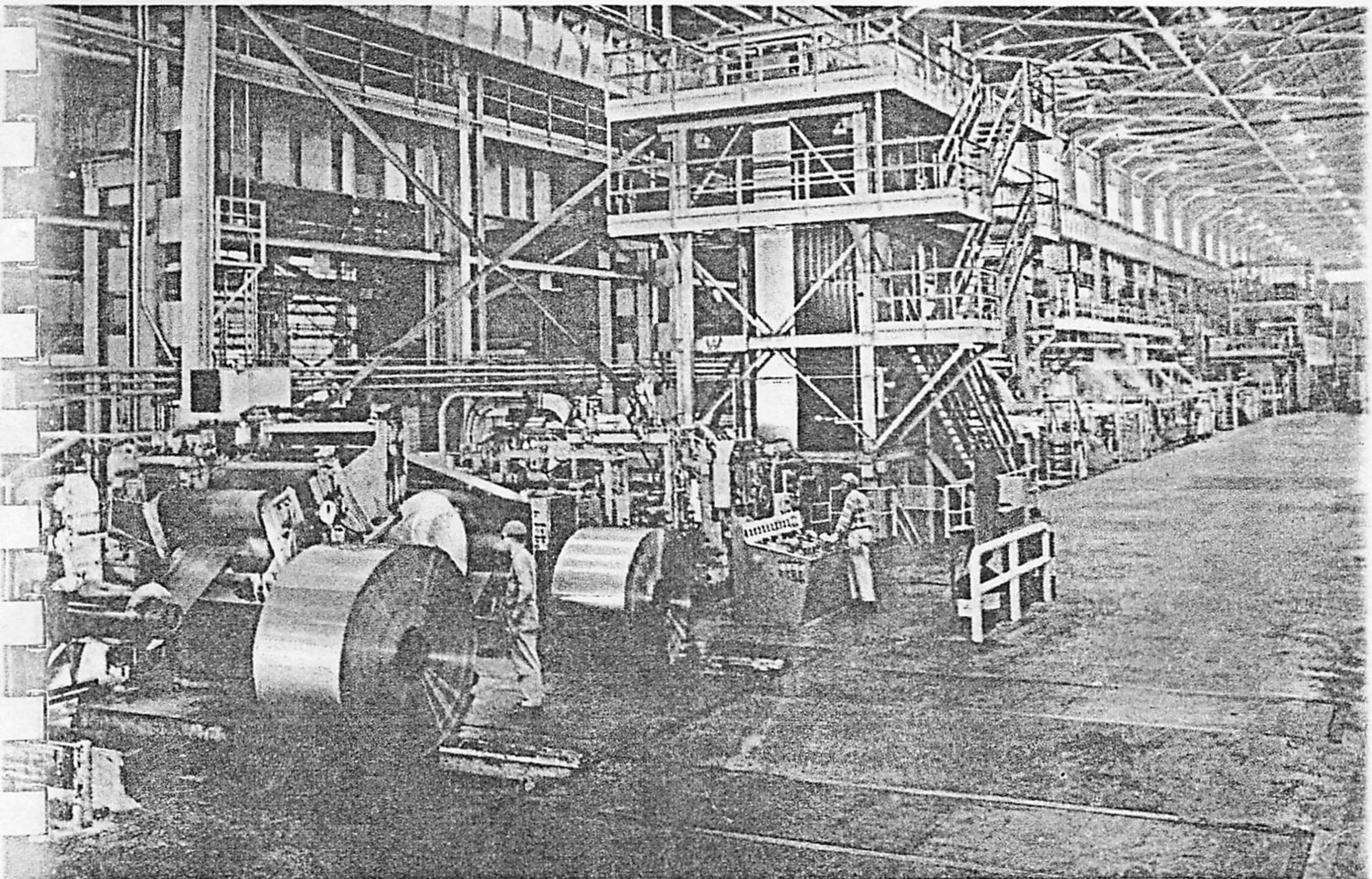
# Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JULY 1965


## *Wean at work*...at Bethlehem's Sparrows Point plant, "thin tin" line improves competitive position

To meet the challenge of aluminum, glass, plastics and composite materials in the container market, Bethlehem Steel Corporation recently invested $36 million in "thin tin" production facilities at its plant at Sparrows Point, Maryland.

Bethlehem added these facilities to provide for efficient production of large volumes of double-reduced tin plate. Included in the modernization program was this high-speed Wean halogen tinning line, which was designed to process steel strip from .0135″ down to .003″ in thickness.

Low voltage rectifiers supply the plating current to the 32 individually controlled plating cells in the line. Provisions were made for adding more plating cells to increase the speeds at which heavier coatings can be applied.

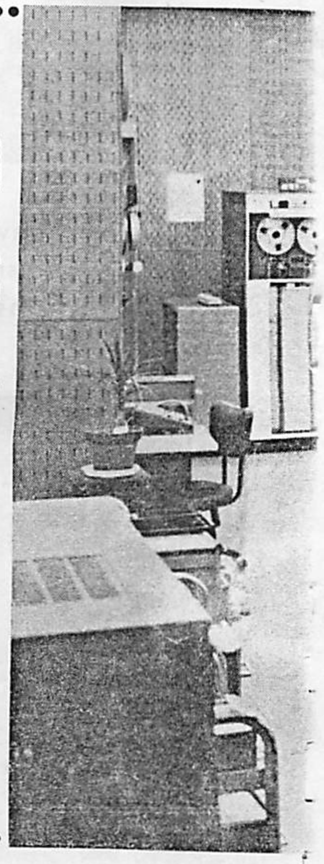
This modern installation reflects Wean's unequaled experience in tinning line design . . . experience that accounts for more than 80% of the world's tinning facilities . . . experience that is ready to work for you.

WEAN

THE WEAN ENGINEERING COMPANY, INC. • WARREN, OHIO

# Computer System Used as Production Planning Tool at Yawata Works

by HIDEO OGOSHI, Chief, Production Planning and Scheduling
and YOSHISUKE INOUE, Staff of the General Manager of Systems Planning
Yawata Works, Yawata Iron & Steel Co., Ltd., Kyushu, Japan



*The benefits derived by the computer program can be summarized as follows: improved delivery dates, optimum facility utilization, decreased production costs, improved control, increased flexibility and production of alternate plans.*

BETTER utilization of facilities, lower production costs and improved delivery to customers are some of the major benefits attributed to the use of a computer in planning production at a Japanese iron and steel mill.

Yawata Iron & Steel Co., Ltd., was established in 1950 as a result of the dissolution of Japan Iron & Steel Co., Ltd. Yawata produces a wide range of types and grades of steel products to meet the needs of domestic and foreign customers. Crude steel production in 1964 approximated 7,700,000 tons.

Yawata works, comprised of the original Yawata plant (over 60 years old) and the newly constructed Tobata plant (Figure 1), produces various kinds of steel products ranging from tin plate and sheet through structural shapes, plate and electrical steels (Table I). The works also supplies blooms and slabs to the Hikari works and the Sakai works.

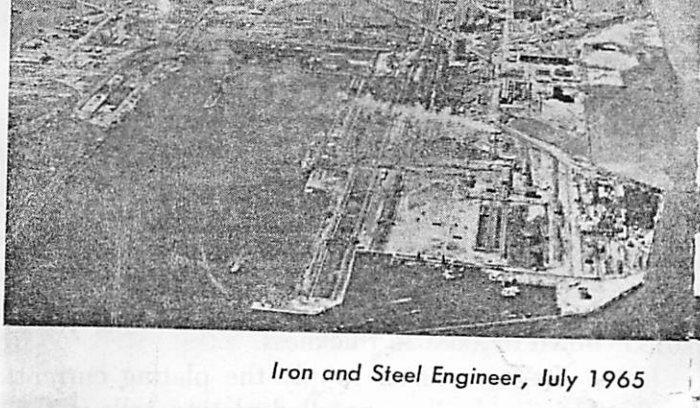
Since Yawata works consists of two adjoining fully integrated steel plants and is a supplier of slabs and blooms to the other two plants, production planning is not only a necessary function but a very formidable one (Figure 2).

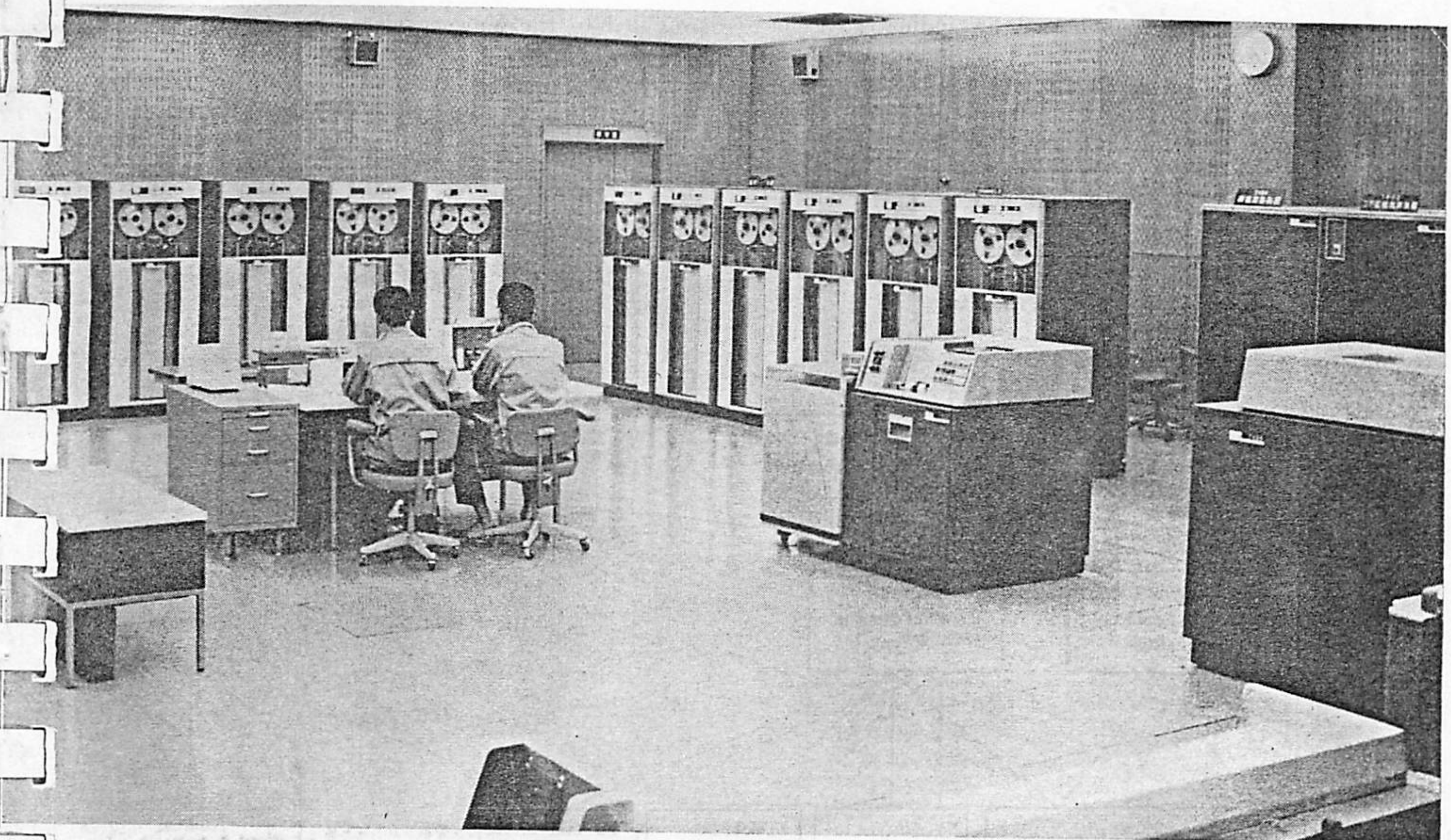
Long term production planning—five years, one year, three months and one month—is performed at the headquarters in Tokyo. The monthly plan is the most meaningful and accurate and is adjusted to reflect the current order status. Since the monthly plan is used to form the basis for production budgets, the production planning and scheduling section of each steel works participates in its development under the direction of headquarters personnel. Each steel works production planning and scheduling section then develops the required weekly and daily operating schedule.

Prior to 1962, it became increasingly apparent that changing market demands and production costs were placing growing importance on the production planning function. Accuracy and flexibility were needed as well as the ability to plan (with alternates) in a less time-consuming manner. (The Yawata works' quarterly plan required 60 man-days to prepare one plan and did not provide for alternative choices.)

In early 1962 the decision to conduct a system study for the project of mechanizing the production planning function was made and a project team organized within

Figure 1 — The Yawata works consists of the Tobata plant (foreground) and the Yawata plant (upper left). Each plant is a fully integrated steel plant.





the production planning and scheduling section of Yawata works with the assistance of systems group. By October 1962, system design work and programming had progressed sufficiently by 10 project members or so to permit parallel operation—computerized and manual plans (monthly and quarterly) were produced. The parallel operation was continued and the computerized system improved on a step-by-step basis until March 1963. In March 1963 the computerized system was adopted and has been used with success monthly and

**TABLE I**
**Production Facilities**

| Yawata Area | | | | | Tobata Area | | | |
|---|---|---|---|---|---|---|---|---|
| | | No. of units | Metric tons per day | Net tons per day | | No. of units | Metric tons per day | Net tons per day |
| Blast furnaces | Higashida plant | 1 | 1100 | 1210 | Tobata plant | 1 | 2000 | 2200 |
| | | 1 | 500 | 550 | | 1 | 2100 | 2310 |
| | | 2 | 650 | 715 | | 1 | 2400 | 2640 |
| | | 1 | 800 | 880 | | | | |
| | Kukioka plant | 2 | 1100 | 1210 | | | | |
| | | 1 | 1500 | 1650 | | | | |
| | | 1 | 1600 | 1760 | | | | |
| | | | Metric tons | Net tons | | | Metric tons | Net tons |
| Steelmaking | Open hearth plants | 15 | 60 | 66 | | | | |
| | | 3 | 100 | 110 | | | | |
| | | 7 | 120 | 132 | | | | |
| | | 3 | 130 | 143 | | | | |
| | | 3 | 150 | 165 | | | | |
| | LD converter and electric furnace plant | 2 | 50 | 55 | LD converter plants | 2 | 60 | 66 |
| | | 1 | 60 | 66 | | 1 | 70 | 77 |
| | | 1 | 60 | 66 | | 2 | 130 | 143 |
| | | 3 | 20 | 22 | | | | |
| | | | Metric tons per month | Net tons per month | | | Metric tons per month | Net tons per month |
| Primary rolling mills | No. 1 mill | | 50,000 | 55,100 | No. 1 mill | | 160,000 | 176,320 |
| | No. 4 mill | | 35,000 | 38,570 | No. 2 mill | | 150,000 | 165,300 |
| | No. 6 mill | | 70,000 | 77,140 | | | | |
| | No. 7 mill | | 60,000 | 66,120 | | | | |
| | No. 8 mill | | 135,000 | 148,770 | | | | |
| Finishing mills | Rail mill | | 35,000 | 38,570 | | | | |
| | Large size section mill | | 30,000 | 33,060 | Hot strip mills | | 120,000 | 132,240 |
| | Medium size section mill | | 9,000 | 9,920 | Cold strip mills | | 180,000 | 198,360 |
| | Small size section mill | | 11,000 | 12,120 | | | 52,000 | 57,300 |
| | Heavy plate mill | | 62,000 | 68,320 | | | 32,000 | 35,260 |
| | Electrical sheet mill | | ... | ... | | | 10,000 | 11,000 |
| | | | | | | | 45,000 | 49,590 |

quarterly as an indispensable tool. Extending the use of the computer to more improved functions of planning and scheduling has been the objective to date.

Information pertaining to ordered products (order book) plus a monthly forecast of orders expected is provided to the Yawata works by the head office in Tokyo. This data is supplemented by information received direct from the sales department and knowledge of tonnage committed to Hikari works and Sakai works. A gross monthly tonnage is thus achieved;

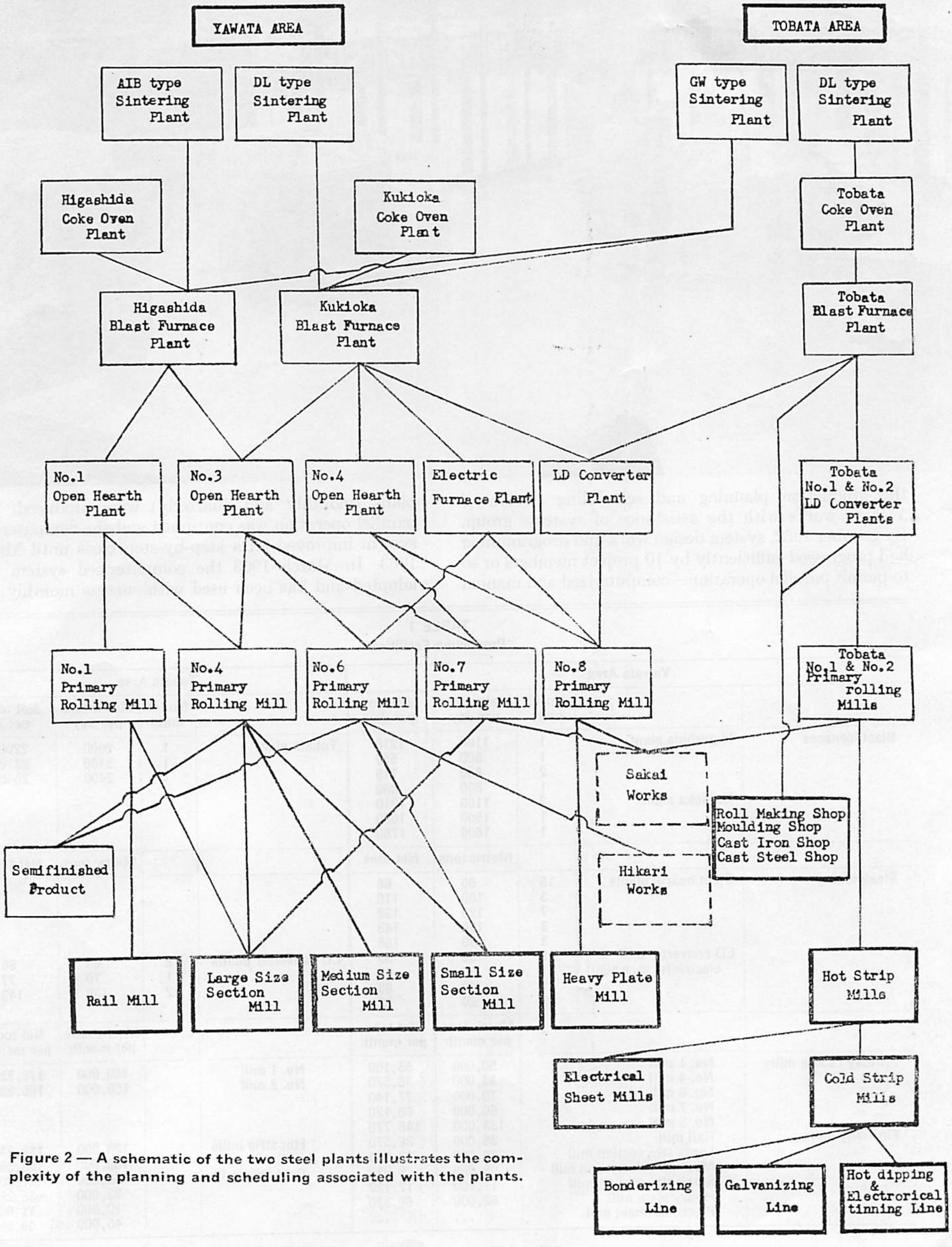



Figure 2 — A schematic of the two steel plants illustrates the complexity of the planning and scheduling associated with the plants.

this is illustrated in Figure 3.

An expression of the monthly plan plus development of weekly and daily schedules is next developed by performing a loading operation in reverse order to the product flow. In this development the facilities are loaded product by product and ton by ton. Taken into account are standards of product yield, product throughput, quality performance and facility utilization.

The required tonnage, by product class, is assigned on a preferential basis to the most efficient process. Utilizing production standards, the computer calculates the load of the facility to capacity. When a facility becomes loaded to capacity, the computer recognizes the "overflow" condition and automatically seeks an alternative product flow and production facility. The alternative choice is made automatically in strict accord with previously established rules of priority (rules are stored in the memory of the computer and are adjusted as required to reflect management decisions and facility availability). As mentioned previously, the order of loading and computation is in reverse order to the production flow. The computation is performed in three stages (A, B and C).

*Stage A, finishing mills computation*—Orders and forecast orders are classified and assigned on trial to the finishing mills. The capacities of the individual units are computed in terms of hours short or surplus. Loads and product mix are adjusted to achieve a satisfactory balance among the production units. Applying standard yield factors, requirements for blooms, slabs and ingots are also computed in this stage.

*Stage B, primary mills computation*—A facility situation, uncommon to integrated steel plants, exists at Yawata works. The multiplicity of the primary mills and also of the steelmaking and finishing mills makes the production flow complicated but flexible. It is necessary to make careful adjustment of the load/capacity of these facilities so as to maximize the capacity. Similarly, the effect of operation difficulties can be minimized by repeating the slab and bloom requirement computations performed in stage A.

*Stage C, ingot providing*—The material requirement or providing computation is performed in this stage. Ingots required are assigned the steelmaking facilities and the schedule of operations is developed. If an appropriate schedule is not readily achieved—appropriate with regard to facility availability and utilization, mold sizes and availability, and hot metal ratio—the computation can be repeated through stage B, or if necessary, through stage A.

It should be noted that throughout the three stages (A, B and C) an effort is made to keep the computer runs to a minimum, so that a condition change at any particular mill can be recognized and automatically be fed forward or backward to reflect on related production facilities. A continuing effort is under way to reduce the total number of computer system runs. Obviously, the size and make-up of the computer system (Figure 4) plus the desired flexibility of the planning and scheduling function determines the total number of runs.

Facilities and processes included in the stage A computation are the shaped section mills, rail mill, plate mill, silicon (electrical) steel mills, hot and cold strip mills, and galvanizing (Figure 3).

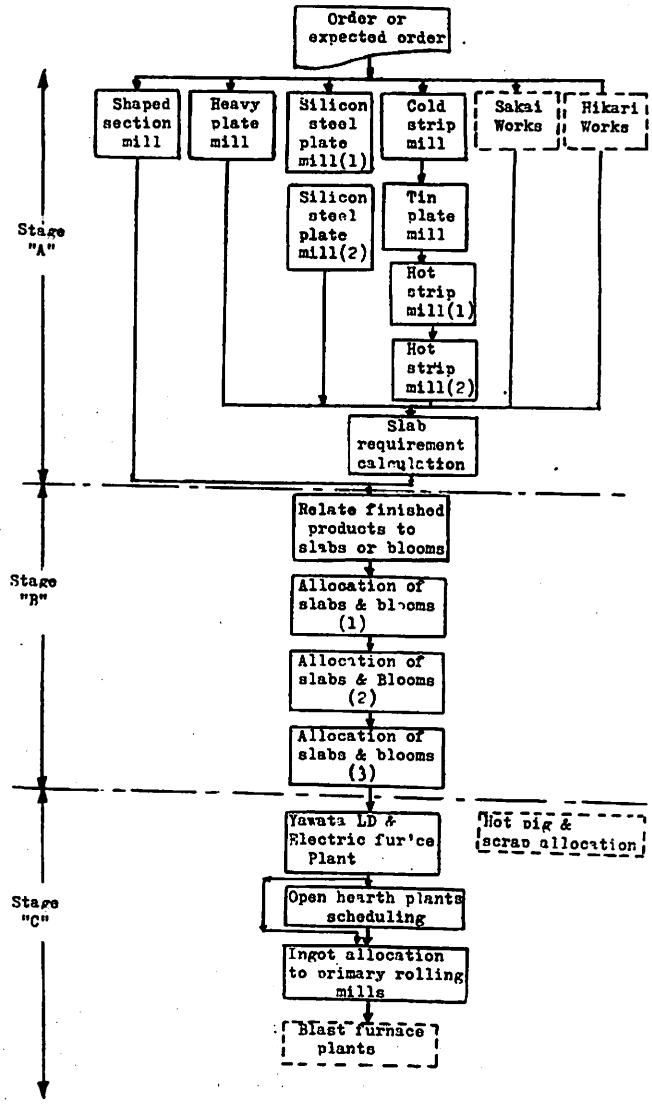



**Figure 3 — A loading operation in reverse order to the product flow is used in developing monthly, weekly and daily schedules.**

With due regard to proper rolling sequence, tonnage for the shaped section and rail mills is assigned on a trial basis. A yield standard provides required tonnage at the after-saw section and permits computation of required blooms. With recourse to production standards stored in the computer memory, the mill operating hours for each product section size can be computed and allotment made for roll change hours required. If the total of the required hours for the assigned load is less than the planned monthly hours, the surplus hours are listed and predetermined sections can be added to load the facilities. If the trial load requires more than the planned hours, the overflow tonnage is printed out along with the number of hours of the last rolled section. The printed rolling schedule permits rapid determination of satisfactory or unsatisfactory performance with regard to promised delivery times. If required to accommodate delivery times, rescheduling can be tried and an alternate load and schedule produced in approximately five-min computation time. After several tries, if an overload condition still exists, then the appropriate management is notified.

The loading, scheduling and providing planning functions are performed for each of the facilities (finishing mills) in essentially the same way as described for the shaped section and rail mills, except that in heavy plate mill the gas cutting capacities are checked, and in strip mills as well as in silicon steel mills the optimum process flow within the mills is considered.

Having determined the bloom and slab requirements of the Yawata finishing mills, it is next necessary to include the bloom and slab requirements to supply the other works. This summation of slabs and blooms required is compared to available in-process inventory and a slab and bloom total requirement is determined.

In the primary mills area several choices of mills are available; each capable of producing product to meet requirements previously developed. Also, slab and bloom requirements must be properly allocated. Requirements comprise a wide variety (approximately 300) of product by type, size, grade, etc.

The variety of product plus the physical ability of the various primary mills to roll a wide variety of product poses a complex loading and scheduling problem. It is of great importance that the best choice among the alternate routes possible is determined.

File records have been developed and are continually updated reflecting:

1. Mill throughput by product and ton.
2. Mill cost per ton by product and ton.
3. Mill quality performance by product and ton.
4. Time and cost of setup change, such as a roll change.
5. Facility availability and maintenance (heating, rolling, handling).
6. Customer order promise (priority).

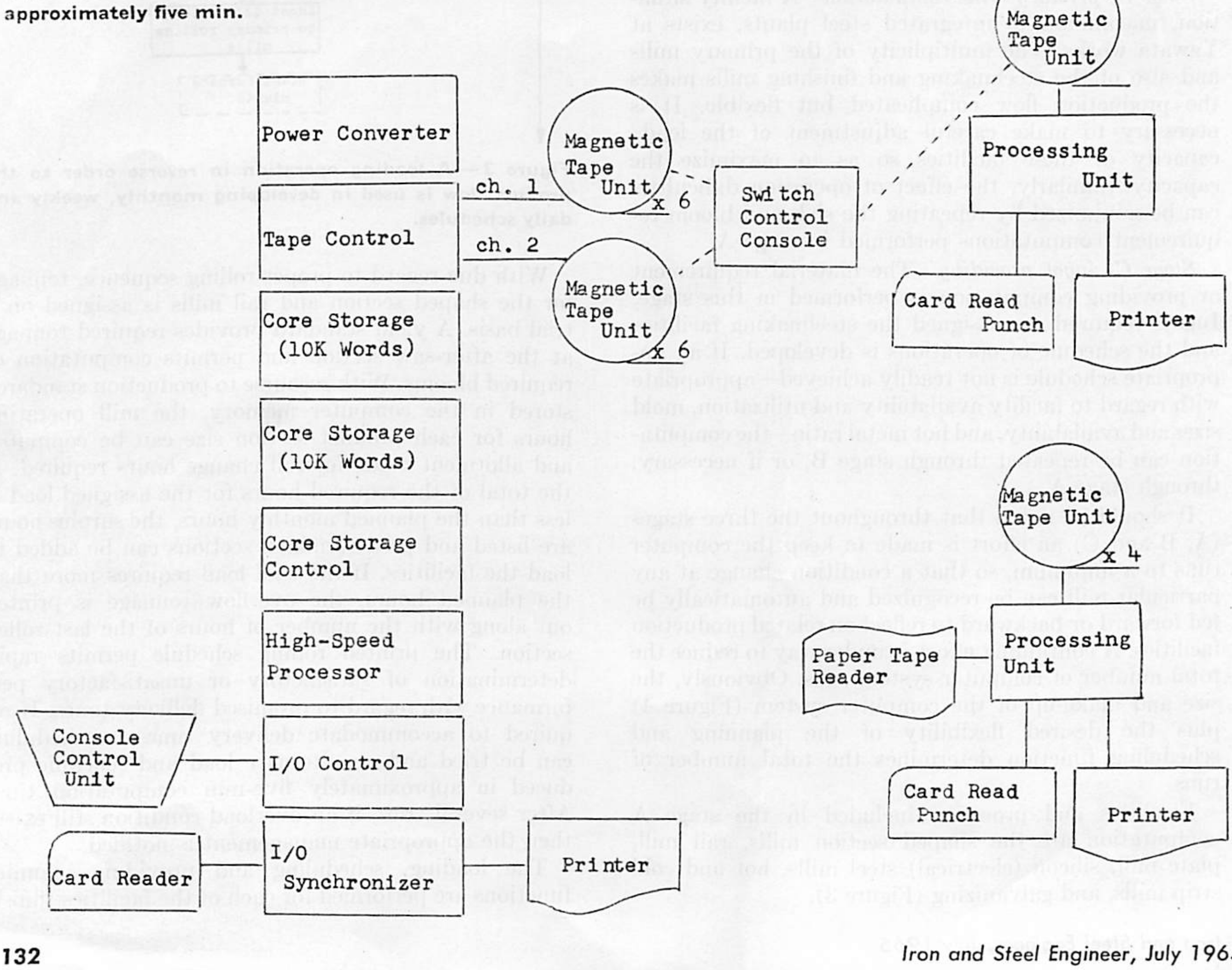
If it is determined that product A can physically be rolled on mills No. 4, 7 or 8, it can quickly be determined that the order of preference of rolling mill for this product may be No. 7, next No. 4 and last choice is mill No. 8. Based on facility availability, product A is loaded against mill No. 7 until mill No. 7 capacity is reached. If mill No. 7 becomes loaded and product A tonnage requirement is not fulfilled, the remaining tonnage is assigned to the second choice, mill No. 4, etc. This procedure, while not developed to the optimum, is functioning in a most worthwhile mode.

The stage C computation encompasses the steel providing function—the production planning function for the steel producing facilities:

1. Tobata basic oxygen furnaces.
2. Yawata basic oxygen furnaces.
3. Yawata electric furnaces.
4. Yawata open hearth furnaces.

Quite naturally, the type of steels required are grouped in accord with specification particulars. The steels it is necessary or most desirable to produce in the electric furnace facilities are selected and a total tonnage developed. The corresponding furnace operating schedule is calculated and adjusted to best utilize the producing capacity available. Once the product de-

**Figure 4 — The computer schematic is illustrated. Alternate schedule can be computed in approximately five min.**



mand and proper facility assignment is made for electric furnace steel, the tonnage to be produced in the basic oxygen furnaces is assigned. Finally, the remainder of the monthly steel requirement is distributed among the three open hearth shops. Attempt is made to utilize the most efficient furnaces and minimize cost of steel production. In adjusting the assigned load to the open hearth shops, there are several management rules and directives to be observed. A typical management directive would be: once a furnace starts operation, it is not to be idled (scheduled off) except immediately following a down period for refractory repair.

Since combined basic oxygen and open hearth capacity frequently exceeds the steel to be provided, rules regarding the use of oxygen are also observed.

It is by the restricted use of oxygen and the idling of furnaces, after refractory repair, that balance between demand and capacity is achieved. The balance sought is the one providing the best order service at lowest practicable production cost.

The computation for the open hearth facilities production is divided into two phases. Phase one computation maximizes the facility utilization to determine the maximum available capacity. Phase two schedules furnace operation and oxygen usage to meet the production required. Figure 5 is an example of the computer print-out.

It is planned to carry out a providing and scheduling program for the blast furnace production, but this is still in development. Operation standards were not readily available and the other succeeding production facilities naturally had to be assigned preferential priority.

## SUMMARY


In addition to the normal production planning functions of providing and scheduling, use of the computer system to solve problems associated with the selection of proper steelmaking facilities respecting the type and size for the steel produced at the various steelmaking furnaces has produced worthwhile results. Linear programming techniques have been used to good advantage in solving this problem. The production planning staffs have been responsible for the operation and improvement of this computer system with the assistance of systems and computer personnel.

Work continues on the refinement of programs as well as development of additional programs to encompass more of the production control function. Benefits thus far realized are:

1. On-time delivery to customers.
2. Better utilization of facilities.
3. Lower production costs.
4. Improved management control plus increased flexibility.
5. Ability to respond quickly to changing conditions (alternate plans).
6. Clerical reduction in planning function. ▲


**Figure 5 — The computer print-out shows the status of each open hearth furnace for an entire month. A balance between demand and capacity is attempted.**

SORO KEIKAKU HYO 1

| | 1 | 2 | 3 | 16 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| plant No. | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| capacity | 100 | 100 | 100 | 130 | 150 | 60 | 130 | 130 | 150 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| f'ce No. | 1 | 2 | 3 | 4 | 5 | 7 | 8 | 9 | 10 | 2 | 3 | 5 | 7 | 6 | 1 | 4 |
| 1st Day | 7 | 7 | 7 | 7 | 2 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 4 | 7 | 2 |
| 2nd " | 7 | 7 | 7 | 7 | 2 | 7 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 |
| 3rd " | 7 | 7 | 7 | 7 | 2 | 7 | 7 | 7 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 2 |
| 4th " | 7 | 7 | 7 | 7 | 2 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 |
| 5 | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 |
| 6 | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 |
| 7 | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 |
| 8 | 7 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 4 | 7 | 7 | 7 | 7 | 2 |
| 9 | 7 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 2 |
| 10 | 7 | 4 | 7 | 1 | 7 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 4 | 7 | 2 | 2 |
| 11 | 7 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 2 |
| 12 | 7 | 7 | 4 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 2 |
| 13 | 7 | 7 | 7 | 1 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 2 |
| 14 | 7 | 7 | 7 | 1 | 7 | 7 | 1 | 7 | 4 | 7 | 7 | 4 | 7 | 7 | 2 | 2 |
| 15 | 7 | 7 | 7 | 1 | 7 | 7 | 1 | 7 | 7 | 4 | 7 | 7 | 7 | 7 | 2 | 2 |
| 16 | 7 | 7 | 7 | 1 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 2 |
| 17 | 7 | 7 | 7 | 1 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 2 |
| 18 | 7 | 7 | 7 | 1 | 7 | 7 | 1 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 2 |
| 19 | 7 | 7 | 7 | 1 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 7 | 2 |
| 20 | 7 | 7 | 7 | 5 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 7 | 7 |
| 21 | 7 | 7 | 7 | 5 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 7 | 7 |
| 22 | 7 | 7 | 7 | 5 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 7 | 7 |
| 23 | 7 | 7 | 7 | 5 | 4 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 7 | 7 |
| 24 | 7 | 7 | 7 | 5 | 7 | 4 | 1 | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 7 | 7 |
| 25 | 7 | 2 | 7 | 7 | 7 | 7 | 5 | 7 | 4 | 7 | 7 | 7 | 4 | 2 | 7 | 7 |
| 26 | 7 | 2 | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 5 | 7 | 7 |
| 27 | 4 | 2 | 4 | 7 | 7 | 7 | 5 | 7 | 7 | 7 | 4 | 7 | 7 | 5 | 7 | 7 |
| 28 | 7 | 2 | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 5 | 7 | 7 |
| 29 | 7 | 2 | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 5 | 7 | 7 |
| 30 | 7 | 2 | 7 | 7 | 7 | 7 | 5 | 4 | 7 | 7 | 7 | 7 | 7 | 5 | 7 | 7 |
| 31 | 7 | 2 | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 1 | 7 | 7 | 7 | 7 | 7 | 7 |

1 major refractory repair
2 medium refractory repair
3 minor refractory repair
4 bottom making
5 idle
7 in use