the water levels is not usually great these pumps are, as a rule, standardized for the maximum head against which they will have to operate. This seldom exceeds 300 feet and in some mines is as low as 15 feet. Owing to their relatively large number and scattered location, these pumps are usually driven by direct current motors and operate from the locomotive feeder wires, although they are sometimes served by cables run into the mine through a centrally located bore hole. They are frequently semi-portable, so as to facilitate their movement or replacement to meet the varying requirements developed by the constantly changing conditions incident to coal mining. Like the main pumps, they normally operate without attendance except for occasional inspection, cleaning and lubrication, and can be equipped with automatic control, if required.

Perhaps the best demonstration of the superior flexibility of electrical operation in coal mines is found in the portable pumping set, which can be lowered down the shaft or slope and rapidly hauled to any portion of the mine by a locomotive and immediately put into service by connecting the suction pipe, unreeling the discharge hose and connecting the motor leads to the locomotive feeder wires. The equipment varies in details, but not in essentials at different mines, and consists of a centrifugal or plunger pump direct connected or geared to a direct current motor provided with a simple drum controller. There is also a suction pipe with a strainer end and a discharge pipe or hose reel, and if the set is intended for fire service, the necessary fire fighting auxiliaries are included. The complete outfit is compactly mounted on a truck having the same wheel gauge as the mine locomotives. It constitutes a valuable adjunct to the ordinary pumping equipment, as it can be used in all emergencies to replace any pump of approximately the same capacity which may be shut down for repairs or other reasons, and for intermittent dip pumping roadways where the expense of drainage grading would not be justified and a permanent pumping set would not be economical, owing to the short and irregular periods of operation.

Ventilating Fans and Air Compressors.

Uninterrupted service is the primary requisite of a coal mine ventilation system. The imminence of the hazard to the workers underground involved in a failure of the supply of fresh air being, of course, dependent on the character and formation of the mine.

Mechanical ventilation by means of rotary blower or exhaust fans which give a positive and fully controllable supply of air is almost universal in coal mines, the furnace system being used only in small isolated mines, or as a temporary arrangement in some of the larger ones, while the water fall or trompe ventilator or the steam jet or water jet methods are rarely resorted to. In driving ventilating fans with electric motors it is customary to couple the motor and fan shafts together and avoid the use of belting, as the nature of the load is such that with high speed fans direct drive minimizes the power requirements and economizes space.

Where large slow speed fans are changed over from steam to electric drive the retention of belting is often necessary, due to the difference between the speeds of the fan and the motor, but with both forms of electric drive the reliability of the service is increased, attendance cost reduced, and better speed control assured, while the installation of the fan itself is not influenced by the location of the power house. Where remote control is desirable, as in the case of fans situated at a considerable distance from the central or substations, it can be accomplished with remote control switches and any interruption of the service indicated promptly by connection alarm lights or bells in the motor circuit.

For mines using induction motors for other work, the question of adopting synchronous motors for driving the fans should be carefully considered, especially if the induction motor load is such as to seriously affect the power-factor of the generating and distribution systems, as by utilizing synchronous motors of higher rating than is actually required for driving the fans, their excess capacity may be devoted to correcting lagging power-factor by supplying leading current to the distribution system. This will frequently obviate the necessity for providing unloaded synchronous condensers to counteract the influence which underloaded induction motors and transformers have on the power-factor, and consequently the effective capacity of both generators and conductors.

When compressed air machinery is required in coal mines, electric drive renders it possible to locate the compressors with a view solely to securing the best air service irrespective of the location of the prime movers, in contradistinction to the necessary limitations of steam-driven air compressors. The motor operated units may be installed in distant substations or in the mines, and as a result short pipe lines with a correspondingly reduced pressure drop may be used, while individual compressors can be provided for isolated working sections.

If automatic unloaders are used with the compressors to regulate the pressure, and by-passes provided so that the motor is enabled to start at very light loads, the conditions are most favorable to the use of synchronous motors on slow speed reciprocating compressors, as very little overload capacity is then required in the motor, and it may be designed as in the case of those driving ventilating fans to compensate for conditions of low power-factor.

It is not usually advisable to drive high speed centrifugal air compressors with synchronous motors, as the best operation of this type can be secured by the use of high speed induction motors. Both types of motors can ordinarily be direct connected to the compressor shaft, but belting is of necessity sometimes retained in changing over from steam to electric drive.

Rock and Coal Crushers.

When motors were first applied to the centrifugal type of rock and coal crushers it was considered advisable to retain belt drive, due to the onerous starting conditions, excessive vibration and the possibility of the severe operating requirements resulting in stalling or injuring the motor. Familiarity with the use of electric motors, however, induced many of the engineers of the mining companies to attempt direct drive and both alternating and direct current motors are now successfully applied in this manner, being connected to the crusher shaft through flexible couplings.

When driving these crushers with engines it was necessary to utilize belting in order to obtain the required speed, and space economy was attained by installing the engine close to the crusher and reducing the belt-slip caused by the short arc of contact by interposing idlers. This was accomplished at a sacrifice in the power applied in useful work and the cost of belting renewals was excessive, amounting in some cases to approximately $100 per month for a single crusher. It is manifest that direct motor drive not only eliminates this expense, but reduces the amount of space necessary, while at the same time applying a greater percentage of the power in useful work.