

of machinery nor excellent supplies can produce satisfactory results unless they are handled by men who are not tired, mentally or physically. Our experiments with the firemen show that, other conditions being equal, a fireman on a 12-hour watch is found to be about 4.5 per cent less efficient than the same man on an 8-hour shift. (Considering a man's pay \$3 per shift, and one ton of coal per hour at a price of \$3, nothing can be gained by 12-hour shifts except an increased risk of accidents; a decided loss will result in cases where wages are lower and coal consumption is either larger or more expensive fuel is used than in our example.)

One familiar with the common layout of a power-plant cannot over emphasize the importance of the hygienic conditions to enable the men to live up to their task day in and day out. While engine rooms not infrequently offer very pleasant and sanitary surroundings, boiler houses, the most important part of any plant, are often so built as to make them unbearably cold in winter and uncomfortably hot during the summer. Good lighting is an unusual luxury, so that after looking into the furnace the fireman cannot read the gages or examine anything around the boiler. Good drinking water is rarely provided, and restful seats with backs (seats without backs are as bad as no seats at all) were never found by the writer in any boiler house. Yet the mere fact that the firemen, if provided with seats having backs, can clean the fires in 18 minutes per 100 sq. ft., while without them they require at least 24 minutes, should convince any unbiased mind. The absence of an elementary condition of comfort in a working place where the men spend the better part of their lives is more harmful to the employers than to the employee. The petty annoyances and feelings of discomfort divert the attention of the men from the performance of their duty to means of avoiding the annoyance or harm. Steady attention on the part of the fireman is much more important than is generally realized. Of no less importance is the hygienic surrounding on the switch-board gallery. Flickering light from low frequency circuits, glare on the instrument glass fronts, cement floors to walk on, inconveniently located telephones, telautographs, too low log-desks, etc., are all excellent means to increase steam consumption per kilowatt-hour and reduce the safety to men, property and service.

It should be at least as much the duty of a planning department to periodically investigate and test the effect of surroundings on the attentiveness and physical fatigue of men as it is its duty to test each coal delivery and supervise the treatment the equipment receives. There are many ways to ascertain the degree and the character of fatigue to which we shall not make reference here for the want of space.

Whatever the methods may be, they shall be applied at regular intervals to each and every employee, and their individual health-record cards shall be kept, using some convenient rating to easily watch the decline or gain of vitality of each man. Should the decline be noticed, the measures shall be taken at once to find out the cause. If it is of individual nature, good advice or doctor's services shall be offered; if it affects a group, the harmful condition must be eliminated as rapidly as possible. Little alterations that are usually required to remove harmful conditions are a great deal cheaper (not to say humane) than breaking in and training a new employee, or even temporary substitute. However, complaints of this nature are rare since the properly organized planning department in a power plant usually materially decreases the amount of physical labor to be done for the same results, that is required under the old regime.

17. The maintenance of equipment in first-class operating condition is another imperative task of a planning department. Proper upkeep of power equipment is of far greater influence on output and economy than it is in any other manufacturing department. Neglect to clean the heating surface of boilers, prevent numerous little leaks here and there, etc., seriously affects the cost of power. Careless, sporadic inspection of equipment is much more hazardous in power plants than anywhere else, as it may result not only in crippling of one section of a plant or even cause a shutdown, but is liable to cause more serious disaster. The old saying that a stitch in time saves nine is nowhere more applicable than in a power plant.

In order to secure a possibility of obtaining uniformly good results from proper methods of operation—that is make it possible for the men to live up to their tasks and earn a bonus—the plant's equipment must be maintained in uniformly good condition. To that end, the planning department contributes by studying physical causes affecting economy and safety and determines reasonable periods at which inspections, cleanings and other similar work shall be made. Such schedules are exemplified by the boiler-cleaning record chart, Fig. 12, and electrical inspection card, Fig. 13. The by-effects of work done at regular intervals are: Reduced time the equipment is idle, reduced number of maintenance men needed, lower repair and maintenance cost, and above all, the operating men (who may be poor mechanics) are not dividing their attention between operating functions and mechanical work, but consistently live up to their tasks. The general procedure of this work is simple. The planning department assigns at specified intervals the qualified men to make inspection routes through the plant and report all findings on a card as shown Figs. 14 and 14a. Necessary repairs are authorized

LAYOUT SHEET FOR Boiler Inspection, Cleaning, Etc.

| MACHINE | August | 7 | 12 | 14 | 19 | 21 | 26 | 27 | 2 September | 9 | 11 | 16 | 18 | 23 | 25 | 30 | 2 October | 7 | 9 | 14 | 16 | 21 | |
|------------|--------|--------|----|----|----|----|----|----|-------------|---|----|----|----|----|----|----|-----------|---|---|----|----|----|--|
| BOILER | 1 | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | | | | | | | | | | | |
| | 3 | XXXXXX | | | | | | | | | | | | | | | | | | | | | |
| | 4 | | | | | | | | | | | | | | | | | | | | | | |
| | 5 | | | | | | | | | | | | | | | | | | | | | | |
| | 6 | | | | | | | | | | | | | | | | | | | | | | |
| | 7 | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | XXXXXX | | | | | | | | | | | | | | | | | | | | | |
| | 10 | | | | | | | | | | | | | | | | | | | | | | |
| ECONOMIZER | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | |
| FEED PUMP | 1 | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | | | | | | | | | | | |
| | 3 | | | | | | | | | | | | | | | | | | | | | | |
| | 4 | | | | | | | | | | | | | | | | | | | | | | |

XXXXX indicate days allowed for work
 Indicate extent of time consumed

Fig. 12. Boiler Cleaning Schedule.

by the issue of a work order specifying details, Figs. 14b and 14c, and time when it is to be started and finished, so as not to interfere with operating requirements. When the job is finished, all expenses are computed and entered on the record card, Figs. 15 and 15a, one covering each unit of equipment in the plant. The data on these cards are further used in the planning department to analyze what method of

ELEC. INSPKC. ROUTE CARD

Make the following inspections in the order named.

Jan. 1 to July 1, 1916.

| WATCH | 7 - 3 | EVEN SUNDAYS |
|------------------------|-------|--------------|
| APPARATUS | | |
| 1. 25 Cy. Gens. | ✓ | ✓ |
| 2. No. 11 | ✓ | ✓ |
| 3. No. 15 | ✓ | ✓ |
| 4. No. 12 | ✓ | ✓ |
| 5. A. | ✓ | ✓ |
| 6. B. | ✓ | ✓ |
| 7. C. | ✓ | ✓ |
| 8. D. | ✓ | ✓ |
| 9. S. | ✓ | ✓ |
| 10. CS | ✓ | ✓ |
| 11. T | ✓ | ✓ |
| 12. Coal Larry No. 3 | ✓ | ✓ |
| 13. Coal Larry No. 4 | ✓ | ✓ |
| 14. Battery Blower | ✓ | ✓ |
| 15. Economizer | ✓ | ✓ |
| 16. Coal Elevator (Ry) | ✓ | ✓ |
| 17. Coal Crusher | ✓ | ✓ |
| 18. Coal Conveyor | ✓ | ✓ |
| 20. Ventilators | ✓ | ✓ |
| 21. Ash Locomotive | ✓ | ✓ |
| 22. Oil Filters | ✓ | ✓ |
| 23. Oil Pump | ✓ | ✓ |
| 24. Control Bench | ✓ | ✓ |
| 25. Feeder Board | ✓ | ✓ |
| 26. Local Ser. Board | ✓ | ✓ |
| 27. Exciter Board | ✓ | ✓ |
| 28. Signal Board | ✓ | ✓ |
| R—repair suggested | | |
| O—ordered out. | | |
| SIGNED | | I.P. |

Fig. 13. Inspection Route Card for Electricians

MAINTENANCE REPORT

POWER PLANT

LOCATION OF MACHINE

PLANTLY DISABLED

TYPICALLY DISABLED

COULD BE DONE

| OWN PUNCH | REPAIR SHOP | MONTH | DAY | YEAR | A.M. | P.M. |
|-----------|-------------|-------|-----|------|------|------|
| | | | | | | |

PARTS BROKEN OR WORK STOPPED

MATERIAL NEEDED FOR REPAIR:

CAUSE OF BREAK:

REASON FOR WATCH WHEN BREAK OCCURRED:

| MONTH | DAY | YEAR | A.M. | P.M. |
|-------|-----|------|------|------|
| | | | | |

PLEASE START AND/OR REPAIR BY

MACHINE AVAILABLE FOR REPAIR ON:

REPAIR MUST BE COMPLETED BY:

SIGNED

Fig. 14 front

MAINTENANCE REPORT

OPERATION

| NO. | COST | | TIME SPENT | REMARKS |
|-------|----------|-------|------------|---------|
| | Material | Labor | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |
| TOTAL | | | | |

COMPLETED

| MONTH | DAY | YEAR | A.M. | P.M. |
|-------|-----|------|------|------|
| | | | | |

SIGNED

MATERIAL NEEDED

Fig. 14a back

Maintenance of Equipment Inspection Report Card.

repair and what material produces the best results at the lowest cost, and thus leads to continual improvements in this direction.

As far as stimulation of maintenance men is concerned, they receive their bonus over and above the daily wages only for those days when no interruption in operation occurs on account of their defective maintenance, and they lose their bonus whenever it is proved that the operating men fall short of their tasks on account of poor upkeep. For instance, a fireman fails to secure the expected boiler-efficiency rating,