Applications of the Amplifier

Oscillogram, Fig. 15, shows telephone control of the alternator output. The two curves on the oscillogram which are relatively upside down show that the variation of the alternator voltage is in all details an almost exact reproduction of the controlling telephone current.

While a specific method of adapting the magnetic amplifier to an alternator as described above has been worked out both theoretically and experimentally in greater detail, there are obviously a variety of possibilities for adapting the same devices and theories to other conditions. Outside of telephony, the magnetic amplifier will probably be found of value as a non-arcing key for telegraphy and particularly will make possible high-speed telegraphy at the same rate and with the same means as high-speed automatic telegraphy on land lines. Oscillograph records have been taken of telegraphic control from 500 to 1500 words per minute.

The structure and the mode of operation of the magnetic amplifier which has been described is such that there appears to be no limit to the power that might be controlled in this way if apparatus are designed with suitable dimensions. The 72-kw. control which has been demonstrated may be sufficient for most purposes but there would be nothing surprising if several times this amount of energy were to be used in transatlantic radiotelephony or high-speed telegraphy in order to make the service thoroughly reliable.

SWITCHING LOCOMOTIVES FOR THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY

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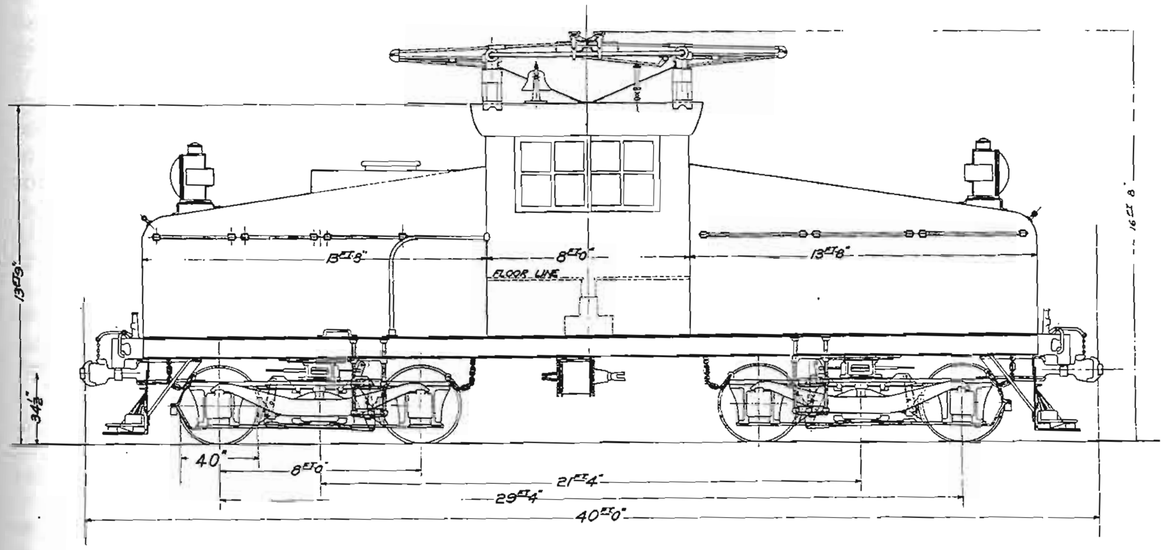
The adoption of 3000 volts for locomotive equipment, with the purpose of realizing high efficiency on long hauls, and powerful locomotives, has imposed hardships on the designer of the smaller locomotives used for switching on the same system. In this service the hauls are short and the loads relatively small. The switching locomotive described in this article, which has only one-fourth the weight of the main line locomotives, is a small high-voltage unit that is the equal in reliability and performance of the standard 600-volt switching locomotive. Wherever possible its equipment has been made the same as that of the road locomotives, in this way keeping down spare parts to a minimum.—Editor.

In attacking the problem of the electrification of steam railroads, the foremost thought has been to secure electric locomotives of enormous power that would be capable of performing service beyond the natural limitations of the steam locomotive. This secures one of the chief economies of electrification. In working out systems of electrification the problem of getting a suitable electric switching locomotive has generally been lost sight of for the reason that the switching load is only a very small part of the total power requirements, and for the further reason that the assumption has usually been made that, if the large road locomotives could be successfully worked out, there would then be very little trouble in securing a satisfactory switching locomotive. The road locomotives of an electrified system often require a capacity of several thousand horse power, while on the other hand the average switching service seldom requires a locomotive with a capacity of more than a few hundred horse power. For this reason the choice of a system of electrification is made with a view to meeting only those conditions imposed by the road locomotives and after the system has been chosen the switching locomotive must be designed to meet existing conditions. From the foregoing it will be seen that the design of the switching locomotive to be used on an electrified system may become almost as difficult a problem as the design of the main road locomotives themselves.

In the case of the Chicago, Milwaukee & St. Paul Railway there is being installed an electrification of 440 miles of main line over which is operated a very heavy traffic. This condition as well as the heavy grades encountered required the choice of a 3000-volt direct current system, with provision for regenerative braking on the road locomotives. The use of 3000 volts has made the design of the electric switching locomotive somewhat difficult and in fact when using regenerative braking on the road locomotive the voltage imposed on the switching locomotives may be even higher than 3000 volts. It is a well known fact that for simplicity, reliability, and low cost it is difficult to surpass the standard type of 600-volt switching locomotive. There is every indication, however, that in the design of the new 3000-volt switching locomotives which are now building for the Chicago, Milwaukee & St. Paul Railway, there has been secured a locomotive which will be in every way as satisfactory as any switching locomotive ever built. There is the still further advantage in this accepted design that a great majority of the electrical parts used will be interchangeable with parts of the road locomotives, thus simplifying the work of the railway company's store-keeper.

The two electric switching locomotives now in process of construction are known as Type 404-E-140-4GE255-3000-volt locomotives and are shown in outline in the accompanying illustration. As the above classification indicates the locomotive is an eight-wheel, swivel truck type weighing 70 tons and is equipped with four geared motors. The general features of the locomotive are approximately as follows:



Seventy-ton Switching Locomotive for Chicago, Milwaukee & St. Paul Railway

Length inside knuckles	40 ft.
Height over cab	13 ft. 10 in.
Height, trolley down	16 ft. 8 in.
Width over all	10 ft.
Total wheel base	29 ft. 4 in.
Rigid wheel base	8 ft.
Diameter of wheels	40 in.
Diameter of axles	7 in.
Main journals	6 by 11 in.
Minimum clearance under locomotive	4⅞ in.
Weight—locomotive complete	140,000 lb.
Weight mechanical equipment	85,000 lb.
Weight electrical equipment	55,000 lb.
Weight per driving axle	35,000 lb.

The running gear of the locomotive consists of two swivel equalized trucks, these trucks being of the standard type used on all small switching locomotives. Each truck is formed of steel bolster and side frames bolted together and carried on semi-elliptic springs. Steel tired wheels are used consisting of 3-in. tires shrunk on cast steel centers. The axles are of the usual type designed for mounting an electric motor and are provided with outside bearings of MCB collar design.

The platform superstructure carried by the swivel trucks is built up of longitudinal steel channels stiffened laterally with cross sills and brace plates and over the whole platform is laid a steel floor. The end frame, attached to this platform, consists of a heavy steel casting designed to distribute the severe shocks met with in switching service. The draft gear, which is attached to the end frame and platform, is of the standard friction type and is provided with the usual MCB coupler.

The cab necessary for housing the electrical apparatus and providing for the motorman's position is of the usual steeple type which has been found especially applicable to switching locomotives, on account of the sloping end providing an opportunity for the motorman to see clearly along the track in either direction. This cab which is built entirely of steel is divided into three portions consisting of one main cab approximately eight feet long by ten feet wide and two sloping end cabs each approximately fourteen feet by six feet wide.

On account of the advantages of a steeple cab as mentioned above only one operating position for the motorman is provided, and in order to assist further in giving the motorman a clear view in all directions the floor of the main cab has been raised approximately two feet above the floor of the platform. Thus with the exception of the electric cab heater and necessary controller and air brake apparatus, the entire space within the main cab is unobstructed. This plan of raising the motorman's position as high as possible is new on this type of locomotive, and besides affording the motorman a better view of the track this arrangement has the added advantage that all the electrical apparatus is located out of the way, either in the end cabs or under the floor of the main cab, where there is no possibility of injury to persons due to accidental contact with high voltage parts.

The electrical apparatus provided on this locomotive is in general very similar to the apparatus found on any small switching locomotives, but is novel to the extent that this is the first time such high voltages as 3000 volts have been applied to a small locomotive of this type. In order to simplify maintenance much of the apparatus used is similar in its details to the apparatus required on the road locomotives.

The motors, of which four per locomotive are used, are known as the GE-255 railway motor. This is a box frame commutating pole single-geared motor designed for operation on 3000 volts when connected with two motors permanently in series. This motor is mounted in the usual manner by a suspension on the axle and by the motor nose resting on the truck transom. The motor is provided with forced ventilation, the air being furnished by a blower in the cab from which the air is led through a duct in the platform down through a hollow center plate and hollow transom into a sliding duct connected to the motor.

The control apparatus furnished is a type M single-unit equipment providing ten steps with motors connected all in series and nine steps with motors connected two in series and two such groups in parallel. The apparatus provided in this equipment is of the most rugged type designed to stand severe service. The fuse compartment, main switch and contactors are of the same type as used on the large 3500-h.p. road locomotives. The transition from series to parallel is accomplished by means of a large electro-pneumatically operated switch, which also serves as a motor cutout switch.

The air brake furnished is of the usual locomotive type providing straight and automatic braking features. The air compressor provided affords a displacement of 150 cu. ft. per minute, this amount being much larger than necessary on a switching locomotive. It was, however, thought expedient to provide this extra large compressor so as to have the parts interchangeable with those furnished on the 282-ton road locomotives.* This compressor operates directly on 3000 volts and has already demonstrated its rugged qualities on those road locomotives now in service.

With regard to the other details of auxiliary apparatus provided on the locomotive, these are arranged to conform as far as possible to the equipment of the road locomotive; for example, all small switches, headlights, cab heaters and the pantograph trolley are exactly similar on both locomotives. On the switching locomotives, however, a small 3000-volt motor-generator blower set is furnished to provide forced ventilation for the motors and to provide energy for operating the control and headlights. In the case of the road locomotives this set is, of course, much larger on account of the greater requirements in the way of forced ventilation and energy for control purposes.

The locomotive has a nominal rating of 542 horse power. The horse power rating of a switching locomotive, however, is not altogether a satisfactory measure of its capacity for service. This locomotive will develop a tractive effort as high as 42,000 lb. for short periods providing rail conditions are suitable. The locomotive, is, moreover, capable of developing 13,480 lb. tractive effort continuously at a speed of 13.2 miles per hour, or 18,400 lb. tractive effort for one hour at a speed of 12 miles per hour. Both of these ratings are on a basis of forced ventilation. These locomotives will take the place of the present steam locomotives in operation in the yards of the electrified system, and will be capable of handling the same service.

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* For description of these locomotives, see GENERAL ELECTRIC REVIEW, July, 1915, page 600.