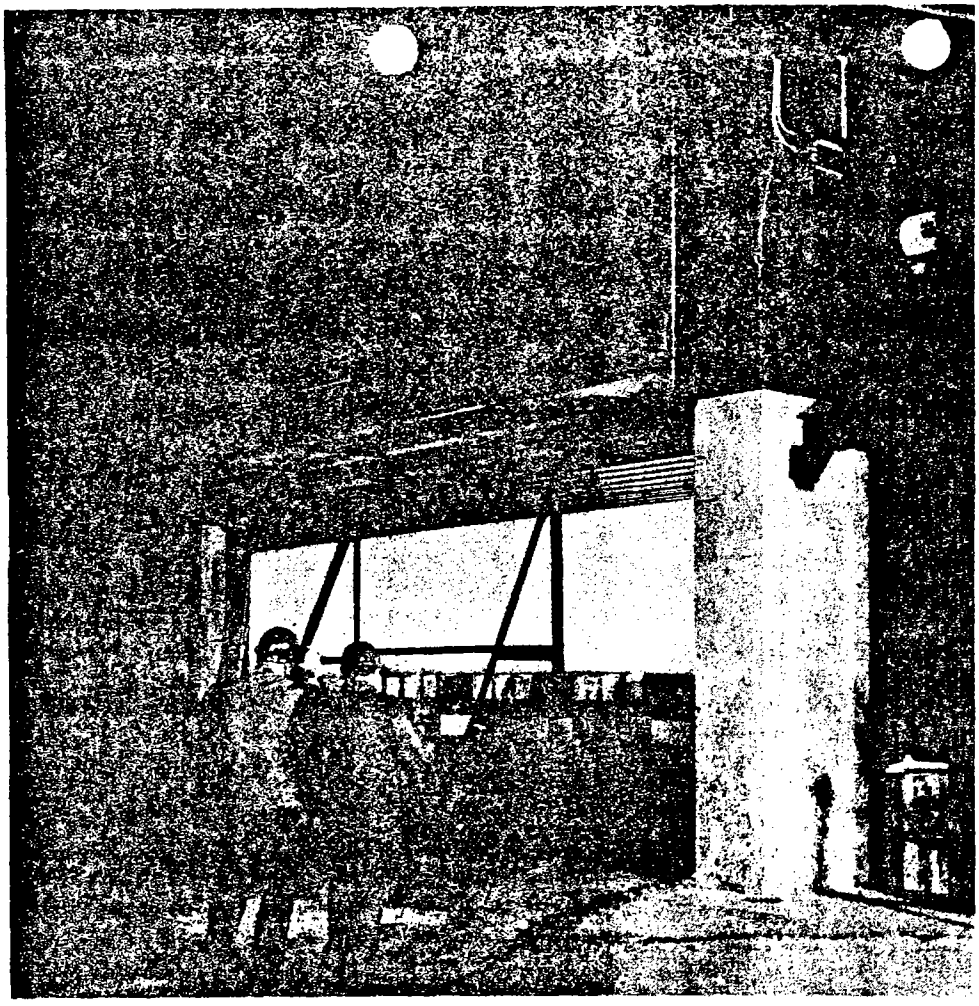


Steel slab weighing about 30 tons is raised to rolling temperature of about 2,300F in third-stage or soak-out induction heater. The induction heating installation at McLouth Steel Corp consists of three heaters in six lines totaling 35Mw each. The facility will use about 500 million kwhr annually at high power factor

210-Mw induction heaters produce high-quality steel

Slab-heating facility uses solid-state breaker and new induction coils to cut per-ton cost of heating steel to less than half that of a gas-fired furnace

Better quality "rimmed" steel at lower cost and in less time are just two advantages of induction heating for steel slabs at McLouth Steel Corp, Trenton, Mich. When the installation is in full operation, this new approach to slab heating will provide a higher yield of product for a given input, greater operating flexibility to ease scheduling, and better utilization of the new steel mill, lower maintenance costs, and improved working conditions.

Based on costs of gas and electric power and other factors [see table on p 24] a savings of $2.53 per ton of steel is possible through use of induction heating. This potential saving exceeds the cost of gas used in the example.

For Detroit Edison Co, the serving utility, the installation represents an annual consumption of over 500-million kwhr at a power factor of 80% or better. The 210-Mw induction load plus capacitors for power factor correction will be served through step-down transformers from Edison's 120-kv system.

This installation, the first of its kind, is not only the largest induction heating load but also the largest single electric heating installation in the world. It represents a cooperative effort among McLouth Steel Corp, General Electric Co, Ajax Magnethermic Corp, and Detroit Edison Co. The slab-heating "breakthrough" follows development of an ac solid-state circuit breaker by GE and the Ross wide-rectangular induction coil by Ajax.

In all, 18 induction heaters and power control units are installed at the steel company's new continuous wide-slab-casting facility. The installation makes possible the heating of a 30-ton steel slab [26 × 1 × 5 ft] to rolling temperature of 2,300F in less than 1 hr to better utilize the 2.5-million ton capability of the four continuous casting lines.

DSW 199949

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Under test at GE's Philadelphia lab are left to right the Ajax slab heater and GE's autotransformer and breaker

Induction heating saves $2.53 per ton*

Amount/ton	Induction slab heater	Fuel-fired pusher furnace
Fuel	337 kwhr	3,940 cu ft
Fuel cost	$2.02	$1.94
Cost of scale loss	0.50	2.50
Maintenance, est.	0.05	0.15
Residual heat [credit]	[0.51]	....
Total cost	$2.06	$4.59

* *Comparison is based on these factors: Net energy of 765 x 10^3 Btu [224 kwhr] to raise one ton of carbon steel to 2,300F from 70F; reported or actual efficiencies of furnaces and induction heaters; utilization factors of equipment; energy at $0.006 per kwhr vs gas at $0.50 per 1,000 cu ft; reported or actual scale losses; reported or estimated maintenance costs; and a 50% credit for residual heat of 502 x 10^6 Btu in slabs from continuous casting, assuming half the slabs will go directly to induction heaters.*

The solid-state breakers handle the high continuous-current requirements and the repeated heavy-duty switching needed for high-tonnage induction slab heating. Six of the breakers are rated at 10,000 amp, 2.7 kv for the 20-Mw heaters; six at 6,000 amp, 2.4 kv for the 10-Mw heaters; and six at 4,500 amp, 1.7 kv for the 5-Mw heaters. These breakers use new high-power, silicon-controlled rectifier cells which operate in one-half cycle [60 cps base]. Circuit breakers for the 20-Mw heaters have an interrupting capability of 212,000 amp at 2.7 kv.

The 18 breakers take power directly from six, 3-phase, 120-kv [primary] transformers. Each transformer has three, single-phase, secondaries. The secondaries are rated at 25, 12.5, and 6.25 Mva, respectively, for the 20-Mw, 10-Mw and 5-Mw heaters in each of six heating lines. Total transformer capacity for the installation is about 260 Mva.

Banks of capacitors, ranging in size from 50,400 kvar for the 20-Mw heaters to 20,080 kvar for the 5-Mw heaters, are fed from the load side of each autotransformer, which in turn is fed from a solid-state breaker.

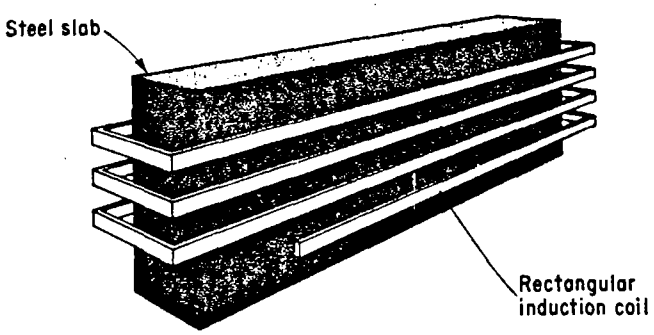
Ownership of electrical facilities divides at the McLouth property-line end of the 120-kv transmission line supplying the plant.

Each breaker controls power to a wide-rectangular vertically-mounted induction heater. Each heater has a number of horizontal coils located to envelop the slab end-to-end.

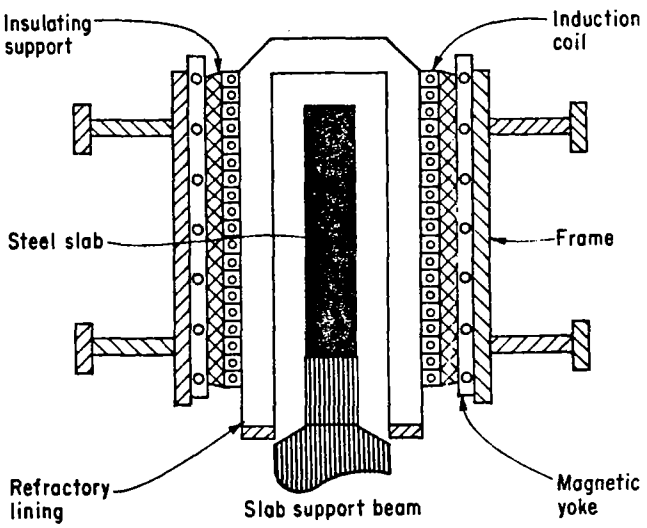
Heaters are designed so that a slab turned on its side can be raised into and become the "core" of the work coil. In this manner the entire 30-ton slab may be brought to uniform heat in a short time. Each of the six heating lines has three induction heaters with a total rating of 35 Mw. The first heater, rated at 20 Mw, heats a slab coming from storage at room temperature to a mean temperature of 1,500F. It also is used to equalize the temperature of a slab coming directly from the continuous caster.

The second heater, a 10-Mw unit, raises slab temperature to between 2,000 to 2,250F. The third heater, a 5-Mw soak-out coil, raises slab temperature another 50F to about 2300F.

At any given time 18 slabs will be in some stage of



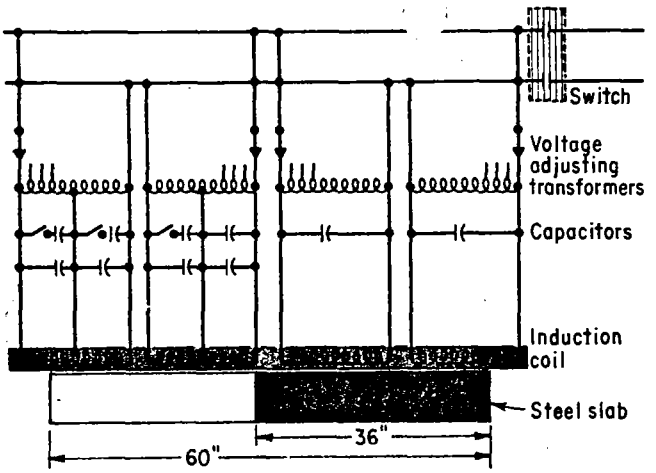
The Ross wide-rectangular induction coil is a key component in faster production of high quality steel



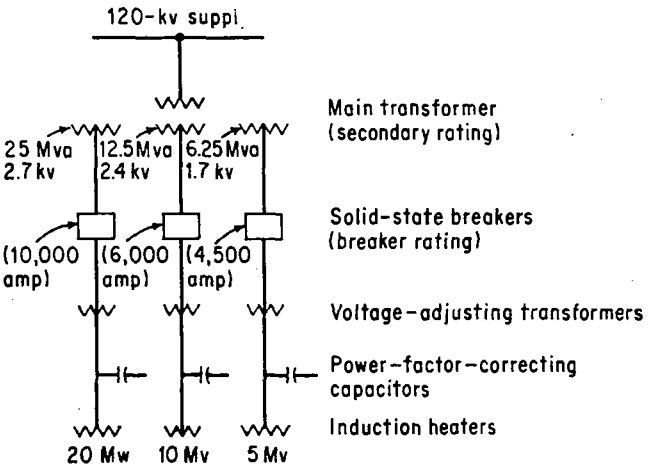
Upended steel slab is positioned from below in each induction heater. Transfer time between heaters is 1 min.

DSW 199950

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Each single phase secondary winding feeds a solid-state breaker, induction coil and associated equipment



Each of six induction heating lines is served from the incoming 120-kv supply through a step-down transformer

the heating cycle. Total heating time for a cold slab is about 54 min, or 18 min in each heater, including transfer time. This offers a production rate of more than 600 tons per hr, or one slab every 3 min.

Slab temperature is controlled automatically at each heater through a combination proximity and contact thermocouple developed by Ajax for high temperature measurement of large metal masses.

A slab is brought to a line of heaters upended so that it rests on its 1 × 26-ft dimension, transferred mechanically beneath the first heater, and then raised into position within the heater. After reaching desired temperature, the slab is lowered to the transfer device and moved to succeeding heaters.

Each heater is energized only while a slab is in heating position. After a slab has been heated, the desired temperature is maintained by switching the heater off and on.

The operation of all 18 heaters in the three lines is controlled by a process-control computer located in the central control room. The computer, with monolithic integrated circuits, controls the solid-state breakers not only to regulate total demand of the steel plant but also to maintain proper balancing of load among the phases of the 3-phase 120-kv supply. Additionally, the steel company will schedule the heating and rolling of its widest slabs [width will range from 3 to 5 ft] during non-peak periods on the Detroit Edison system.

It is expected that this new installation will provide slabs of greater heat uniformity than can be obtained with fuel-fired slab-heating furnaces and is expected to eliminate many rolling problems.

Because total heating time is less than 1 hr, compared with 5 to 6 hr for fuel-fired furnaces, fewer slabs are heating at one time. The shorter heating time greatly reduces scaling of surfaces, resulting in a better surface condition of the rolled strip and a consequent higher yield of finished product. Floor space for the three lines of heaters is about one-fifth that required for conventional heating equipment.

According to a spokesman for Ajax, with the cooperation of electric utilities, "there will be no limit to the use of induction heating for hot metal working" of ferrous or non-ferrous metals.

First stage at McLouth Steel peaks at 19 Mw in first 2 min then drops rapidly to 9 Mw

The first stage in each heating line at McLouth Steel peaks at 19 Mw during the first 2 min, according to N. V. Ross, chief development engineer—heating for Ajax Magnethermic Corp, in a paper presented before a recent IEEE meeting at Philadelphia, Pa. At that time he reported five of the six heating lines and two of the four casting lines in limited operation.

He told the Conference on Electric Process Heating in Industry that the steel slab's mean temperature is raised by the 20-Mw-rated heater to 1,550F in 18 min. The slab is then transferred to the 10-Mw second heating stage where the mean slab temperature is raised to 2,050F. The power draw in the 10-Mw heater is essentially constant at 7 Mw. The slab is finally transfered to the 5-Mw heater where the power draw is about 3.9 Mw. The mean temperature of the steel slab in the heater is raised to 2,300F, and it is ready for "rolling".

He reported that in heating from room temperature to rolling temperature, power consumption has been less than 325 kwhr per ton regardless of slab size. Scale formation has been less than 0.25%.

"Temperature uniformity over the slab" Ross said, "has been very good, with a much flatter time-temperature curve of the strip through the finishing stands than was obtained with slabs rolled from ingot. The temperature variation from slab to slab in normal operation, as measured on the plate just prior to entering the finishing stand, has been less than 50F."

In his paper Ross said that the depth of penetration of the induced currents is about 1 in. in carbon steel slabs below curie [the point at which the magnetic properties of steel disappear] at about 1,400F using 60 cps. Above curie penetration will average 2.75 in.

About 87% of the heat is generated within this depth and flows to the core of the slab. "However, because 87% of the thermal energy is generated within the body to considerable depths, heating times are much shorter with induction heating than with fuel-fired furnaces."

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