rotary converter, so that the direct current voltage can only be changed by regulating the alternating current voltage. The ratio of alternating current to direct current is .6 for three-phase circuits, and .7 for single and two-phase circuits. Steam turbines, in small sizes, are not ordinarily as efficient or as easily regulated as the small steam engine. Also, they are not so frequently used, and, in consequence, are more expensive.

The field is thus limited to motor generator sets, rectifiers and steam engines, where electric or steam mains are available, and to the gasoline engines, for isolated locations.

The efficiency of the mercury arc rectifier is approximately constant at 80 per cent and of motor generator sets from 60 to 72 per cent, within limits at which they are operated. The thermal efficiency of the gasoline engine is much higher than the steam engine, but this advantage is usually much more than offset by the cost of fuel. In general, it may be said that the first cost of the mercury arc rectifier will usually be least; motor generator sets will be only slightly higher, with steam engine sets next, provided boiler capacity is available, and gas engine outfits most expensive. These types will rank in the same order as regards the amount of floor space required.

Motor generator sets are in common use for signal battery charging. They should be preferably direct connected, because more reliable, and requiring less floor space. They are readily adapted for all of the current and voltage requirements for signal work. While constant voltage is desirable for driving the motor, even trolley current, fluctuating rather widely, may be used, with a proper automatic voltage regulator. A particularly desirable method of operation may be obtained by using a small motor generator set for continuous operation, with the battery, load and generator all in multiple. This method, which is ordinarily known as "floating the battery," permits the generator to carry most of the load, and charge the battery at a slow rate. When heavy current output is required, and the generator voltage is pulled down, the battery helps out the generator by feeding into the circuit in parallel with it. The battery is also available as a reserve to carry the load for some time in case of a failure of the power supply or motor generator set. The shunt wound type of generator is best adapted for battery charging, because of convenience of voltage regulation, a primary essential for any generator for such service. Alternating current motors for a.c.-d.c. sets should be three-phase if it is possible to obtain three-phase power service. This is due to the fact that a three-phase motor is usually smaller, and less expensive, and the small sizes require no starting apparatus. Some phase-splitting starting device is necessary with any single-phase motor. In sets of odd size, where direct connection would be expensive, because of special speeds or sizes, an alternative is presented by the use of a "silent chain drive," which is reliable, requires much less floor space than any possible belt connection, and may sometimes prove economical in first cost, without increasing operating expense.

The mercury arc rectifier with the improvements made in recent years is proving to be one of the most valuable devices for battery charging. They are complete in themselves, requiring no apparatus not included within the smallest floor space required for any battery charging outfit. They are made in standard sizes ranging from zero to 175 volts, direct current, and from 10 to 40 amperes. This range of voltage limits the rectifier at present to battery charging at concentrated locations, and for short transmission lines, as its maximum voltage is not high enough to operate a long series charging line successfully, even at a low charging rate. Ordinarily the rectifier is designed for operation on 60 cycles, at 110 volts or 220 volts, single-phase alternating current, but it may readily be adapted for other voltages, or frequencies down to 25 cycles.

Steam driven units can be obtained in small sizes, adapted for steam pressure as low as 80 pounds. These sets are useful wherever steam pressure may be had. Steam sets are ordinarily provided with a heavy fly-wheel and closely regulating governor, which results in close speed regulation, and practically constant voltage. Consequently, no automatic regulators of any sort are necessary or advisable.

With the present cost of fuel, gasoline engine sets are more expensive in operation than any of the previously mentioned outfits. They require some cooling apparatus beside the engine and generator. With slight modifications, they may be operated by either gasoline or gas. They are built with various numbers of cylinders, for either two or four cycle operation. When reliably built, and of good design, the gasoline engine is, however, undoubtedly the best, and practically the only economical prime mover for battery charging service at isolated locations.

PENNSYLVANIA INSTRUCTION SYSTEM.

In the article entitled, "A Pennsylvania Signal Department Repair Shop," published in *The Signal Engineer* for May, 1911, mention was made of the instruction room which forms part of the east side of the shop building, as shown in Fig. 2, page 181. Classes are held in this instruction room twice a month for the benefit of the signalmen on the western end of the Pitts-

LESSON NO. 9. 8

machine we only need the one wire B from the battery K to the machine. This battery wire taps on to copper strip in the machine and this strip carries the current to the different bands as shown in the drawing. The normal control circuit goes

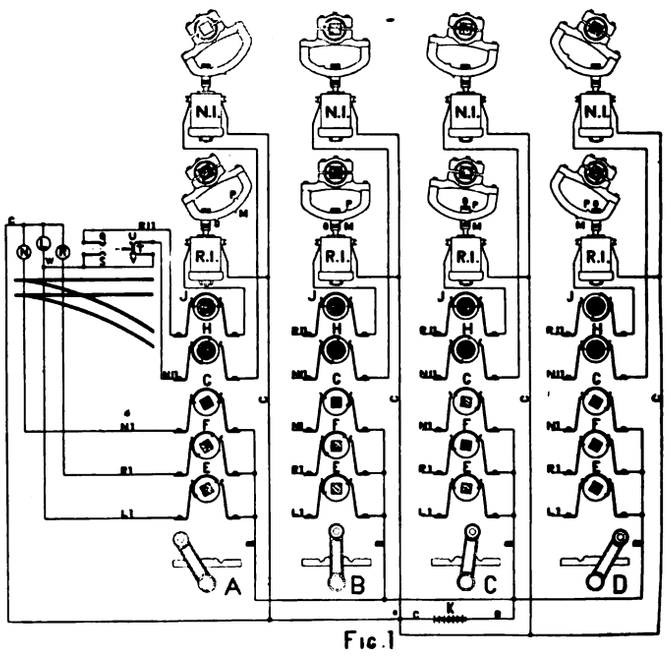

FIG. 1

through the band G, out on wire N1, to the normal magnet N at the switch and back on wire C to the negative side of the battery from where it started. In moving the lever toward the reverse position, as far as B, you can see the first band to make

Fig. 1. A Page from the Instruction Book.

burgh division, and the Conemaugh and Monongahela divisions of the Western Pennsylvania grand division. These form part of the instruction system conducted under the direction of E. J. Clark, supervisor of the Pittsburgh division. The instructor holds sessions at two other points, viz., New Florence and Gallitzin, both on the Pittsburgh division. Two classes are held at each point every month. Eighteen lessons constitute the complete course of instruction. Written examinations are given after each four lessons, and the averages are marked, an average of 80 per cent being required for advancement. The instructor informs the maintenance foreman as to when and where the sessions are to be held, and also, because it is considered advisable not to have more than 15 men in a class, tells him which men to have present at each session. If there are more than 15 men present, sessions are held at one point on two days.

The instruction is given at hours when it is convenient to get the men to the classes and to return them to their work by regular passenger train service. The men attend during working hours and are paid for the time of their attendance.

The instruction room in the shop building at East Liberty is equipped with a two-lever electro-pneumatic interlocking machine, miniature tracks and signals, and an electric signal mechanism, indicators, relays, pole changers, and other apparatus. The interlocking machine is arranged so that it can be shipped by passenger train to any point desired. The instruction book is in pamphlet form and bound in a loose-leaf binding. The figures show some of the diagrams used in connection with the classes. Fig. 1 explains the movement of an electro-pneumatic switch lever; Fig. 2 shows a section of the electro-pneumatic switch valve, and Fig. 3 is a circuit plan which forms part of lesson No. 15 of the course.

Many of the signalmen of the district covered by the instruction system have been graduated from the course. The beneficial effect that the instruction has had on the district signal work in general is shown by great improvement in the work of the individual signalmen.

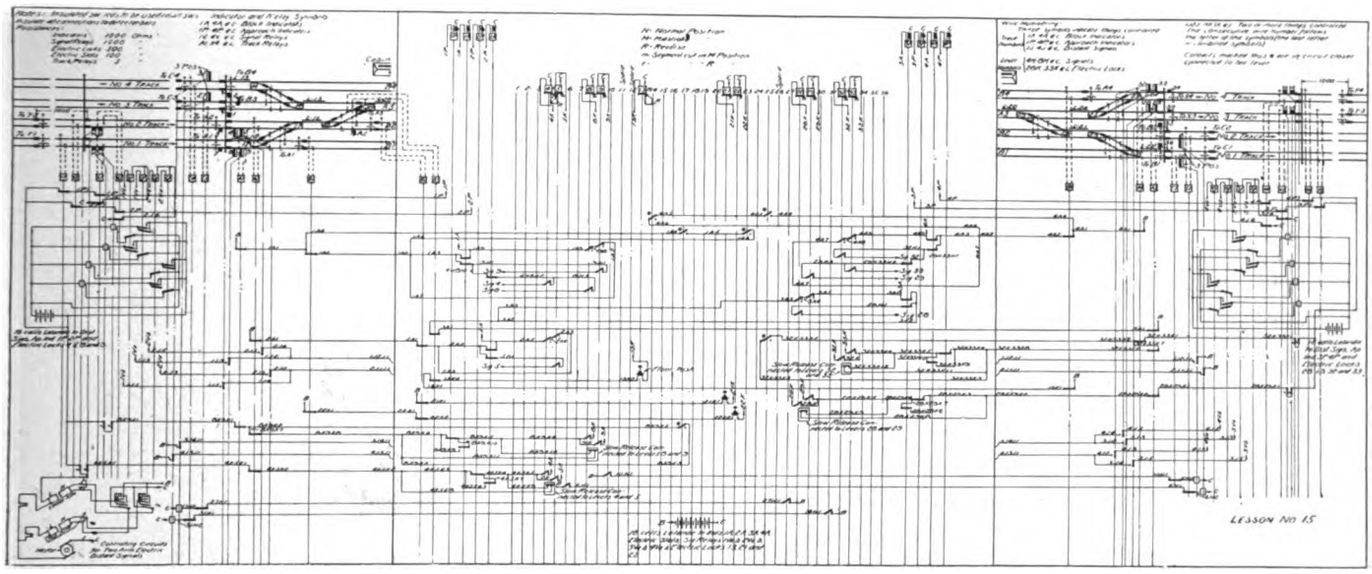

Fig. 3. Circuit Plan. (Part of Lesson 15.)

LESSON NO. 8.

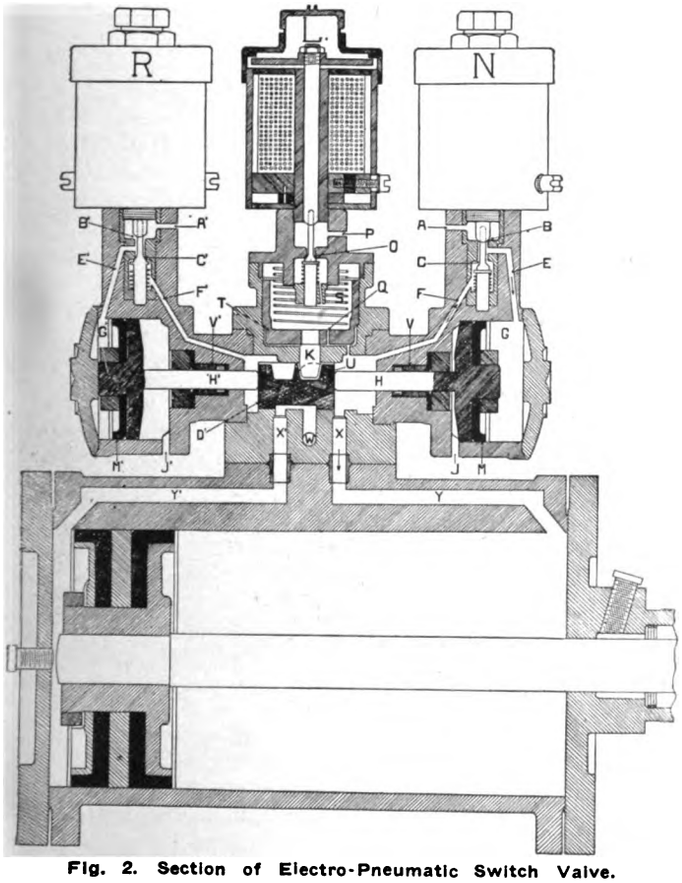

Fig. 2. Section of Electro-Pneumatic Switch Valve.

UNION PACIFIC SIGNAL REPAIR SHOP.

BY CHARLES F. SMITH.

The Union Pacific signal repair department, which was organized in February, 1908, is located at the motive power and mechanical department shops at Omaha, Neb. It occupies half of the electrical shop, and is under the direction of the electrical engineer, A. J. Collett, and in charge of a signalman of 18 years' experience in practically all branches of the work, who is assisted by mechanics from the shop force, as required.

The work consists principally of repairs to relays and signal motors, with some repairs to block signal mechanisms, electric interlocking, apparatus connected with a small installation of alternating current track circuit, and some experimental work. During the past year there were repaired 940 relays, 41 motors, 25 motor armatures, 129 pairs of slot coils and eight charging station generators. Twenty-eight signal mechanisms were practically redesigned and reconstructed, and apparatus was made for the complete installation, on two engines, of an automatic train-stopping device.

The Union Pacific has in service about 8,000 relays, mostly of the "Universal" type, and 3,137 automatic block signals.

In spite of the most improved lightning arresters a large number of relays annually have magnet coils, or contacts, or both, damaged by lightning, especially on the Wyoming division, many of them being practically destroyed by "freak" discharges. These, with relays taken out of service for other reasons, are shipped by baggage, accompanied by a requisition for repairs, to the general storekeeper at Omaha, who makes an order on the repair shop. This officer also handles the accounting for the repairs. Specially designed cases are furnished for shipping relays to and from the five divisions. These are made to contain four relays each, with felt packing designed to hold them firmly, and each case is numbered, to facilitate its handling.

Repair parts for all apparatus are kept in the general store, to be drawn as required, and charged to the proper store order number. In the shops the relays are first tested for coil resistance, a "Queen Decade" portable testing set being used; and