the surplus. The stones were never thoroughly coated, thus allowing water to get into the crust.

The method employed in one instance was a double layer. The size of stones used for the lower layer was 3 to 2 in. and for top layer 1½ in. with ½ in. chippings. The lower layer of stone is spread and levelled and is rolled dry. The pitch and sand mixture (as above described) is poured on, but not brought to surface. The pitch lying ½ in. or so below surface of the lower layer to form a key for top layer.

When the top layer has been laid, the pitch mixture is poured on surface, which is rolled and consolidated to proper shape. During rolling chippings are applied to form finished surface.

The quantity of pitch mixture used was 3½ gal. per sq. yd. for the two layers. The finished surface in this case was 4½ in. thick. This method was very satisfactory during the year, almost dustless, and not slippery during frost.

(To be concluded next week.)

ELECTRICAL DRIVING OF WINDING ENGINES AND ROLLING MILLS.

In a very complete and well-illustrated paper, delivered last month to The Canadian Society of Civil Engineers and to the Canadian Mining Institute, C. Antony Ablett, A.M.Inst.C.E., and H. M. Lyons, A.M.I.E.E., described the use of electrical machinery for driving hoisting engines in mines and reversing mill plants in steel works.

The first winders of importance were introduced in 1902, and the first electrically driven reversing rolling mill was installed in 1906, though non-reversing rolling mills were driven electrically some eight or ten years earlier.

The developments along these lines have been extremely rapid, as is shown by the fact that at the present time about one thousand large winding engines and nearly sixty reversing rolling mills are being driven electrically. The earlier winding engines were extravagant in power and had the disadvantage of drawing very heavily upon the source of electrical supply at the moment of starting. It was, therefore, impossible to use them on systems where the supply of current was limited, and even on comparatively large plants their use resulted in serious interference with other machinery. These disadvantages were, however, practically done away with when the Ward Leonard system and Ilgner's adoption of the flywheel to this system were introduced, but the last few years have seen greater improvements in the Ward Leonard and the Ilgner system.

The paper delivered by Messrs. Ablett and Lyons dealt chiefly with the developments of these systems by the various Siemens companies, who have installed about half the total plants in existence, and with whom the authors are associated, as general manager and assistant manager, respectively, of Siemens Company of Canada, Montreal. Following is a very brief abstract of the paper:—

In the Ward-Leonard system a direct current motor is used to drive the winding engine or rolling mill, the motor being supplied with power from a direct current dynamo, and the essential feature of this system is that the voltage supplied to the motor, and consequently the speed of the motor, is controlled by controlling the field current of the generator, instead of by varying the resistance in the armature circuit of the motor.

Thus, as the field current of the generator is increased from nothing to a maximum, the motor speeds up from standstill to full speed, and if the field current of the generator is reversed, the motor reverses its direction of rotation.

This system enables a very exact control of the speed to be obtained, because the speed of the motor is practically proportional to the strength of the generator field, whatever the load on the motor may be, while with any control system where resistances are inserted into the armature circuit of the motor, the speed would vary within very wide limits with a change of load, rendering the exact speed control quite impossible.

The control of the dynamo field involves scarcely any waste of electrical power, but where resistances are inserted into the armature circuit the loss of power may be, and usually is, very great. The field currents of the generator are small, so that the control mechanism is small, compact and very easy to handle, the armature currents are perhaps fifty times as great, so that any control mechanism which varies the resistance of the armature circuits is large, clumsy and difficult to handle, in fact a complicated relay system is often necessary to enable it to be handled at all.

The dynamo used to supply the motor in the Ward-Leonard system is usually driven by a motor supplied from the available power circuit, forming a motor generator set, and this motor may be either direct current or three-phase, according to the power available. The dynamo may be, and sometimes is, driven by an engine, water turbine, or other prime mover, if this happens to be more convenient.

The paper gives a full description of the application of the Ward-Leonard system to winding engines and hoists under the titles of Speed Control, Use of Flywheel, Details of Ilgner System, Brake Gear and Safety Devices.

It also describes the application of this system to reversing and three-high rolling mills, discussing power diagram for reversing blooming mill, action of flywheel, safety devices, etc.

A three-phase motor cannot be built for a very low speed without its power factor being bad, which tends to upset the regulation of the supply system, and for this reason where three-phase motors are driving winding engines they nearly always run at higher speeds than the drums, and are geared to them. In the Ward-Leonard or Ilgner system, however, where a direct current motor is used, this is almost invariably direct coupled to the drum. The three-phase system was described under the following headings: Control, Power Diagram of Three-Phase Winder, Comparison of Three-Phase Winder with Ward-Leonard and Ilgner Winders, Lowering Load, Starter and Controlling Resistances, Emergency Gear, Winding Men and Shaft and Rope Inspection.

As a number of winding engines have been equipped with three-phase commutator motors, an account of that system is also given.

The conditions governing the selection of the type of drum differ very considerably, according to whether the winder is to be driven electrically or by a steam engine. It is characteristic of the steam engine that its overload capacity is not very great and that the turning moment varies according to the position of the cranks. For a two-cylinder engine with cranks at right angles, such as is usually used for a steam winder, the minimum turning moment is .785 of the mean turning moment, and