the necessity of keeping out all deleterious organisms, and permits a good product under conditions which otherwise would make it impossible to manufacture cheese at all.

A NEW SINGLE-PHASE RAILWAY EQUIPMENT.*

By A. FREDERICK COLLINS.

In Europe there are several electric railway systems in operation that are using three-phase alternating currents, while it is well known that here in America engineers have held long and lovingly to the direct-current system. Naturally, these opposed conditions have been the cause of more or less discussion in railway circles at home and abroad.

Three-phase railway systems are not by any means a new and untried feature in traction work, but they have stood the test of time since 1895; three years prior to this date Siemens & Halske, of Berlin, Germany, conducted the first tests at Charlottenburg on a short length of road with two overhead trolleys, the rails forming the third conductor, when cars were operated by a 600-volt, three-phase current at 50 cycles.

Then Brown, Boveri & Co., of Baden, Switzerland, put into service an alternating-current system when they completed the Lugano tramways, the first ever installed for commercial use. This has been in operation ever since 1895, and the success of this installation led to the construction of the Gornergrat railway,

per cent, and three-phase current at 7,000 volts and 38 cycles, generated by the water-power developed at the White Lutschine, is transmitted by overhead wires to transformer stations, which are located every 1,000 yards, where it is stepped down to 500 volts. Then there is the Burgdorf-Thun railway, which forms an important link between three of the main steam lines

motor, especially where the profile of the track is irregular, and the cars have to make frequent stops; again, the rate of acceleration of cars operated by three-phase current motors is low when compared with the acceleration of direct-current motor cars; and further, where induction motors are used, a large amount of current is required in starting, although since the current and voltage are not in phase, the total energy consumed is relatively small.

Opposed to these outward features are numerous advantages, the principal ones being the elimination of sub-stations, where rotary converters change the alternating into a direct current, which on railroad lines are essential; the ease with which a high-potential current can be stepped down by a stationary transformer on the car, and the economy with which long-distance transmission can be effected. American engineers have followed zealously the developments of the multiphase induction motor for traction work, and have been fully aware of its limitations as well as its possible extensions.

For several years past the engineers of the General Electric Company have bent their energies toward a safe and sane solution of the problem, and as a result they have devised a type of single-phase alternating-current equipment suitable for general traction work. The motor under consideration fulfills the exacting conditions imposed by the railway service, but what is yet more striking is its ability to operate on an alternat-

OVERHEAD CONSTRUCTION OF THE LINE.

THE TRUCK OF THE ALTERNATING-CURRENT MOTOR CAR.

ALTERNATING-CURRENT MOTOR CAR, BALLSTON LINE.
NEW SINGLE-PHASE RAILWAY EQUIPMENT.

and it was here that the Swiss engineers felt that they had achieved a signal success, for the road was considered a difficult test, having grades with a maximum rise of 20 per cent.

More celebrated than either of these is the Jungfrau railway, where some grades attain a maximum of 25

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

of Switzerland; the Valtellina line in the northern part of Italy; the Zossen road, on which the high-speed electric tests took place, and a number of others.

In the face of these demonstrable facts, our home engineers have shunned polyphase currents for traction purposes, for the reason that the induction motor is considered less economical than a direct-current series

ing current or a direct current with the same facility and economy, hence its wide range of usefulness and adaptability to direct-current trolley systems in cities and interurban extensions using alternating-current lines.

This single-phase compensated motor equipment is now in operation on the Ballston division of the Sche.

nectady railway, and is the first alternating-current railway in this country carrying passengers, demonstrating absolutely the feasibility of using a direct-current system within the city limits and a single-phase current on the line to Ballston.

The alternating-current motors employed are known as the compensated type, so named in virtue of the character of the field winding, which fully neutralizes or compensates for the armature reaction. Both the compensated motors and control are designed for operation on the 2,000-volt alternating-current trolley between the two cities and the standard 600-volt direct-current trolley in Schenectady.

The compensated motor is essentially a variable-speed motor, differing in this respect from the multiphase induction motor, whose constant-speed characteristics caused it to be looked upon in this country as a serious handicap to its successful employment in railroad work. The speed-torque characteristic of the compensated motor is very similar to that of the direct-current series motor, while its commutating qualities and method of control have proven equally satisfactory.

In construction the compensated motor consists of an annular laminated iron field with a distributed winding similar to that of an induction motor, and an armature provided with a commutation similar in general mechanical design to that of a direct-current railway motor. Motors of this type are wound for 200 volts, are permanently connected two in series, and are fed from the 400-volt secondary of an 80-kilowatt air-blast, step-down transformer which is carried on the car.

The distributed character of the field winding fully compensates for the armature reaction, so that the power factors are relatively high throughout the range of operation; moreover, it is so designed that at the free running speed of the car, which is the condition most frequently met with in suburban work, the power factor and efficiency are nearly at their maximum values. A high power factor is desirable, as it reduces the capacity and cost of the generating and distributing systems, and more especially effects a material im-

and the commutating switch can only be thrown when the oil switches are in the off position.

With equipments operating on both alternating and direct current power, it has been found preferable to utilize the standard series parallel controller, in order

rectly overhead, hence the necessity of interlocking oil switches and commutating switch to prevent trouble, should both trolley poles accidentally be up at the same time.

The commercial development of the single-phase mo-

PREPARING THE SOIL FOR PLANTING.

to minimize the weight of the controlling apparatus. Such a method of operation does not give quite so high an efficiency when accelerating the car with alternating current as could be obtained with a potential control. This difference in efficiency, however, is very small, due partly to the infrequency of stops occurring

tor is opportune at just this time, as steam railway managements are displaying great activity in acquiring competing electric roads, and in electrifying certain portions of their systems which are now operated at a loss with steam locomotives.

A CALIFORNIA HOP GARDEN.

By JANET MACDONALD.

FIVE hundred and thirty acres of verdant beauty in the lowlands of California's golden heart, miles of swaying verdure in the sunlit region of prosperity and contentment, hundreds of willing hands and happy faces, the ringing laugh of childhood, the sonorous tones of middle age mingling with the subdued tones of later life engaging in healthful and profitable employment—this was the scene of Arcadian simplicity which greeted my vision in a recent visit to a California hop garden in Yuba County. Impressive as an object lesson looking to development in a country so richly productive and so easily tilled, and which will give profitable employment to so many people.

The yield in green hops in this garden alone amounted last year to more than three million three hundred thousand pounds. The picking alone of this prodigious crop cost \$34,000, requiring the services of fifteen hundred people for twenty days. As hops ripen at different times in different localities in this highly diversified climatic State, hop pickers pass rapidly from one garden to another, usually putting in the entire season in this pleasant and profitable employment. Among them is numbered a conglomerate mass of humanity. "All sorts and conditions of men," women, and children are here represented. College professors, students of both sexes, and various nationalities, eager to earn the money with which to carry on their ambitious educational aspirations, and sober-faced men and women of good families, with their children of tender years, Japanese of both sexes, Chinamen, as well as entire families from sunny Italy.

Those pickers, irrespective of nationality, who are industrious, and deft of fingers, and who are picking hops for every cent there is in it, will make as much as \$75 in the season of twenty days. If they work

PICKING HOP BLOSSOMS IN A FOREST OF HOP VINES.

provement in the regulation of the alternating-current generators.

Unlike a direct-current system, which has a practically constant potential at the sub-station bus-bars, irrespective of the load, the drop in an alternating-current railway system is cumulative up to and including the generator and engine regulation. It is desirable therefore to maintain as good a power factor as is consistent with good motor design, in order to limit the total drop of the system to a reasonable amount.

Motor characteristics that have been plotted for both alternating and direct current running show that the speed torque for alternating-current running is equal to direct-current running in meeting the requirements of railway work. Different from the multiphase induction motor with its practically constant speed characteristic, the compensated alternating-current motor varies its speed with its load, and is thus better adapted to operate trains over an irregular profile.

The commutation of the compensated motor is satisfactorily secured, when running on either alternating or direct current, by careful electrical and mechanical design, and without resorting to high-resistance leads, and other expedients which are likely to give trouble in case of a sustained overload. There is a comparatively small additional expense attached to adapting alternating-current equipments to run either on single-phase or direct currents, and in the Ballston line installation it is accomplished by the use of a standard K-28 direct-current series parallel controller used in connection with a commutating switch to change the field connections and line fuses and cut out the step-down transformer.

The arrangement of these connections is shown in the accompanying diagram. The commutating switch is interlocked with two main oil switches, one for the high-tension alternating current, and the other for the direct-current circuit, the interlocking being so arranged that only one switch can be closed at a time,

upon those sections of the road equipped with alternating-current trolley, but chiefly it is due to the flexibility of the speed-torque curve of the single-phase motor, which gives a high efficiency of acceleration with series parallel control.

LOADING HOPS FOR SHIPMENT.

A CALIFORNIA HOP GARDEN.

It has been found necessary on the Ballston line to provide double sets of trolleys, one for the alternating and the other for the direct current. The alternating-current trolley construction is off center, while the standard city and suburban trolleys are arranged di-

to the end of the season, they are paid an additional ten per cent, but many pickers flit away before the entire crop is gathered in, finding fresh fields and pastures new, where picking is easier, and they can therefore work more rapidly. A family of even mod-