

SUGAR MILL DRIVES

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A large variety of driven machines are to be found in a sugar mill—fortunately these drives fall into only three basic types, viz.,

- (1) Constant speed,
- (2) Variable speed over a wide range,
- (3) Variable speed over a limited range.

In most mills the constant speed drives are accommodated by electric motors while steam units are resorted to for the variable speed applications.

A brief survey will be made of the first two drives and special attention will be paid to the electric drive having variable speed over a limited range and its performance will be compared with that of the steam turbine.

Constant Speed Drives

The majority of drives in a sugar factory are of the constant speed type for which the three-phase induction motor is ideally suited.

The squirrel cage induction motor is used for most normal applications while the slip ring induction motor comes into its own where heavy starting torque and/or prolonged run-up time is required.

These motors are of very robust design and require little maintenance. The control gear is simple and compact, thus ensuring reliability in an average installation.

Variable Speed over a Wide Range

There are a number of types of drive having variable speed over a wide range, e.g.,

- (a) Ward Leonard System, which can be classified as the ultimate in variable speed drives, consists of three machines—a constant speed motor driving a variable voltage D.C. generator which in turn is electrically coupled to a D.C. motor. This D.C. motor drives the load and its speed can be varied from zero to maximum with full load torque available over the whole speed range. Speed control is effected by varying the output voltage of the D.C. generator.

The absorption of regenerative braking power presents no problem to this system and regeneration can continue down to very low speeds.

- (b) Many attempts have been made at combining the variable speed properties of the D.C. motor with variable voltage power supplies other than the motor-generator set.

Grid controlled Mercury Arc convertors have been in use for many years but the modern trend

is to use solid state convertors. The variable speed performance of motors controlled in this manner is very similar to that of the Ward Leonard system.

- (c) A.C. commutator motors of either the shunt or series type are available for variable speed applications and it is rather surprising that these motors are not more widely used. Speed control is effected by brush movement or, in some types, by induction regulators.

A comparison of performances and prices for these various systems form the text of a paper entitled: "Comparison of Various Electrical Drives suitable for Cane Crushing Mills" which is presented at this Congress by Mr. A. Gradener.

The Variable Speed Drive with Limited Speed Range

The most important application of this type of drive is that of driving cane milling units, where the basic requirements are constant torque over the speed range. It is of advantage to have a reserve of torque should it be required.

It is rather surprising that an industry as large as the Sugar Industry should resort to the steam turbine as a means of obtaining a variable speed drive, whereas most other major industries rely solely on electric drives.

A Cane Mill Drive

Consider the application of a drive to a cane milling unit where the speed is to be variable from full to half rated speed. The drive is to be capable of producing full rated torque over the entire speed range.

The suitability of the steam turbine will be considered and reference to Fig. 1 will indicate the full throttle torque/speed characteristics of the average mill drive turbine. A very desirable feature is the increasing torque with decreasing speed.

Most mill drives are called upon, from time to time, to handle transient overloads. Should this occur while a turbine is running at rated speed and full throttle, it will be incapable of supplying the extra torque unless it slows down. This state of affairs would, in all probability, be unacceptable and can only be overcome by installing an over-size turbine. It is interesting to note that the installed turbine horsepower of most installations is twice that which is required to mill the rated quantity of fibre.

Cane mills are invariably run at speeds other than their rated full speed and it is under these conditions that the turbine suffers its greatest drawback. Reference to Fig. 2 will indicate the steam consumption at constant torque and variable speed. The horsepower at constant torque is proportional to speed.

The turbine is basically a constant speed device and if it is called upon to operate at a speed other than that for which it is designed, its efficiency drops and it becomes an uneconomical prime mover.

Electric Drive

Another form of drive which is suitable for cane mills is the AC-DC Cascade set, the layout of which is shown in Fig. 3. It comprises a main motor of the slip ring induction type to which a D.C. motor is mechanically coupled. In the case of a 2:1 speed variation the D.C. motor must be rated at the same horsepower as the main motor. The size of the D.C. motor becomes smaller as the designed speed range is decreased.

The slip power of the main motor, which increases as the speed is reduced, is rectified and fed to the D.C. motor, the mechanical output of this motor, therefore, increases as the speed decreases. The full load torque/speed curve for this set is given in Fig. 4. The electric motor has one outstanding advantage in that it can safely develop 175 per cent torque for a period not exceeding fifteen seconds and most manufacturers claim 125 per cent torque for two hours. Figure 5 shows the overload torque available from the cascade set under discussion.

In view of the overload characteristics of the cascade set the drive could be proportioned to run at 90 per cent of its capacity when crushing the rated quantity of fibre.

Comparison of Performance and Cost

The power house steam consumption of a Cascade drive equals that of the simple mill drive turbine operating under rated conditions. The superior steam rate of the turbo-alternator is off-set by the double transformation of energy in the electric system. Figure 6 represents the power house steam consumption of a cascade drive. It can be seen that there is an improvement over the turbine steam rate as the speed decreases.

Unfortunately there are no concrete facts on which to base a comparison of the overall costs of the two systems but an estimation of the cost of systems of equal horse power at 1,450 r.p.m. indicate that the installed cost of an electric drive, excluding increased alternator capacity, is the same as that of the steam system excluding the exhaust steam range. The cost

of the electric drive can be reduced by the installation of a system having a more realistic horse power rating. The comparison of the two systems is summarised in the chart, Figure 7.

Conclusion

The AC-DC cascade drive is the most serious competitor to the steam turbine in that it has similar full load speed/torque characteristics and far superior overload capabilities.

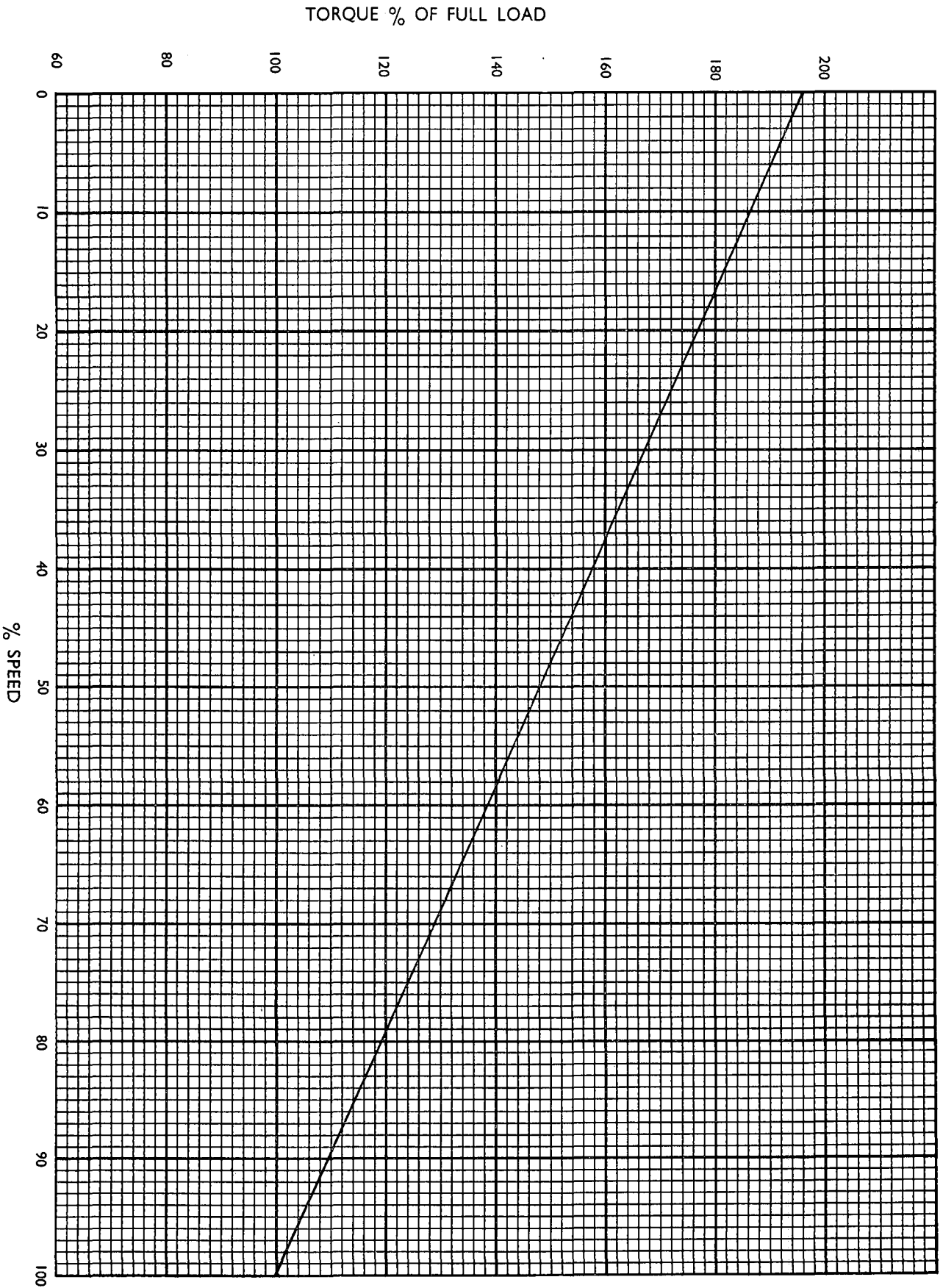
The overall cost of the electric drive can be brought into line with that of the steam system provided a more realistic approach is adopted regarding the installed horse power.

The running troubles usually associated with D.C. machines are not of a serious nature and even less so with the D.C. machine of the Cascade set. This machine runs under almost ideal commutating conditions, i.e. the maximum commutator voltages occur at the minimum speeds.

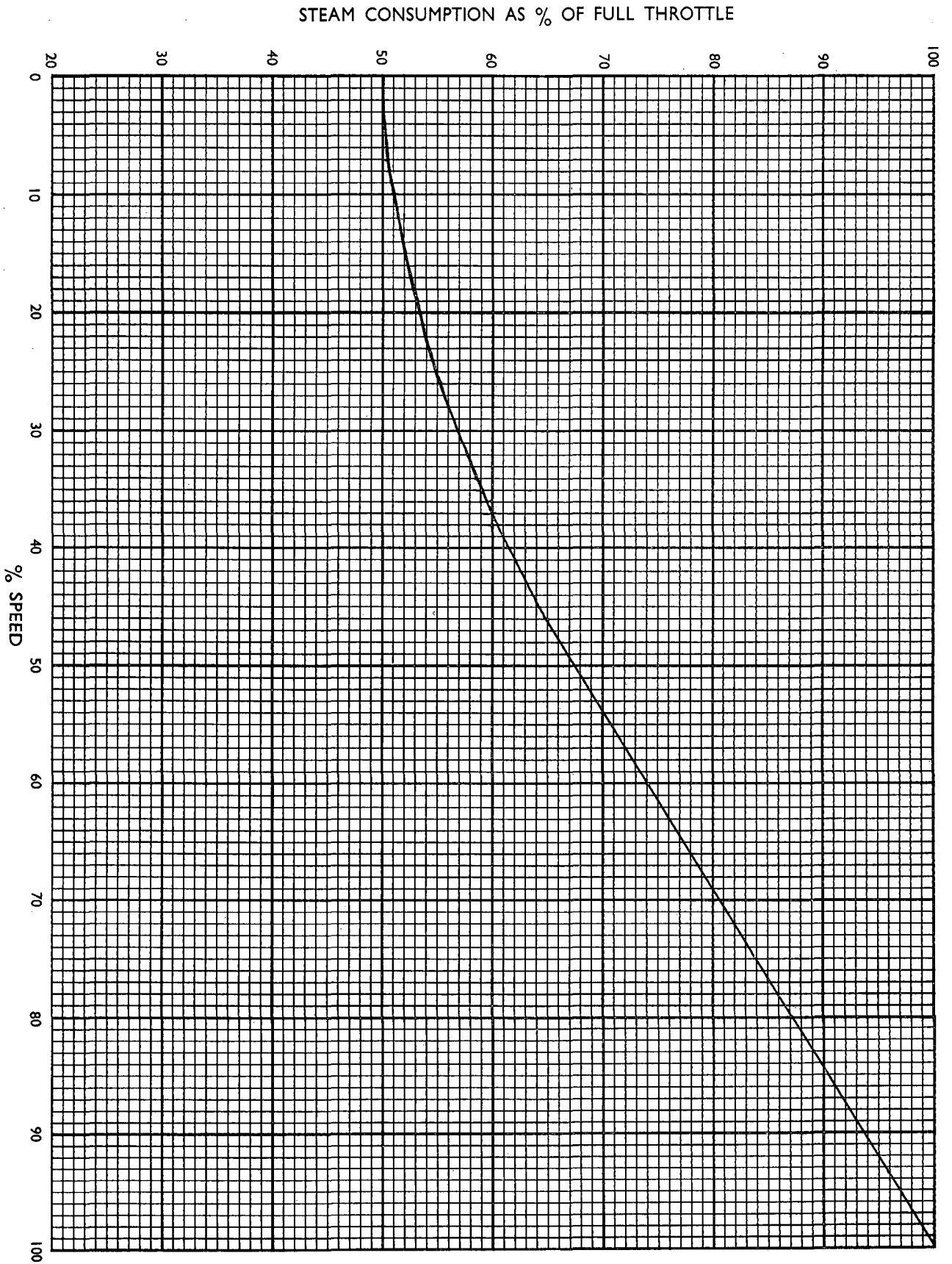
In the light of modern developments in electrical components it can be concluded that the electric drive must become a serious competitor to the steam turbine drive.

FIGURE 7
Comparison of Performance based on Drives
of Equal Horse Power Rating

	<i>Steam Turbine</i>	<i>Cascade Set</i>
Torque available at:		
100% speed	100%	100%
80% speed	118%	125%
60% speed	135%	166%
Steam consumption at 100% Torque:		
100% speed	100%	100%
80% speed	87%	80%
60% speed	74%	60%
Two-hour Overload Torque, % FLT:		
100% Speed	100%	125%
80% speed	118%	156%
60% speed	135%	207%
Size of drives for comparable performance	100%	77%



% TORQUE/SPEED CURVE OF A TURBINE AT FULL THROTTLE
FIG. 1



CURVE SHOWING STEAM CONSUMPTION, AS % OF FULL THROTTLE FLOW, AT 100% TORQUE AND VARIABLE SPEED, FOR STEAM TURBINE
FIG. 2

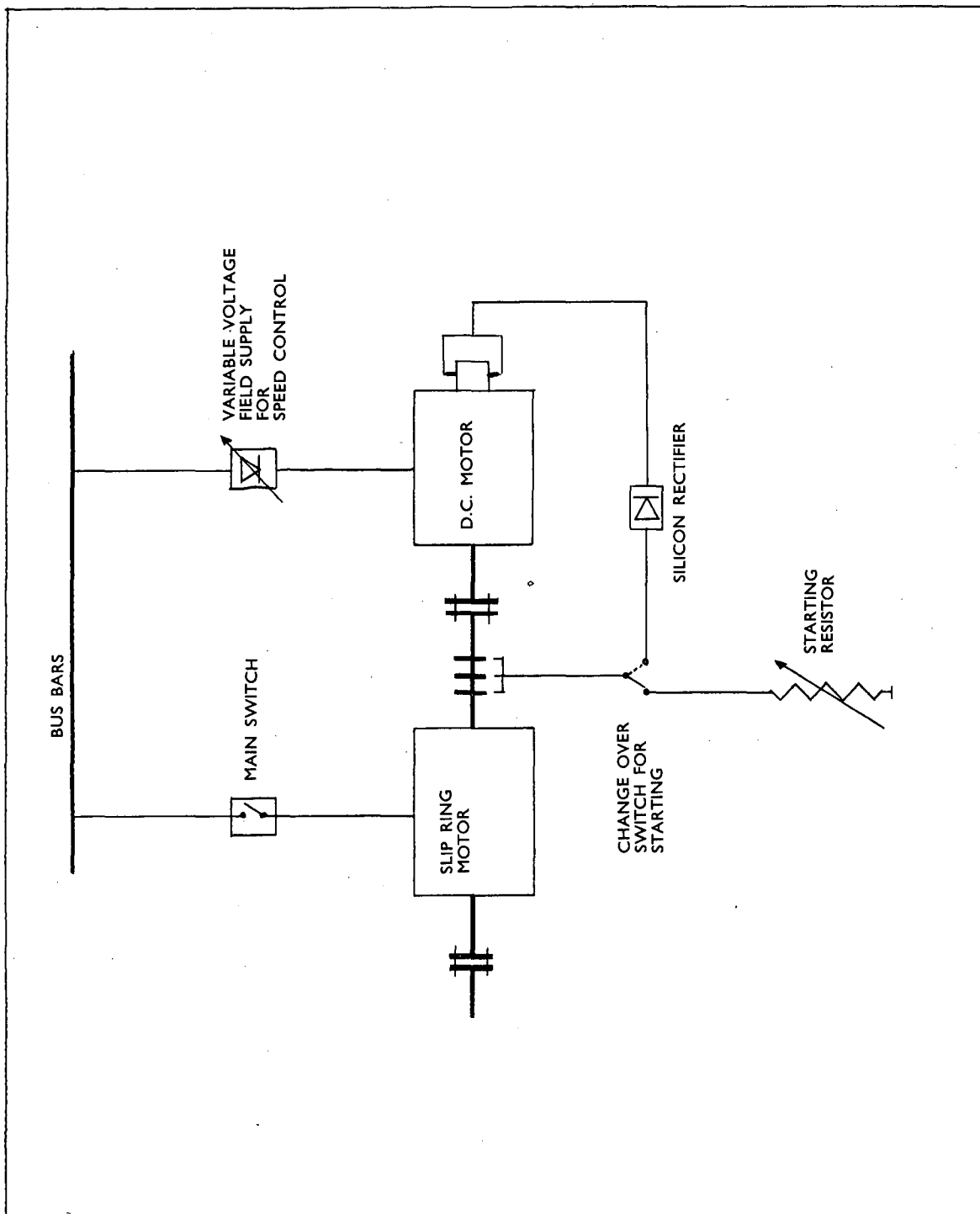
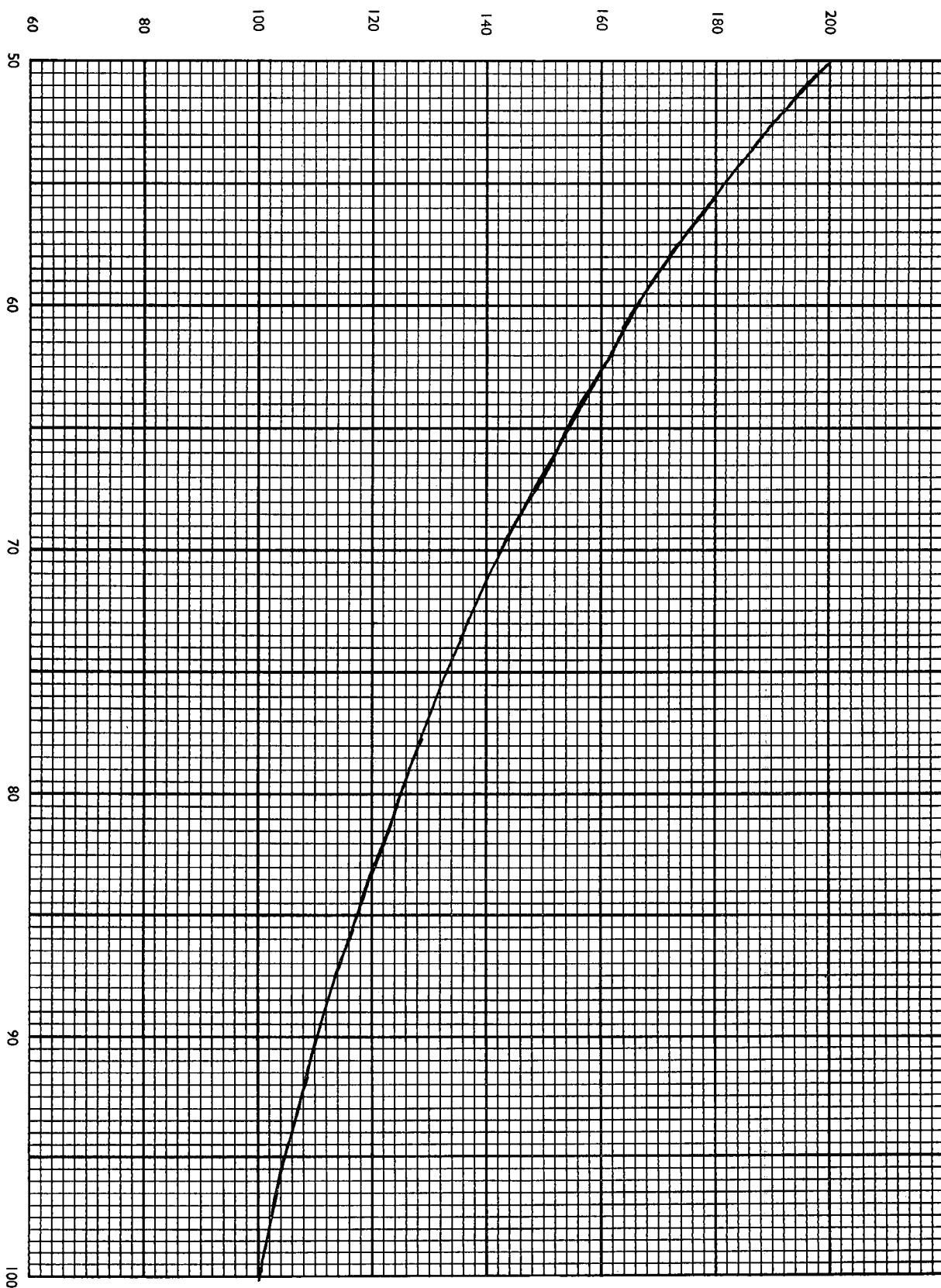


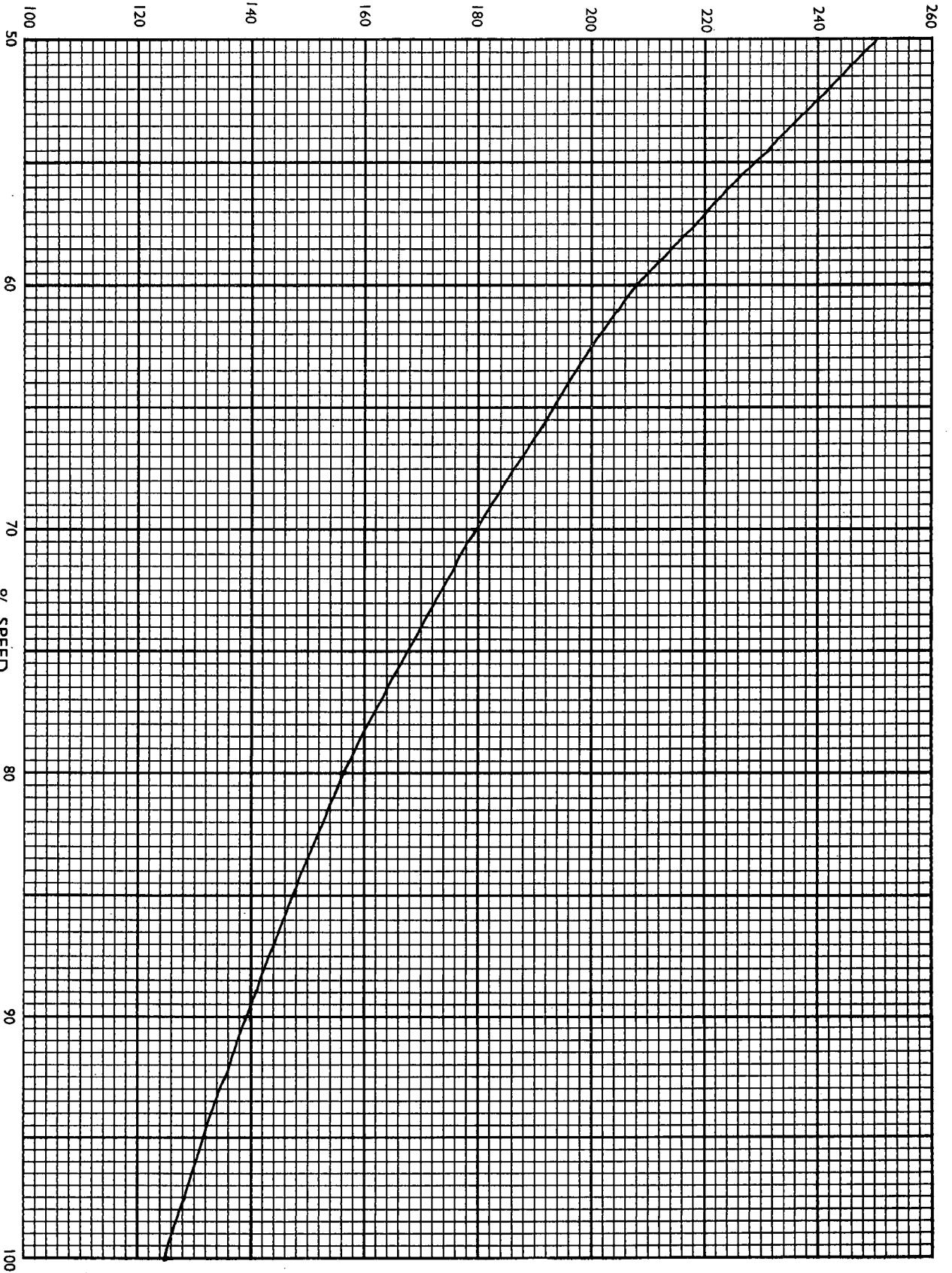
FIG. 3 BASIC LAYOUT OF THE AC-DC CASCADE DRIVE

TORQUE % AT FULL SPEED



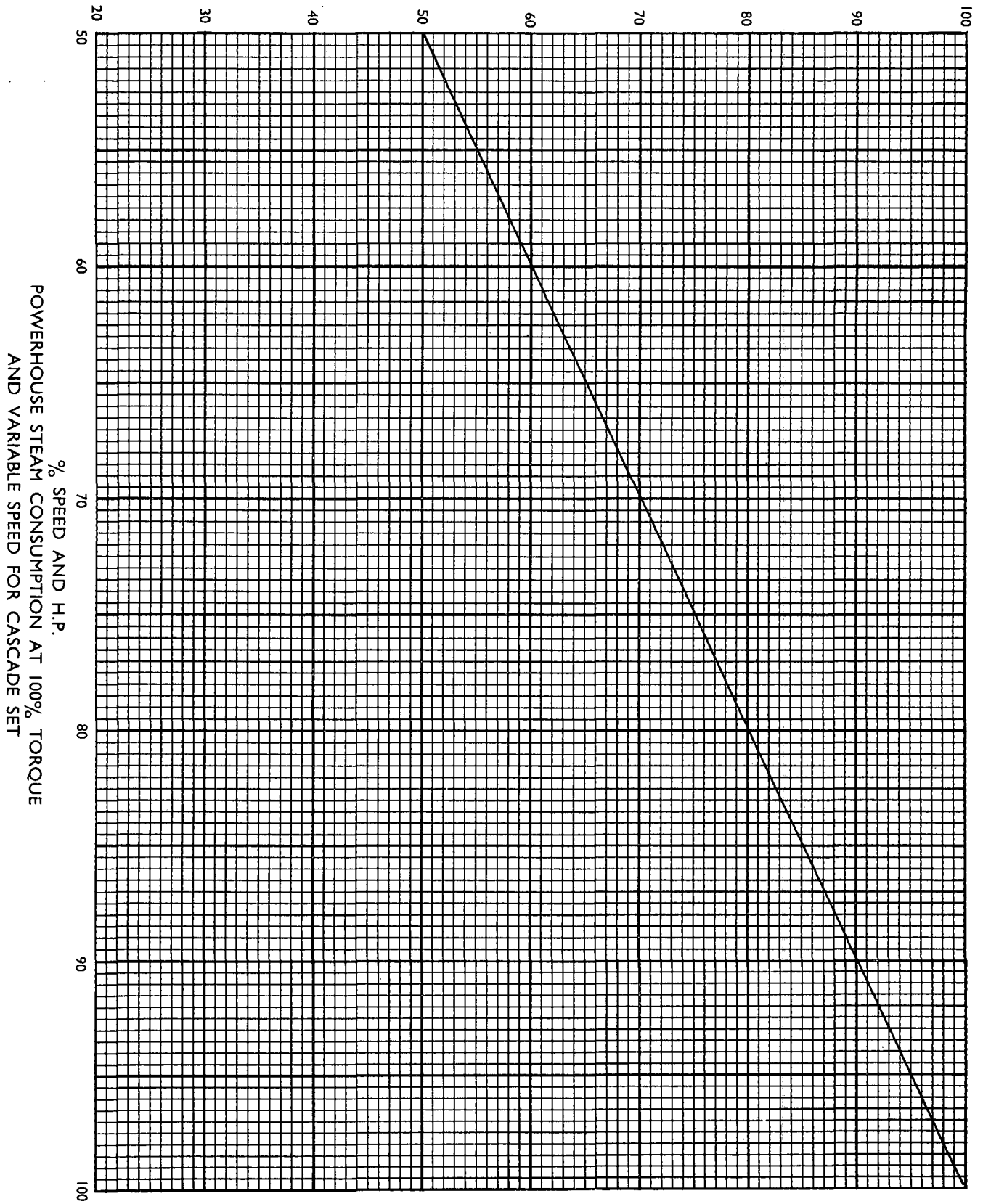
% TORQUE/SPEED CURVE OF CASCADE SET AT FULL LOAD
FIG. 4

TORQUE % AT FULL SPEED



TWO HOUR OVERLOAD TORQUE/SPEED CURVE FOR
CASCADE SET
FIG. 5

STEAM CONSUMPTION AS % FULL LOAD



POWERHOUSE STEAM CONSUMPTION AT 100% TORQUE AND VARIABLE SPEED FOR CASCADE SET

FIG. 6

For discussion on this paper see page 81.