New Development in Rolling Mill Drive

New Electric Drive for the Hot Strip Mill of the Trumbull Steel Company at Warren, Ohio, Described

By A. K. BUSHMAN
Power and Mining Engineering Dept., General Electric Co.

AN interesting electrical equipment representing a totally new development in rolling mill drive has just gone into operation on the new 14-in. continuous hot strip mill of the Trumbull Steel Mill.

The mill itself, which was built by the Morgan Construction Company of Worcester, Mass., consists of a roughing train, having four stands of horizontal rolls, an intermediate train with two stands, and a finishing train having four stands. The roughing stands are driven by a 600-volt, shunt wound, d.c. motor which will develop 1,250 hp. (50 deg. C.) at any speed between 175 and 350 rpm. through reducing gears. The intermediate stands are driven by a similar motor direct connected to stand No. 6 and through reduction gears to stand No. 5. The four stands of the finishing mill are each driven by individual 800-hp. motors of similar design, but different speeds, which are directly connected to the rolls.

The power to operate the whole mill is furnished by two synchronous motor generators, each consisting of a 2,300-kw., 600-volt, compound wound d.c. generator direct connected to a 3,300-kva., 2,200-volt, 60-cycle, 3-phase synchronous motor. The main shunt fields of the generators and d.c. motors are separately excited from a 250-volt d.c. circuit. The electrical equipment was built by the General Electric Company.

The control which makes this drive possible does not work on the principle of maintaining a given ratio between stands, but maintains constant any speed at which a motor is set entirely independent of other motors. It is evident that this system is much simpler and more readily set up than one depending on change gears and cone pulleys and since the speeds of the various motors are constant the ratio between them must also be constant.

On the shaft of each d.c. motor there is mounted a small alternating current generator, known as the pilot generator. The fields of these generators are connected to the exciter bus which is supplied by a small motor generator controlled by a voltage regulator which maintains constant excitation on the generators, therefore the delivered voltage of any one of them will be strictly a function of the speed of the d.c. motor to which it is connected. This voltage is used to actuate a voltage regulator that cuts resistance in and out of the d.c. motor field circuit. For instance, if the motor speed drops off for any reason, the voltage of the pilot generator, being reduced, will cause the regulator to cut resistance into the motor field, weakening it, and bringing up the speed. In case the motor overspeeds beyond its set limits, a reverse action takes place. The use of an anti-hunting winding on the regulator, which causes it to break its contacts without waiting for the motor to come up to speed, prevents any hunting on the part of the motor.

If the pilot generators were operating on open circuit their generated voltage would be exactly proportional to their speed, but in order to obtain a greater degree of sensitiveness the primary of a transformer is connected in series with the regulator coil and the secondary is loaded on a bank of condensers so that a large part of the excitation of the pilot generator is derived from the heavily leading power factor of the armature current. We, therefore, have four factors tending to give a change in voltage across the regulator coil with a change in speed. First, the direct effect on the voltage due to a change of speed; second, the effect on the armature current due to

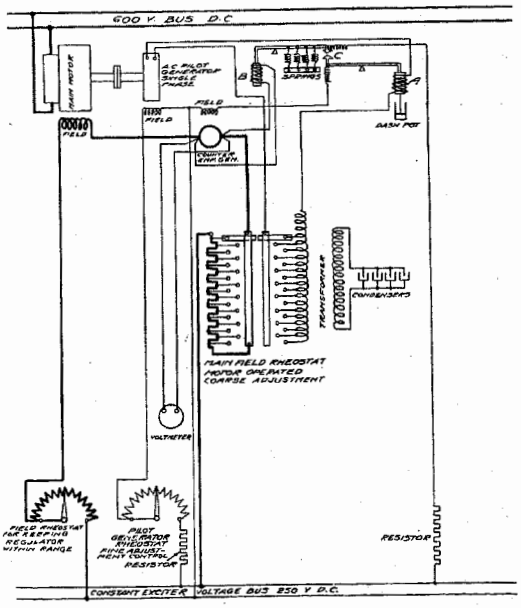

Fig. 1—Schematic diagram speed regulating control for d.c. motors.

a different frequency being impressed on the condensers; third, the effect of the armature current on the generator voltage; fourth, the effect of a change in speed on the power feacot of the armature current with a corresponding change in the voltage drop across the inductive transformer primary, this drop being negative for low leading power factors and positive for lagging power factor. These four effects are cumulative and cause a change in regulator coil voltage many times greater than the change in speed.

Adjustments of the speed on any individual motor are made from the pulpit of the mill, by means of three rheostats, one being motor driven. The latter changes the resistance in the motor fields and adjusts the regu-

lator coil circuit simutaneously by changing taps on the primary of the transformer. These taps are so proportioned that the voltage impressed on the regulator is constant regardless of changes in motor speed caused by the motor operated field rheostat, thus making it unnecessary to make any adjustment of the regulator for different speed settings—in other words, the regulator holds the same pilot generator voltage whether the motor is operating at maximum or minimum speed. The second rheostat makes extremely small changes in the resistance of the pilot generator field, thus allowing the operator to make slight adjustments of the speed setting

factory before the order was placed and experience with the apparatus in actual production has completely fulfilled expectations. With the aid of the extremely accurate tachometers mounted on the pulpit benchboard the mill may be set up for a different product in a very few minutes and the first piece is put through at full speed. As many as 10 different sizes of strips have been rolled in one day.

The control is so simple and easy to operate that the regular operators experienced no difficulty in handling the equipment and on the second day of rolling without special instructions put the entire equipment into opera-

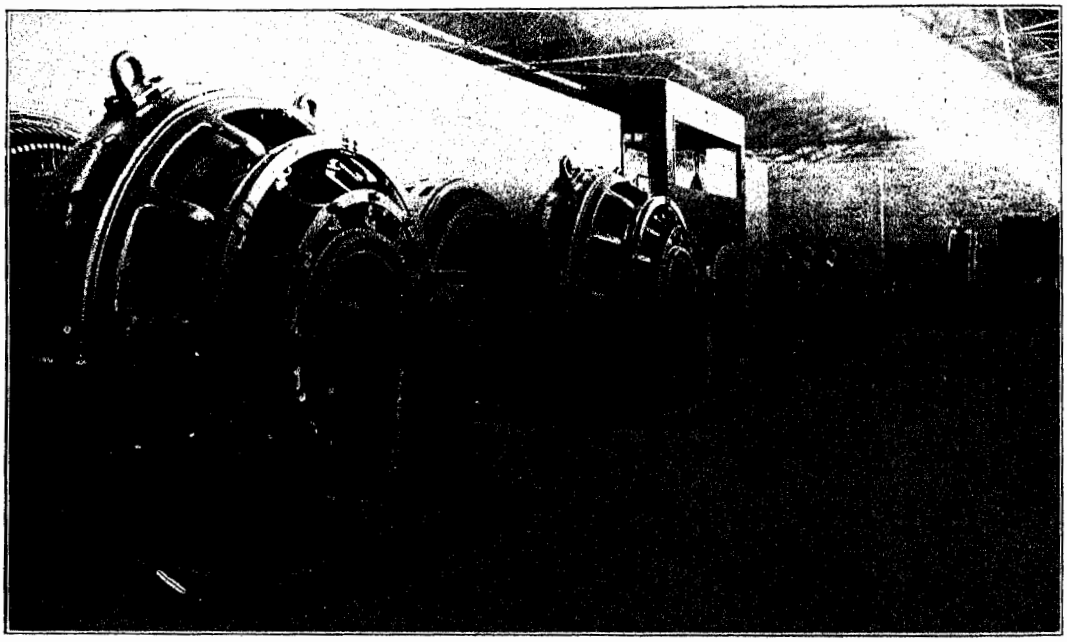

Fig. 2—Motor drive of new electrically driven hot strip mill, furnished by the General Electric Company at Trumbull Steel Company. The large machines in the foreground are motor generator sets. The mill drive is the group of machines in the background.

that may be desirable. The third makes small changes in the main motor field without a corresponding change in the regulator coil circuit and is used in connection with a voltmeter across the armature of the counter E.M.F. generator in the field circuit to form a "range finder" to correct for changes in line voltage and keep the regulator operating in the middle portion of its range.

Looking at the diagram it will be seen that the control system is very simple and involves standard equipment only with the single exception of the transformer in the pilot generator circuit which is one-half kva. in capacity and so rugged in construction as to practically eliminate the possibility of any trouble from this source. The regulators have but one vibrating contact and one relay contact which carries the field current of the counter E.M.F. generator which is less than a quarter of an ampere. Every effort has been made to insure continuity of operation and all delicate adjustments have been avoided.

This control will hold the motor speeds constant under changing load conditions and will not allow the speed ratio to vary enough to cause loops or to pull the strip was thoroughly demonstrated in preliminary tests at the tion before the factory men arrived at the plant. In fact, the first day of operation, in spite of the numerous delays for minor adjustments, such as are always necessary when breaking in new machinery, the mill produced 130 tons of strip for shipment. The mill has produced 235 tons in a single turn and this is not believed to be its maximum capacity.

The continuous mill has been very highly developed by the manufacturers so that some mills produce as high as 97 per cent of their theoretical capacity over long periods of time. It is evident that very little, if any, improvement may be expected in this direction and attention has therefore been turned to increasing the flexibility of the apparatus.

Previous to this installation described, Morgan continuous strip mills have been driven from two or more sources of power through gears on the roughing and intermediate stands and through belts and pulleys on the finishing stands. In order to prevent loops or stretching of the metal the peripheral speed of the rolls of each successive stand must increase in proportion to the elongation of the metal, but since the diameter and rpm. of the

rolls is fixed the reduct
as long as the initial size
makes the mill very infl
to obtain some product
special size billet or e
stands.

Obviously, the ideal
vidual drive for each st
thus allowing the use
speed and draft. This
many years on tandem

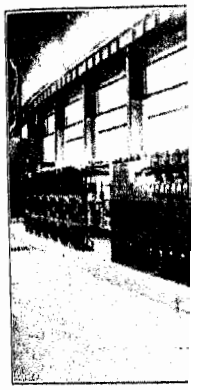

Fig. 3—Switchl
Trumb

speeds are low and th
paratively large so tha
of any two stands do
form a loop too large
such as that at Trum
around 2,000 feet pe
stands is but eight or
between stands must
very closely approxi
been successfully acc
rugged apparatus.

AMERICAN ELEC
MEETI

Final arrangeme
meeting of the Am
Montreal, Que., are
meeting one of the

The meeting wi
derberg on Thursda
technical program
and discussion of p
plating. The recei
deposition, G. B. H
secretary, will be w
in the discussion of

One of the pape
will deal with the
iron—a product w
cially, contrary te
There will also b
electrodeposited m

On Thursday a
interesting sympo

rolls is fixed the reduction for each stand is also fixed as long as the initial size of the billet is unchanged. This makes the mill very inflexible and difficult to set up and to obtain some products it is necessary to start with a special size billet or even to change the rolls in some stands.

Obviously, the ideal continuous mill would have individual drive for each stand, at least on the finishing end, thus allowing the use of any desirable combination of speed and draft. This arrangement has been used for many years on tandem cold strip mills when the rolling

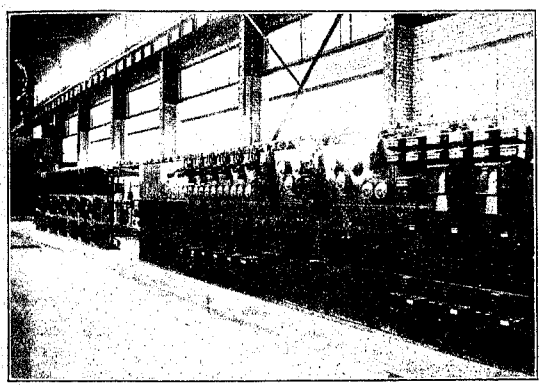

Fig. 3—Switchboard for strip mill drive at Trumbull Steel Company.

speeds are low and the distance between stands is comparatively large so that a small change in the speed ratio of any two stands does not quickly stretch the metal or form a loop too large to handle. A high speed hot mill such as that at Trumbull, however, finishes at speeds around 2,000 feet per minute and the distance between stands is but eight or nine feet, therefore the speed ratio between stands must be maintained with an accuracy very closely approximating that of gearing. This has been successfully accomplished by means of simple and rugged apparatus.

AMERICAN ELECTRICAL SOCIETY TO HOLD MEETING IN MONTREAL

Final arrangements for the forty-second general meeting of the American Electrochemical Society, at Montreal, Que., are being made which will make this meeting one of the best in the history of the society.

The meeting will be opened by President Schluederberg on Thursday morning, September 25, and the technical program will proceed with the presentation and discussion of papers on electrolysis and electroplating. The recently organized Division of Electrodeposition, G. B. Hogaboom, chairman; William Blum, secretary, will be well represented and take active part in the discussion of these papers.

One of the papers of the Thursday morning session will deal with the physical properties of electrolytic iron—a product which is being turned out commercially, contrary to all predictions of 10 years ago. There will also be papers on zinc, brass, and other electrodeposited metals.

On Thursday afternoon and Friday morning a very interesting symposium on "Industrial Heating" will be in progress. The Electrothermic Division, Bradley Stoughton, chairman; Colin G. Fink, secretary, which held a most successful symposium on "Electric Cast Iron" at the Baltimore meeting, in April last, will again be in charge. Twelve papers especially prepared for this session and dwelling on industrial heating in electric furnaces, other than fusion and melting furnaces, will be placed open to discussion.

There will be papers on:

a. "History of Industrial Heating."

b. "Principles of Design of Furnaces."

c. "Comparison of Fuel Costs in Different Types of Electric Furnaces, and With Combustion Furnaces." (In this connection electric energy would be estimated as a "fuel cost.")

d. "Resistor Materials."

e. "Specific Heats."

f. "Electric Conductivity of Insulating Materials at Industrial Furnace Temperatures."

g. "Heat Emissivity."

h. "Heat Transfer."

There will be an excursion to Shawinigan Falls, affording members a rare opportunity to inspect the various industrial plants of one of the most progressive centers on the continent. It is planned to have a special train for this all-day trip from Montreal.

A popular lecture on "The Progress in Physical Science" is scheduled for Thursday evening. Section Q will be in charge of an old-fashioned smoker on Friday evening.

The headquarters for this meeting will be the Hotel Windsor. Members and guests are urged to make their hotel reservations immediately.

M'KUNE-EGLER-DANFORTH OPEN HEARTH SYSTEMS

The Miami Metals Company, Arthur G. McKee & Company and Blair Engineering Company have announced that they have assigned the Egler, McKune and Danforth patents, together with all other patents and patent applications which they own, which relate to combustion in a regenerative furnace, to the Union Trust Company of Cleveland, Ohio, trustee, for the Open Hearth Combustion System and that the trustee is empowered to grant licenses under these patents.

This announcement is of great interest to the trade. No invention in recent years in the steel industry has attracted more favorable comment than that of the blow torch open hearth furnace.

Inasmuch as the McKune and Egler systems obtain practically the same results, it appears as if the best interests of the steel trade will be furthered by a consolidation such as has been effected. As a result of this consolidation of the interests, it is now possible for a steel plant to build a furnace incorporating the best features of both systems without being liable to suits for patent infringements.

The Blaw-Knox Company of Pittsburgh have been appointed general agents for the exclusive sale and manufacture of all equipment covered by these patents. With their plant facilities, special engineering and service departments composed of experts in open hearth design and operation, they are especially qualified for the handling of this department.