American Machinist

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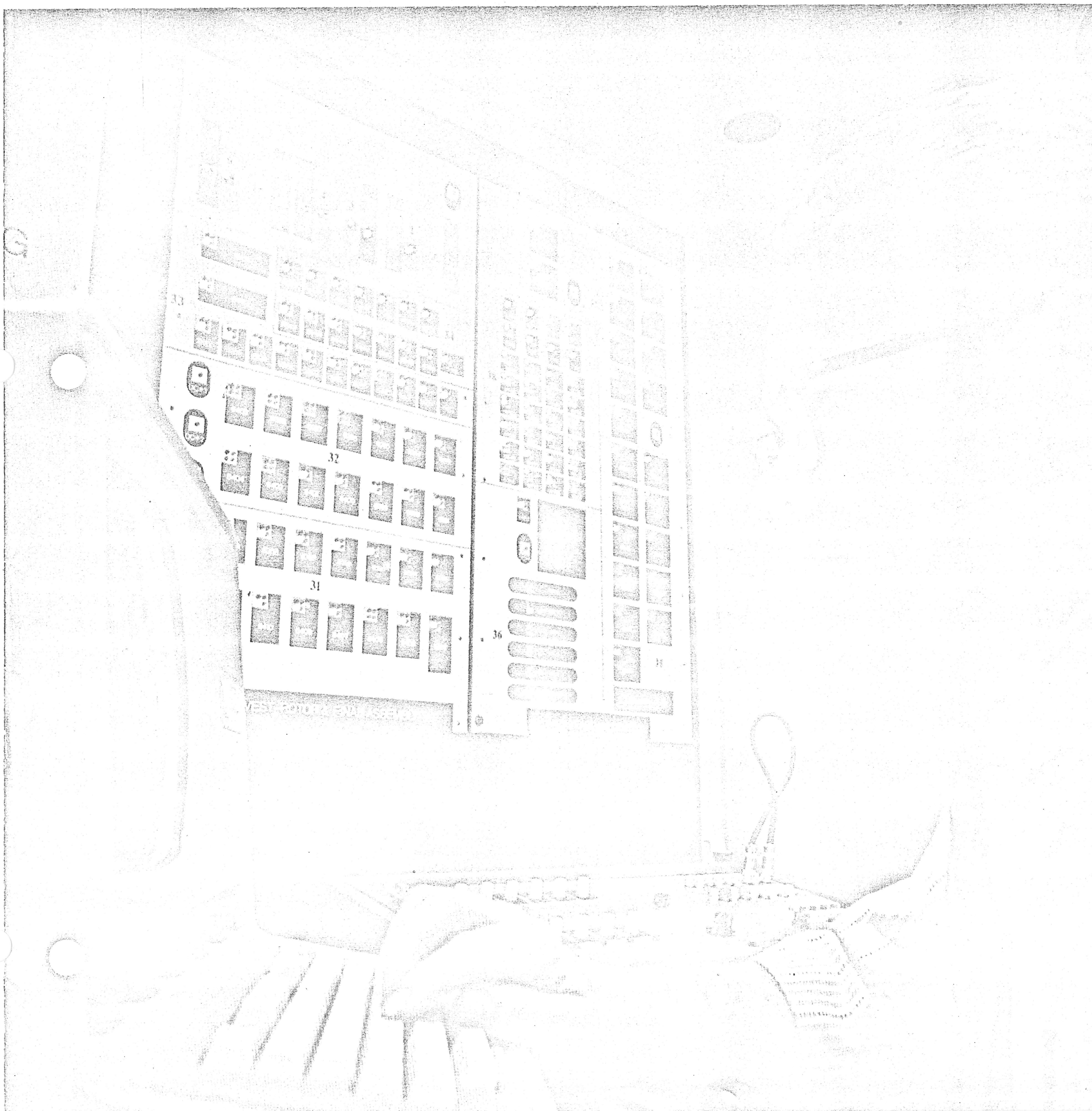
Reprint of

Chevy's new way to make disk brakes

Below: Operations of 225 machines are monitored at computer-fed visual panel at Chevrolet-Saginaw.



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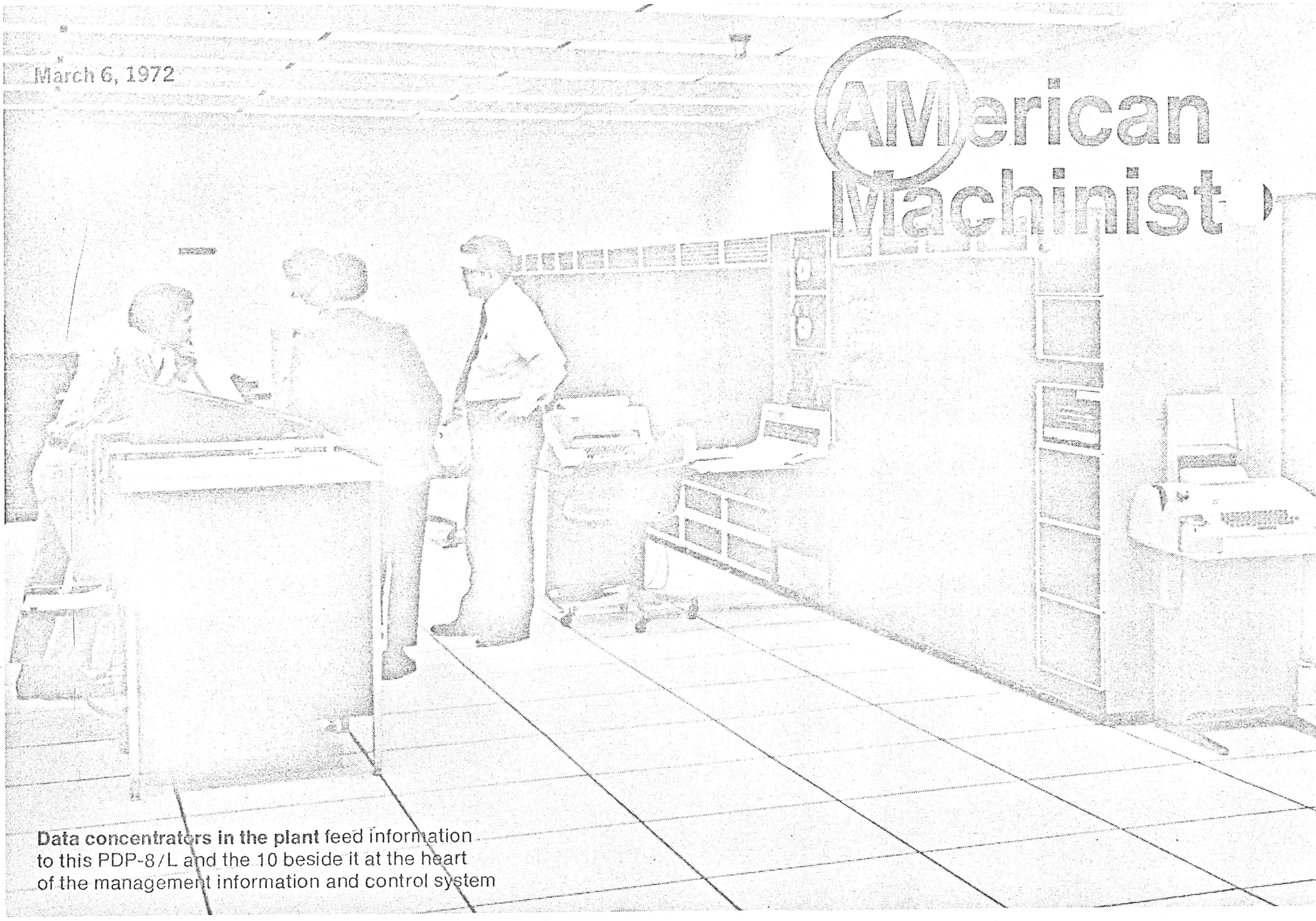


Data concentrators in the plant feed information to this PDP-8/L and the 10 beside it at the heart of the management information and control system

Chevy's new way to build brakes

What may be the most advanced manufacturing system in operation today is at Chevrolet-Saginaw, where computers monitor 225 machines and 7 miles of conveyor

The figures are impressive. There are 21,000 limit switches and 45,000 relays monitored through a ladder of 17 computers, including one used for training and as a service spare. There are 37 conveyor systems, 15 coolant systems, and 13 chip-blowing systems. There are 225 machine tools with a total of 1707 stations. There are 1900 employees.

And there are 20,000 completed disk-brake assemblies per day. Late this year, after the model changes and when the entire plant is on stream, there should be 40,000 disk-brake assemblies per day.

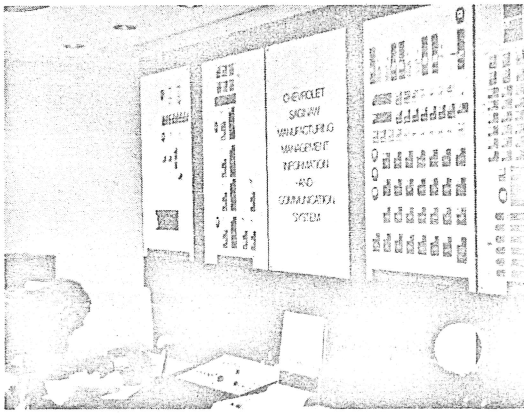
These figures, some of which have been heard in conversations in recent years, refer to the Chevrolet-Saginaw manufacturing plant, which will supply disk brakes to all divisions of General Motors except Cadillac.

Most people who see the plant say it is the most advanced manufacturing system they have ever seen. It is a difficult system to understand, however, because of the modular nature of the manufacturing plan and the variety of techniques that the engineering staff employed to meet the standards they had set. Yet the significance of the system is such that it is well worth a little effort to grasp the total concept. In order to help make that concept clear, this article will first describe the physical arrangement of the buildings, then the mechanical handling and processing methods, and finally the information-handling and control methods.

The basic arrangement

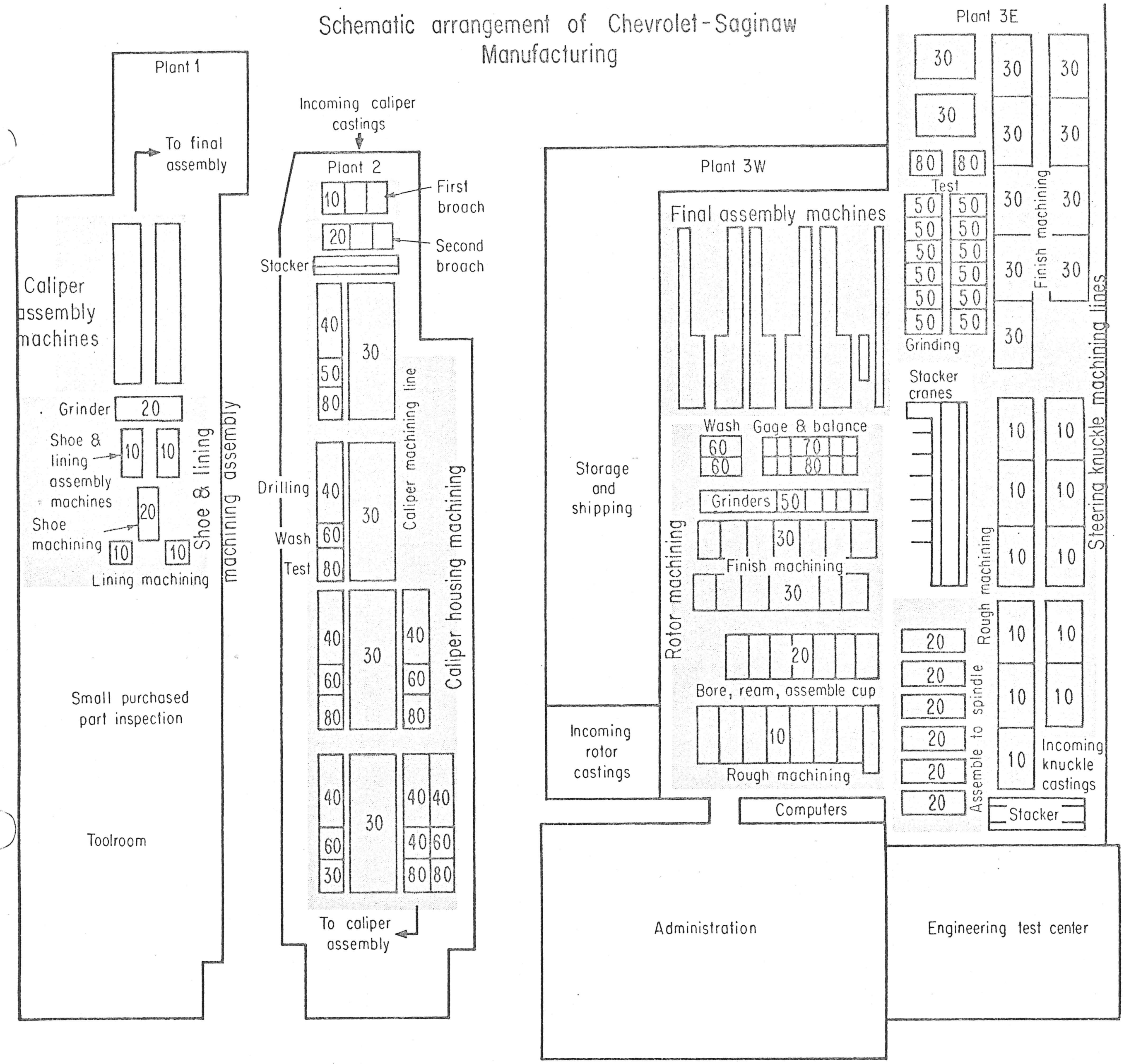
When the GM management decision was made to convert the Saginaw facility to disk brakes after 35 years of building manual transmissions, it consisted of three plants and an administration building. The oldest was Plant 1, a long, narrow building erected in 1920. Next to it was a similar, but much newer building erected in 1936.

These two plants are now used to machine some of the parts and assemble the caliper housings. Machining operations in Plant 2 are served by three coolant and three chip-handling systems



Visual panel shows condition of each group of machines in the plant and operates as part of on-line system

By Anderson Ashburn, editor



installed under the floor. Plant 2 also has a small stacker-crane storage area with 206 storage openings.

Plant 3 East, built in 1941, somewhat to the east of the first plants, has a much higher clearance, about 48 ft. It is now used for the operations on the steering knuckles and wheel spindles, with machining on the second level (ground floor). In the overhead space, two more levels have been built for conveyor systems hung on the original craneways.

The material-handling system in 3E is based on 25 power-and-free conveyors with 700 carriers. In general, the carriers are banked on the top or fourth level between operations and are moved and loaded in the third level. The first level, or basement, contains eight coolant and seven chip-blowing systems.

Two stacker-crane storage areas, one with 614 openings and one with 1574 openings, hold purchased parts. Each is serviced by two cranes.

A large addition to Plant 3 was made in 1967. Called Plant 3 West, it houses the rotor-machining areas and the final-assembly machines. These are all located on the second (ground) level with four coolant and three chip-blowing systems on the first level. This building, with less overhead space, handles rotors automatically on roller conveyor, much of it powered, through machining, balancing, and inspection. Rotors are then loaded automatically into carriers holding 60 rotors and handled overhead by power-and-free conveyors until needed at final assembly. This plant also contains six final-assembly lines, one manual and five automatic.

In 1969 an addition was made to Plant 3W to handle rail and truck shipment of brakes. This has a shipping conveyor system of nine power-and-free conveyors with 300 carriers, each holding 54 finished brakes.

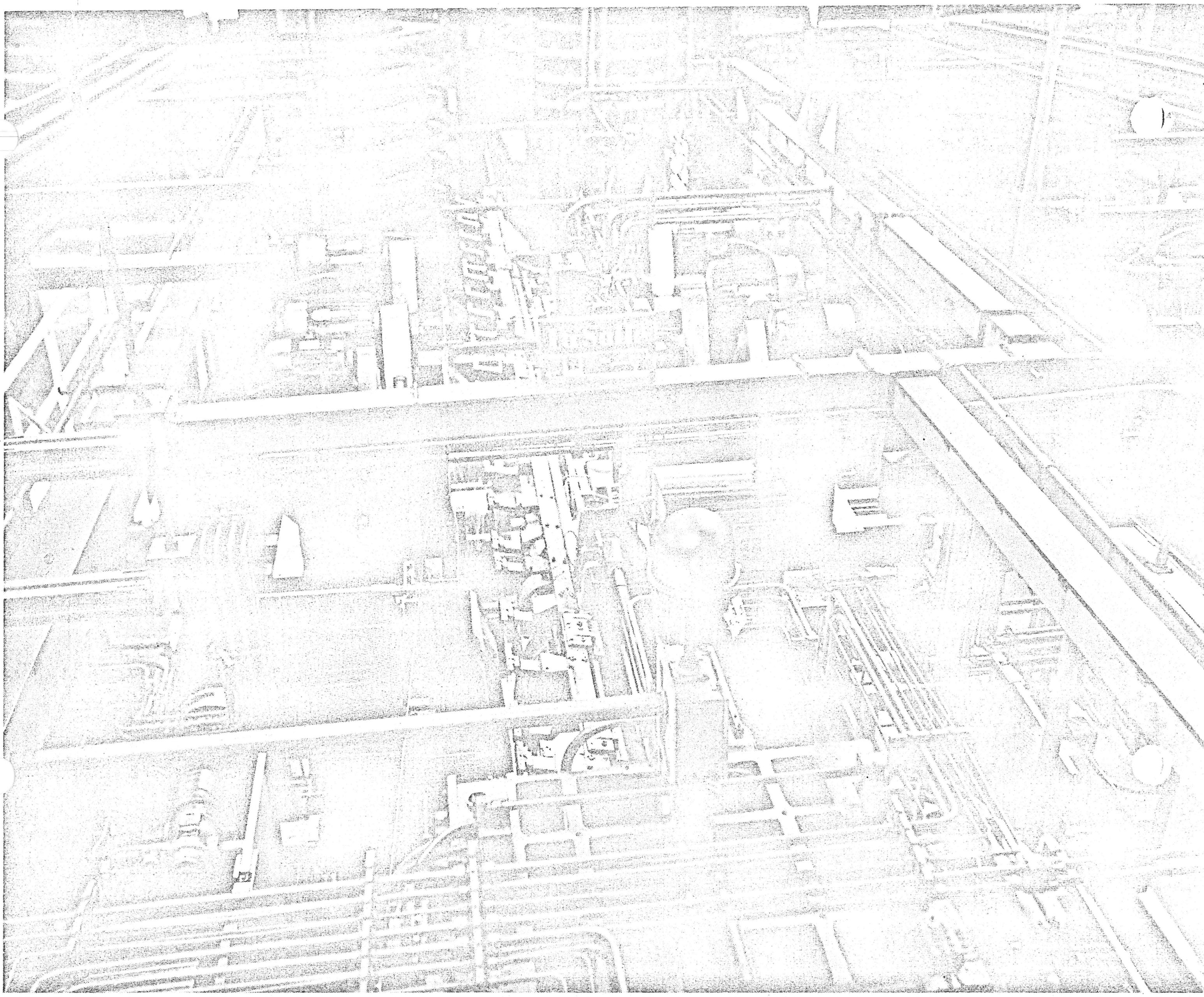
Two sizes of disk brakes, the "regular" and the "standard," are now being produced. Most of the machinery and all of the handling equipment can be adjusted to handle either. There are right- and left-hand models of each, so some machines handle two parts at a time, one of each hand.

The last manual transmission was assembled March 18, 1968, after which parts production phased out as parts for disk brakes were phased in. The first brakes were shipped Dec. 13, 1969.

Throughout the change, production continued. Employees and their wives (or husbands) were kept informed of the plans, and more than 9500 hours have been spent in training people for the requirements of the new system. During the transition, employment has increased from 1200 to 1900.

The mechanical operations

Nodular iron castings for the calipers are delivered by truck, fed by vibratory



One of 7 parallel transfer lines for finish-machining rotors. Two-level conveyor system handles two rotor sizes

conveyors to three U.S. Broach continuous-chain broaches for the first operation, then to a second set of three broaches for finish-broaching. A stacker-crane storage unit with capacity of 30,000 broached castings banks the parts for the transfer lines.

Four 42-station Buhr transfer machines with indexing pallets perform 20 machining and gaging operations. Parts are manually loaded and unloaded and are then transferred in gondolas to one of seven lines in which they pass by automatic handling through the next three machines. The first machine in each line (2 are Michigan, 5 are LaSalle) is a lift-and-carry transfer machine (in which parts move without pallets), then comes a cold-water wash and two tests of the integrity of each casting, a 200-psi air leak check for porosity and a 2000-lb check for casting deflection on a B&K test machine. A walking-beam conveyor serves these three machines. Calipers are then trucked to Plant 1.

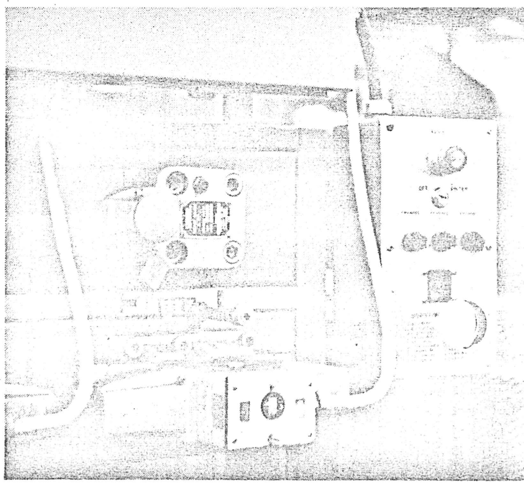
Plant 1 has a Cross system (AM—Mar.24'69,p110) with two dial-type units to machine linings, one to machine shoes, and two machines to rivet linings and shoes together. Assemblies are then distributed by conveyor to eight Gardner disk grinders, then to two Cross floating-pallet machines (AM—May 19,'69,p134) that assemble caliper, shoes, and purchased parts.

Modular system in action

The rotor line in Plant 3W is fully modular. Once parts are loaded, they move automatically through seven operations. Two-level roller conveyor throughout has one size rotor riding on the upper level, the other on the lower. Each machine or transfer line can be adjusted to receive from and deliver to the conveyor carrying the size the machine is tooled to cut.

First operation is rough-milling. Each

Communication box on each machine has assist call button, telephone jacks, and input for downtime reason



of the eight transfer machines (1 Buhr, 7 LaSalle) has six 100-hp spindles. There are three plunge-milling operations on pairs of parts. Conveyors collect parts from the first operation and deliver them to the seven LaSalle transfer lines that rough- and finish-bore, then float-ream the bearing ID, and press in the bearing cone.

Rotors are collected from these machines and distributed to one of 14 LaSalle lines that finish-machine the disk and wheel-mounting faces while rotating the part on the bearing cup.

Next come 11 Gardner disk grinders on which rotors are ground while spun on the bearing cone. After this point, urethane coatings on conveyor rollers protect the ground surfaces.

Rotors next go to two washing machines, then to seven Micromatic gaging machines which check ten characteristics. Then they are conveyed to a static-balance machine (2 Gisholt, 5 Micro-Poise), where three stations check, drill holes on the heavy side, and check again. Rotors not balanced by drilling are conveyed to another Micro-Poise that balances by adding weight (tubes are inserted between rotor cooling fins and crimped at each end).

Conveyors then elevate the rotors to an overhead level where they are automatically transferred to carriers (60 per carrier) for storage until needed.

Steering knuckle lines

There are five sets of operations. First is rough-machining (11 Lamb transfer machines), heating, assembly to the wheel spindle and testing (6 Cross machines with Ajax two-stage heaters), finish machining (11 Buhr transfer machines), grinding of oil-seal diameter and the bearing shoulder (24 Landis plunge grinders), and automatic gaging (4 Micromatic).

Between operations, the steering knuckles are carried on aluminum pallets. There are 5600 of these, each holding two right-hand and two left-hand knuckles. Four pallets fit on each shelf of a steel carrier (32 knuckles per carrier) on the power-and-free system. In a typical operation, a pallet is removed from a carrier on the third level and lowered by elevator to the machine, in which the knuckles are loaded manually. The pallets move to the unloading station, and the knuckles are automatically returned to a pallet, elevated, and loaded into a carrier.

The conveyor system has space on the fourth level to bank 2400 parts ahead of each operation and 4800 parts ahead of final assembly.

For final assembly, rotors are removed from the carrier and placed, 15 at a time, in transport fixtures which take them to 5 assembly lines, where inner wheel bearing, grease seal, and wheel bolts are installed.

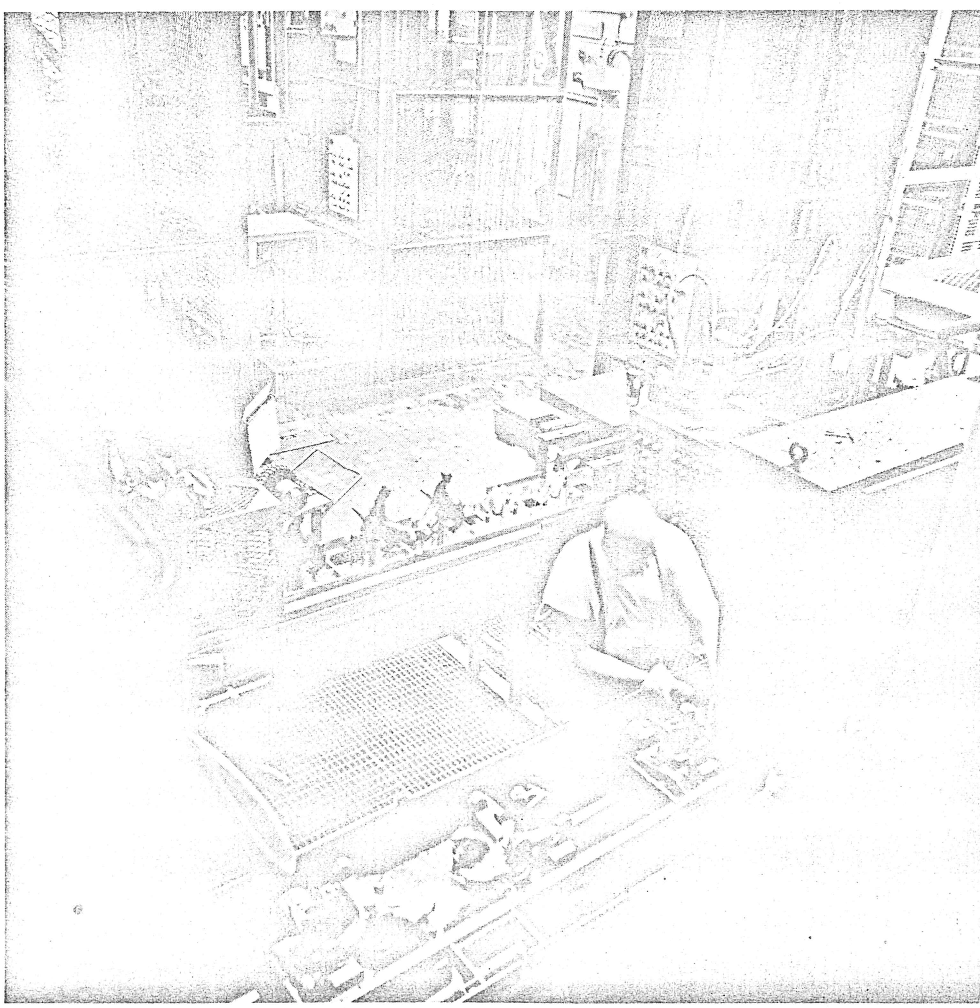
Knuckle assemblies are manually loaded onto the assembly line, the splash shield is attached, and the knuckle assembly is married to the rotor assembly. Caliper assemblies, retaining bolts, cotter pins, and identification tags are then added.

Completed assemblies are then automatically loaded into shipping racks for shipment to an assembly plant. Each steel rack has molded plastic liners that hold and protect nine right-hand and nine left-hand assemblies.

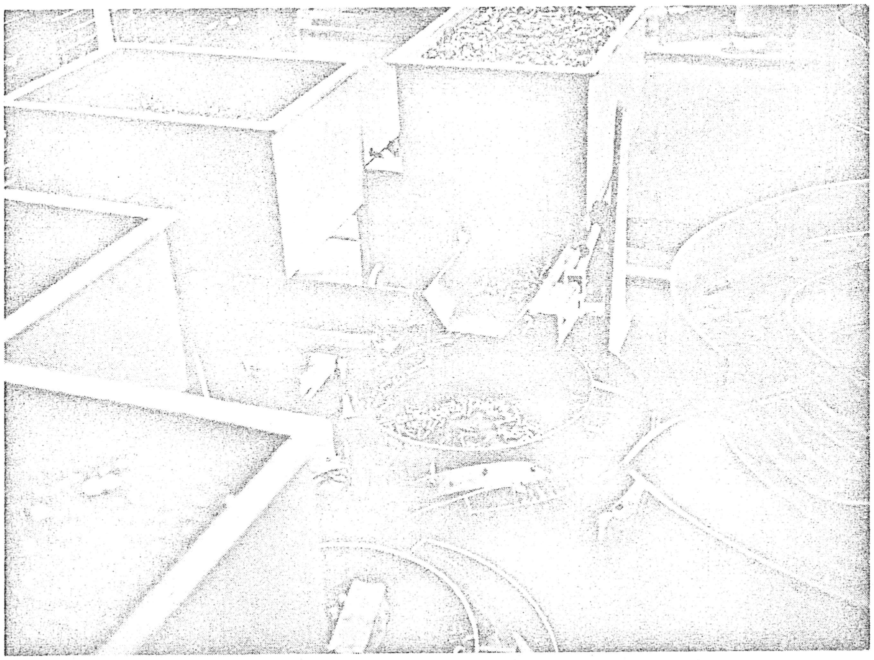
Communication system

The control system for the plant consists of a material-director system built by Cutler-Hammer and a machine-monitoring system to which the material system also reports. The monitoring system was engineered by Entrekin Computers. Computers in the system include one PDP-10, two PDP-15/30s, a PDP-8/L, a PDP-8/I (all by Digital

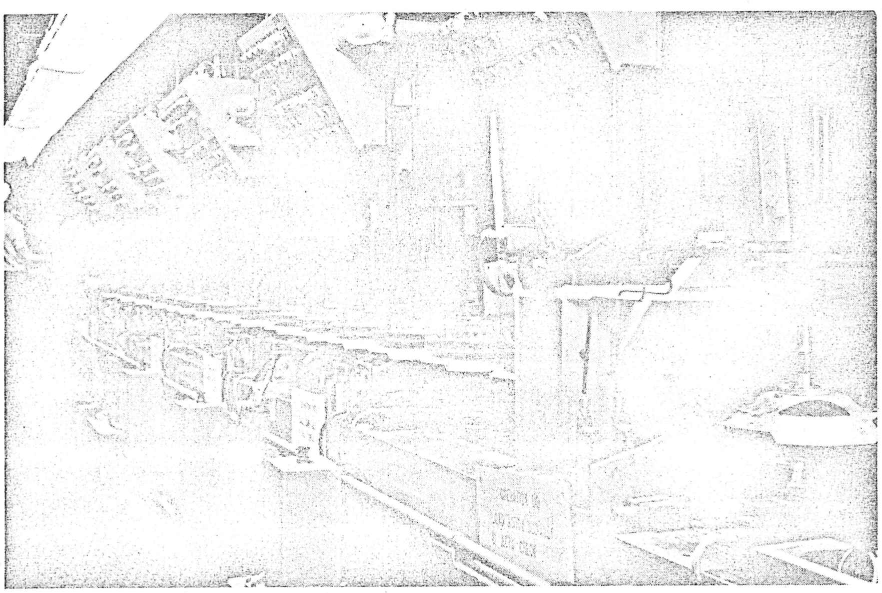
Carrier switching point is overhead, above knuckle-machining lines. This one has gone on-line, is still monitored



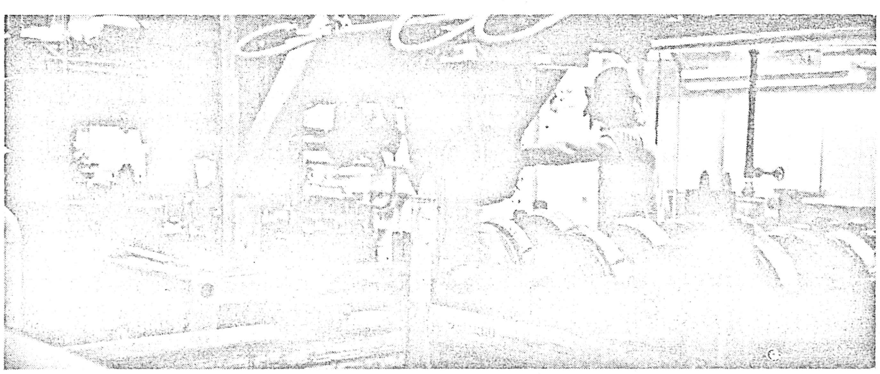
Steering knuckles in aluminum pallets at a typical loading station come down the elevator at left, are manually loaded into machine, automatically unloaded after completing circuit of 20 machining operations, then go up elevator at right



Purchased parts must be 100% inspected by sorting machines like this before use in automatic assembly machines to avoid jams caused by faulty parts. In this case, washers are also assembled onto bolts by vibratory-hopper feeding system



One small section of an automatic assembly line, one of five that do the final assembly and testing of front-wheel steering and disk-brake units



Finished assemblies load into steel shipping frames with molded plastic liners for transport to assembly plants. Frames and liners are returned for re-use

Equip.), and 12 Westinghouse P2000s.

The monitoring system starts at the control panel of each machine. These were originally ordered with a computer terminal strip in the panel. Each limit switch is connected to a relay, and the relay is connected to the terminal strip as well as to whatever machine functions it involves. No limit switches are ever in series. If a function requires two in series, they are connected in parallel to relays, then the two relays are connected in series to a third relay. This arrangement increased the size of the panels about 25%.

Connections from several machine panels are made to one multiplexer and from several multiplexers to one data concentrator. Eleven data concentrators (ten P2000, one 8/I) are connected to the 8/L, which feeds the data to the PDP-10, a large computer with 64K memory. Another P2000 is inside the visual control panel, and the remaining one is used for training and as a spare.

Machine information is collected at three levels. Mode 1 information includes part counts, rejects, whether machine is cycling or down, and cycle times. Mode 2 is a diagnostic routine used when a fault is developed in the Mode 1 checks. Typically it will print out on teleprinters in the service department the last 20 diagnostic checks.

Mode 3 is a preventive type of check which times certain machine motions, looking for undertime or overtime conditions that foretell trouble.

Each signal sent to the 8/L is verified: P2000 sends an A; 8/L says you sent me an A?; P2000 says yes. This "handshake" routine prevents sounding an alarm because of static.

The 8/L decodes the information, checks to see if it is something that should be sent to the visual control board, then passes it in to the PDP-10. Normally, all machines are monitored in Mode 1. Any fault will start the Mode 2 diagnosis automatically. Machines are automatically checked on Mode 3 in rotation.

There is no monitoring of tool condition or of tool life. Most of the machines have the familiar tool-cycle controls, which flash a blue light to a maintenance man when it is time to change tools.

The visual center has a panel (see cover) that represents each machine and has four indicator lights per machine: green, producing parts; white, cycling but not producing parts; red, not running; amber, assistance request. Each machine has three telephone jacks: one for the visual control center, one for the maintenance-dispatch center, and one for talk from machine to machine.

Each skid load of parts in any of the