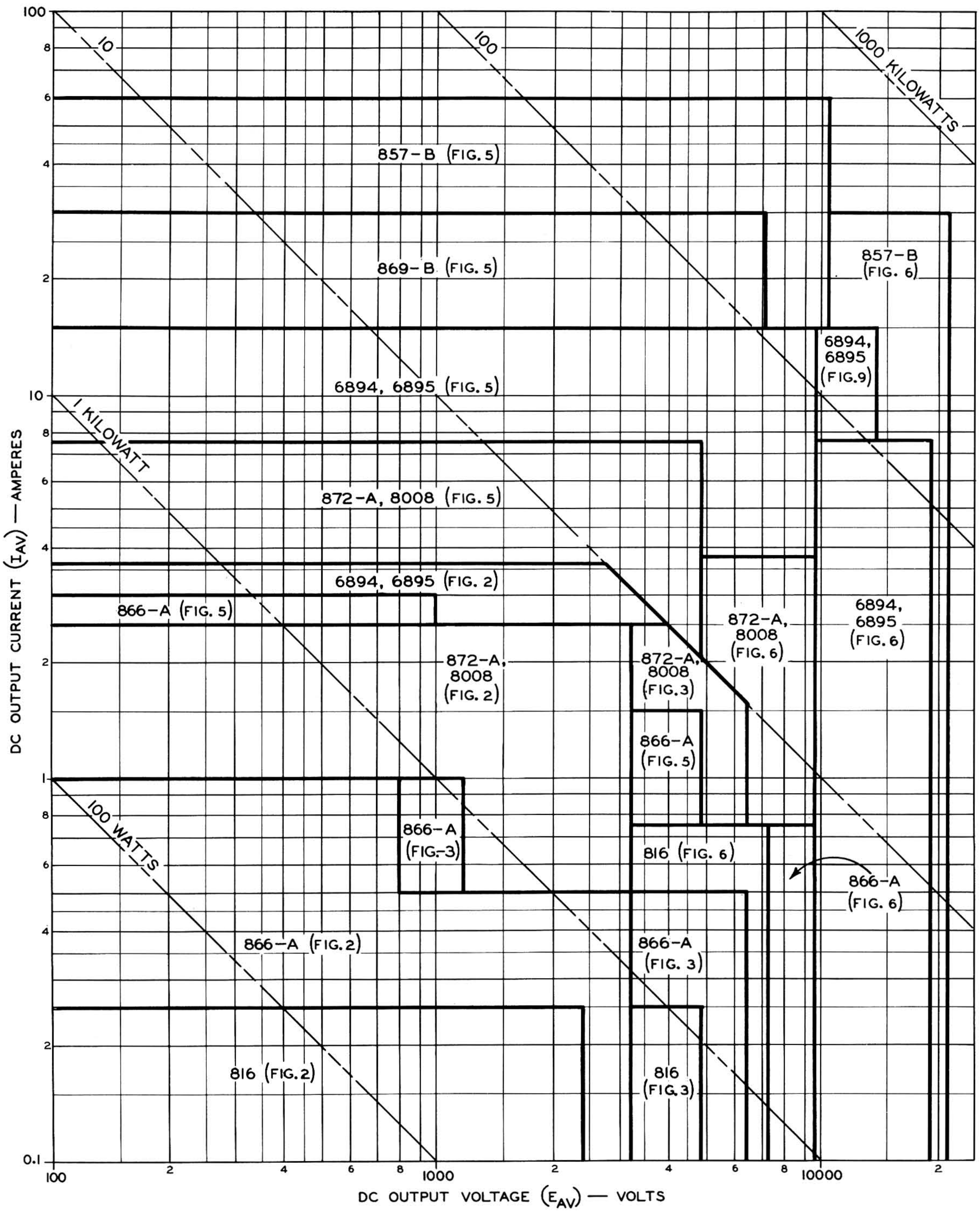


Fig.3 - Series Single-Phase.



Rectifier-Tube and Circuit Selection Chart.

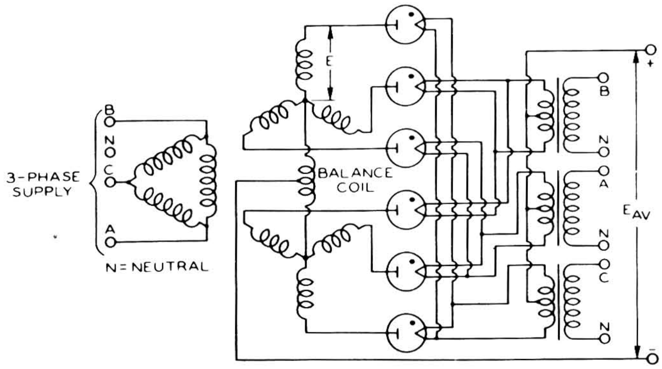


Fig. 5 - Parallel Three-Phase (Quadrature Operation).

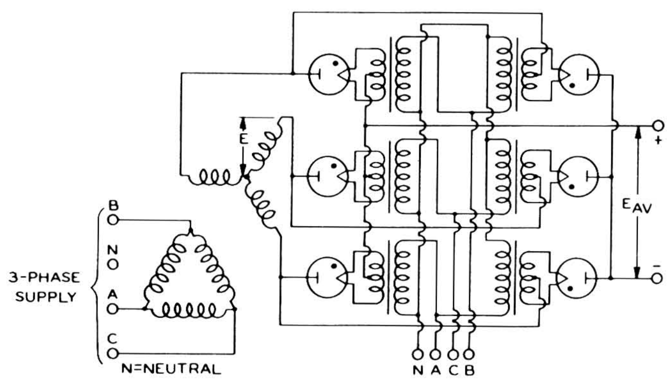


Fig. 6 - Series Three-Phase (Quadrature Operation).

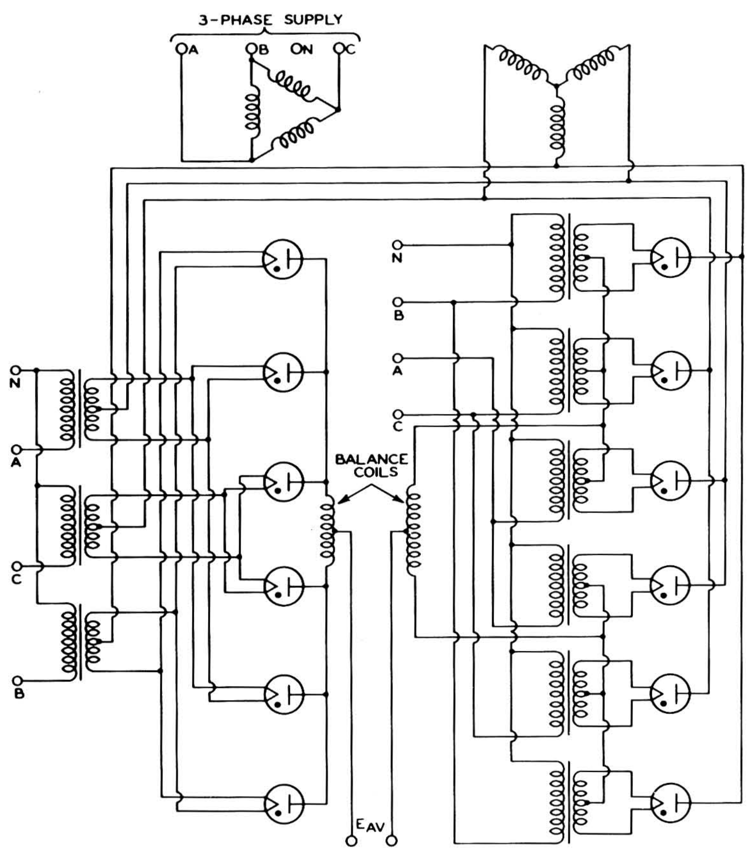


Fig. 9 - Series-Parallel Three-Phase (Quadrature Operation).

TABLE I

E = Trans. Sec. Voltage (RMS)
E_{av} = Average DC Output Voltage
E_{bmi} = Peak Inverse Anode Voltage
E_m = Peak DC Output Voltage
E_r = Major Ripple Voltage (RMS)
f = Supply Frequency
f_r = Major Ripple Frequency
I_{av} = Average DC Output Current
I_b = Average Anode Current
I_p = Anode Current (RMS)
I_{pm} = Peak Anode Current
P_{al} = Line Volt-Amperes
P_{ap} = Trans. Pri. Volt-Amperes
P_{as} = Trans. Sec. Volt-Amperes
P_{dc} = DC Power (E_{av} x I_{av})

Note: The ratios given below assume the use of sine-wave ac supply voltage; zero voltage drop in tubes; no losses in transformer and circuit; no back emf in the load circuit; and no phase-back.

RATIOS	Fig. 2	Fig. 3	Fig. 5	Fig. 6	Fig. 9♦
Voltage Ratios					
E/E_{av}	1.11	1.11	0.854	0.427	0.427
E_{bmi}/E	2.83	1.41	2.45	2.45	2.45
E_{bmi}/E_{av}	3.14	1.57	2.09	1.05	1.05
E_m/E_{av}	1.57	1.57	1.05	1.05	1.05
E_r/E_{av}	0.472	0.472	0.04	0.04	0.04
Frequency Ratio					
f_r/f	2	2	6	6	6
Current Ratios					
I_b/I_{av}	0.5	0.5	0.167	0.33	0.167
Resistive Load					
I_p/I_{av}	0.785	0.785	0.293	0.578	0.294
I_{pm}/I_{av}	1.57	1.57	0.605	1.05	0.525
I_{pm}/I_b	3.14	3.14	3.63	3.14	3.14
Inductive Load□					
I_p/I_{av}	0.707	0.707	0.289	0.577	0.289
I_{pm}/I_{av}	1	1	0.5	1	0.5
Power Ratios					
Resistive Load					
P_{as}/P_{dc}	1.74	1.23	1.05	1.05	1.05
P_{ap}/P_{dc}	1.23	1.23	1.06	1.05	4
P_{al}/P_{dc}	1.23	1.23	1.05	1.05	11
Inductive Load□					
P_{as}/P_{dc}	1.57	1.11	1.48	1.05	1.05
P_{ap}/P_{dc}	1.11	1.11	1.05	1.05	1.05
P_{al}/P_{dc}	1.11	1.11	1.05	1.05	1.05

♦ A bleeder current equal to 2 per cent of the full-load current will provide sufficient excitation current for the balance coil or coils to assure good regulation under light-load conditions.

□ The use of a large filter-input choke is assumed.