on account of its simplicity and also because the starting duty of a centrifugal pump is not heavy, is used to drive the majority of small and moderate-sized pumps.

In sizes over 150 h.p. and in many cases less, the slip-ring induction motor is used instead of the squirrel-cage type, because it takes less current from the line in starting. Also power companies often fix the maximum size of squirrel-cage motor they will allow to be connected to their lines. In still other cases where a system does not have much capacity, throwing a large squirrel-cage motor on the line would cause serious disturbances and possibly a voltage drop that would be enough to prevent the motors coming up to synchronous speed. These cases call for the use of slip-ring motors. This type is used sometimes when a moderate amount of speed control of the pump is required, possibly to maintain a constant pressure with a variable discharge or to maintain a constant discharge with varying heads.

High-Speed D.C. Motors

Direct-current motors as well are used where speed variation is required, but for constant-speed service are not used so much as induction motors. Then, too, for moderate heads standard centrifugal pumps ordinarily run at higher than the best direct-current motor speeds. However, relatively high-speed direct-current motors are now being built that can be used as satisfactory pump drives where only direct current is available.

As a fourth kind of pump drive, synchronous motors are just beginning to receive deserved attention. Many centrifugal pumps, because they offer a constant steady load, present a fine opportunity for using a large synchronous motor to keep up or correct the power factor of a power system, and by using proper care suitable synchronous motor-driven centrifugal pumps can be often selected.

Troubles Traceable to Pump

Before leaving the subject of the horsepower requirements of centrifugal pumps as related to motor drive, possibly it will be well to point out a few troubles that are sometimes encountered with motors and that are traceable to the centrifugal pump. The most common difficulty, which has been mentioned previously, is operating an improperly selected pump at less than the rated head. This will overload the motor and cause it to run hot. Another trouble almost as common is pump and motor out of alignment due to improper erection. This causes vibration and hot bearings and wears out rapidly the coupling bushings. A third trouble sometimes experienced and resulting in hot motor bearings, is when the centrifugal pump develops an end thrust, causing collars on the shaft to rub on the ends of the bearings. End thrust may develop in a single-stage double-suction pump on account of one side of the runner becoming partly obstructed or an obstruction lodging in the suction passage on one side, which unbalances the runner. Unequal wear of the runner wearing rings on opposite sides of a double-suction runner or displacement of the runner slightly to one side of the centre line of the casing also will cause thrust. In multistage pumps thrust is generally caused by failure or partial failure of the arrangements provided to balance the end thrust. Two pumps taking their suction from the same suction pipe or discharging into the same discharge line, if they are not properly arranged and do not have the right kind of characteristics, can cause trouble by dividing the work unequally, but this and similar questions are outside the scope of this article.

Unit Considered in Entirety

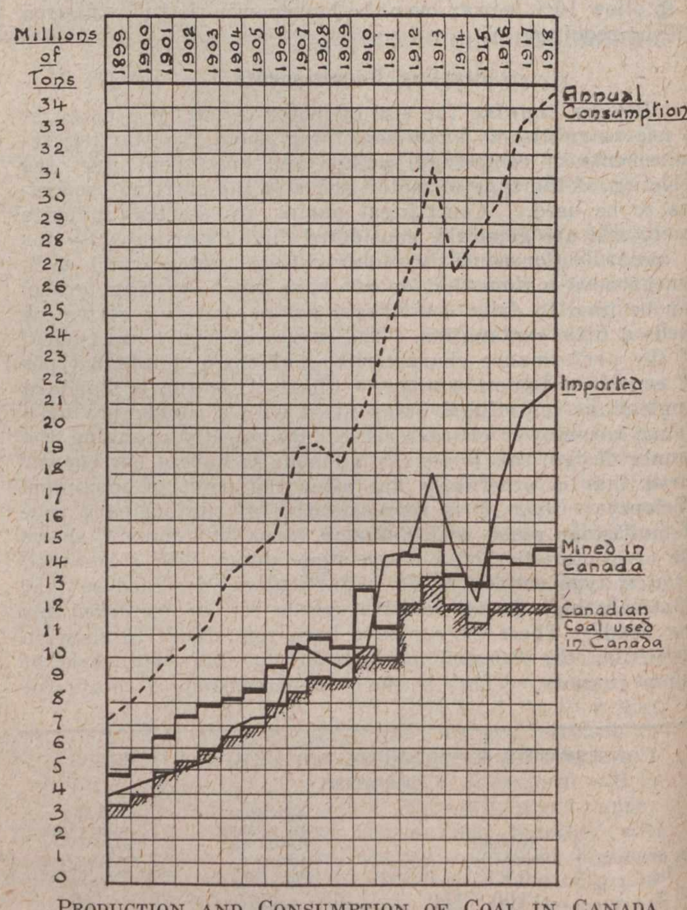
It can be safely stated that a pump should not be bought merely as a pump of a certain size without any reference to the work it will have to do. In conjunction with the driving motor it should be selected to do certain definite work to the best advantage. It is therefore preferable to buy pumps that have been tested carefully and their characteristics determined, with motors of suitable size to run the pumps under all the conditions that will be met with in service. That is, a pump and the drive should be considered as a unit and selected accordingly.

PRODUCTION OF COAL IN CANADA*

By F. D. Gray

THE accompanying graph was compiled from Department of Mines statistics. It shows that up to about 1912 the Dominion was able to furnish from its own coal-seams a little better than half the tonnage of coal consumed for all purposes in Canada. Actually, however, this was not the case, as a certain amount of coal was exported, chiefly from the Cape Breton mines to Boston, Mass.

During the period 1886 to 1899, the coal imported into Canada averaged a little over 54% of the total coal consumption of the country. During the period of 1899 and 1918, included in the graph, the same percentage was maintained, but during the war period the percentage of coal imports was greatly increased. At the present time the imports have risen to 63% of Canadian consumption of coal.



Production and Consumption of Coal in Canada

The coal consumed in Canada during 1918 is estimated at 34,840,000 tons, the highest figure recorded in Canadian statistics, and most closely approached by 1913, when 31,582,545 tons of coal were consumed.

The consumption per capita shows a steadily rising figure, and this is encouraging as showing Canada's progress in the industrial arts and in the conveniences of civilized life, but the discouraging feature disclosed by a study of the statistics is that the Dominion is rapidly increasing its importations of coal, at higher prices than have ever prevailed in the past, and at the same time the home production of coal shows a stationary and even a declining tendency. Any form of production in Canada that is stationary is unsatisfactory and is equivalent to a declining production when viewed in relation to the general growth of population.

There is a difference between the jump in coal consumption that marked 1913, and the peak figure of 1918, namely that in 1913 Canadian coal-mines were increasing their outputs coincidentally with the increase in coal im-

(Concluded on page 247)

*From "Iron and Steel of Canada."