serious troubles encountered in switching and crossing where many cars are used.

The third-rail system has in many cases been discarded, on account of the danger of receiving shocks to which persons and animals are exposed in crossing the rails, and on account of the great loss by leakage due to the extreme difficulty experienced in maintaining proper insulation.

The system using the rails as conductors has been discarded, because of the same objections that have just been urged against the third-rail system. The objections to the underground conduit system are the great first cost; the necessity and the expense of tearing up the streets, which in many cases prohibits its adoption; and the necessity of providing for its perfect drainage, which, in connection with the serious troubles in maintaining insulation, greatly adds to the cost of its maintenance and the running expenses.

The storage-battery plan, at first thought, would seem to be the ideal system. It dispenses with the necessity of a continuous conductor, the electrical generator and motive power are all contained within the car, and there is apparently an entire absence of any possibility of danger to passengers. These favorable anticipations would be justified were it once demonstrated that a storage-battery had been devised that was economical of power, of reasonable weight, and durable in service. Thus far, however, the best storage-battery that has been devised is very wasteful as a source of motive power, yielding at most but forty per cent of the power applied, excessively heavy and bulky, making it necessary to carry about three times the load of an ordinary car, and requiring a special car to be built to provide the necessary space beneath the seats to receive the batteries, — a matter of very notable importance, since it prohibits the use of the rolling stock of the surface roads without considerable cost for alterations. Furthermore, the storage-battery, as thus far developed, has a life of only two years of constant service, and it is subject to the danger of short-circuiting, which at once destroys its usefulness. Whether any or all of these deficiencies, which at present seriously interfere with its usefulness, may be remedied in the future, is a question which time alone can determine. It is sufficient for our present purpose to know that the storage-battery, in the best forms of to-day, is seriously handicapped by reason of these objectionable features.

The construction and mode of operation of the Hauss system will be understood from the following explanations: —

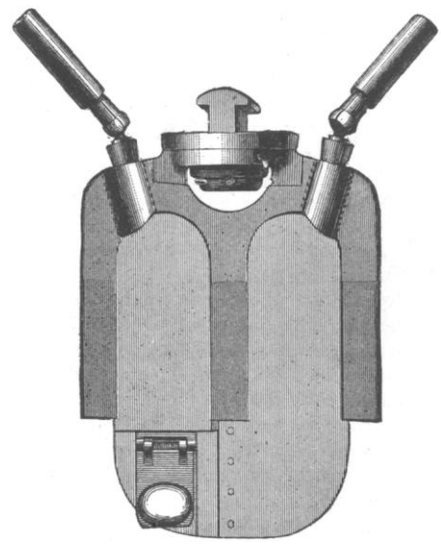
In this system an insulated wire is used, covered with rubber and other material known to be highly efficient in the case of underground electric-light wires. This wire is placed in a groove in the stringer underneath one of the rails, and is passed through metallic pockets, which are also placed underneath the rail. In order to obtain additional insulation, the stringer is coated with asphaltum. The metallic pockets are placed beneath the rail having the grooved stringer carrying the line-wire. The rails on this side are made in sections, each twelve feet long, each section being insulated from adjacent sections. When the car passes over the rail, contact is made with the wire in the pocket, and the current is collected by means of guard-brushes and the wheels. The entire length of the track is dead, and the only portion which is charged is a space twelve feet long directly under the car. When the car leaves one twelve-foot section, this section immediately becomes dead, and the next section over which the car is then passing becomes charged. There is at no time any portion of the track charged except that portion directly under the car, thus not only insuring against all danger to persons or animals, but also insuring efficient insulation along the entire route, and preventing a heavy leakage of current. The current is conveyed from the guard-brushes and the wheels to the motor, and through the other rail to the ground.

The speed or direction of the motor can be controlled from either end of the car. The motor is built as light as is consistent with the best electric results (a twenty-horse motor, weighing one thousand pounds), and the armature is run at a very moderate speed. The efficiency of the motor is affirmed to range, by actual test, at about ninety-five to ninety-eight per cent. The power is applied directly to the axles of the car by means of a worm and worm-gear, the latter being placed on each of the axles, and the worm connected directly to the armature shaft and provided with two ball-and-socket joints, to compensate for any slight derangement in the relations between the motor and the shafts. The motor is bolted to a frame hung on the axles of the car, and fastened rigidly to the journal-boxes. The springs rest on the journal-boxes, and support the body of the car. The motor and truck are entirely independent of the car-body, and have no connection therewith. The motor can be geared so as to run the car ten or more miles an hour, and, as we witnessed at the trial of the system, can be perfectly controlled from the slowest movement up to full speed, and instantly stopped or reversed, if necessary, without injury to the machinery. No hand-brakes are required with this system, as the wheels are automatically locked when the armature ceases to revolve. In going down grade, there is no danger of the operator losing control of the car, and no possibility of the car running away. Another feature introduced on the car is a fifth wheel, shown suspended at the front end, which can be let down, and by means of which the front end of the car can be jacked up. When thus resting on three wheels, the car can be led around any obstruction and brought back to the track, connection with the track-conductor being temporarily made with flexible conductors. By this system the cars are able to leave the track, to go around a breakdown or an obstruction, to go over fire-hose when stretched across the track, or to cross over and take the back track. Finally, there is not an inch of room required for passengers that is used, and not a sign to denote the use of electricity in the propelling of the car to be seen above the floor. By this system, it is claimed, the cost of running is brought lower than has been possible with any other thus far devised, and the claim appears to be based on reasonable grounds.

The simplicity of the motive mechanism is such as to insure the minimum of trouble in operation; and the entire system, in respect of economy of construction, maintenance and running, and absolute safety, appears to have eminent merits.

THE CONDUIT SYSTEM OF ELECTRIC RAILWAYS.

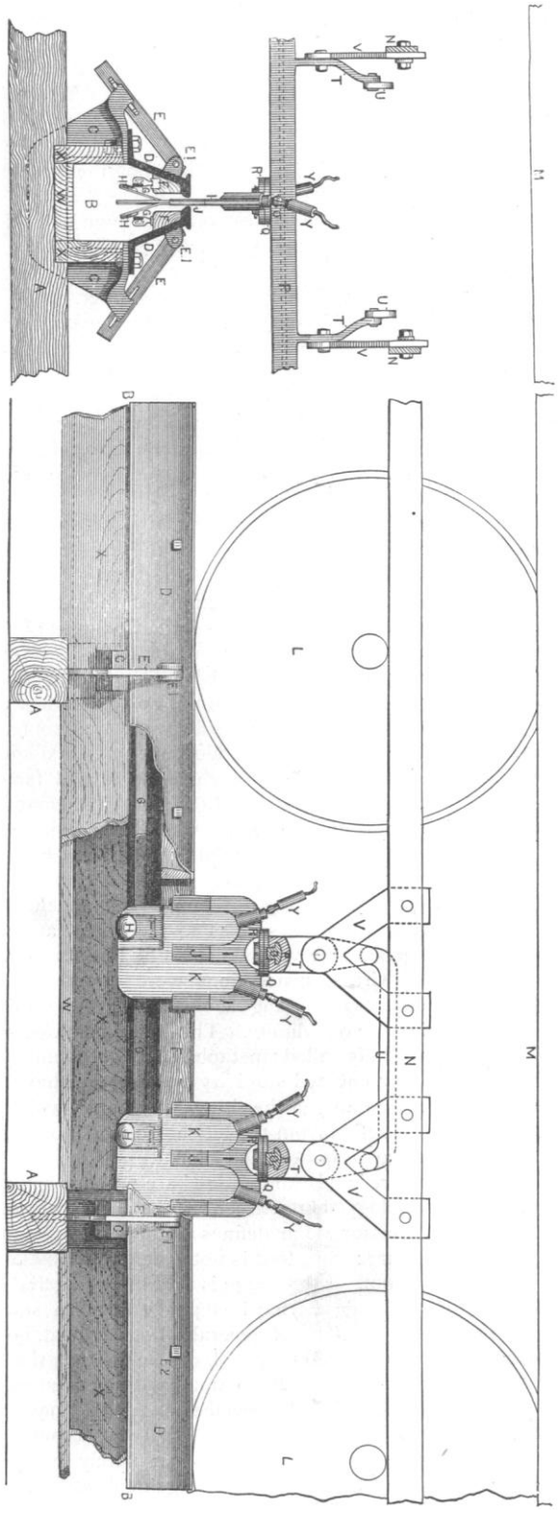
AMONG all the different types of motors which have been pressing their respective claims upon the attention of the public during the last few years, there is none which can compare with the electric motor in its efficiency, its adaptability to all sorts of work, and its practicability as a means for the distribution of power from a central station at a moderate expense. The number of electric motors now in every-day operation, and the extended range of the uses to which they are put, are matters furnishing constant surprise to all who are unpossessed of the latest information on these points.



CONTACT DEVICE.

One of the most interesting of the applications of the electric motor is found in the electrically propelled street-car of to-day which has already created a revolution in the field of locomotion and which promises in the near future to be as commonplace an

familiar as the horse-car now is. In this system the conductors are necessarily bared throughout their entire length, and must be protected both for the safety and convenience of the public and also to prevent injury to the conductors themselves. These requirements are fully satisfied by the underground conduit, which promises to be an indispensable element upon all urban lines.



A, tie; *B*, conduit; *C*, iron yoke; *D*, slot steel; *G*, conductor; *H*, contact shoes; *I*, contact device or plough; *L*, car-wheel; *P*, *Q*, *R*, traveller and swivel; *Y*, flexible conductor.

This system has been developed by the Bentley-Knight Electric Railway Company of New York City, who claim to control by patented rights all practicable methods of locating the supply conductors in a conduit, and who, however this may be, have built the only roads operating on this plan. Either between or outside of the track-rails is laid a conduit about fifteen inches in depth and ten inches in width, consisting of iron yokes set up from three to five feet apart, and slot steels bolted thereto, leaving an opening at the surface of the street of only about five-eight s of an inch. The direct and return supply conductors, consisting of copper bars united by expansion joints, are supported by suitable insulators in the upper part of the conduit, where they are out of the way of any slush and dirt which may collect therein. These conductors are placed opposite each other, and are connected in circuit with the dynamos at the central station. The car carries a plough or contact device, which extends down through the slot into the conduit, and has two contact-shoes insulated from each other, which rub against the two line-conductors. Flexible conductors in circuit with the two shoes extend up to the car, and are in circuit with the terminals of the propelling motor; so that, as the car travels along the track, the two housed conductors are constantly connected through a travelling loop circuit supplying the motor with current.

The shank of the plough is narrower than the slot, and the contact-shoes can be folded into line therewith, so that the entire plough can be inserted or moved from the conduit at will; and accidental breaking of the plough is guarded against by providing a spring catch normally holding the plough in place, but adapted to give way should any accidental obstruction be struck. In order to compensate for any curves or irregularities in the line of the slot, a transverse guide is provided upon the vehicle, and a traveller at the upper end of the plough moves freely along this guide, while swivelling or other jointed connections may be employed when found desirable. The car is propelled by either one or two motors of about fifteen horse-power, which are generally placed underneath the car-body, and centred around the axles, to which they are connected through intermediate speed-reducing gearing. The usual brakes are provided for stopping the car, while circuit switches and resistances control the speed and power of the motors with all the precision and nicety of which steam-motors are capable.

From this description the essential features of construction in the conduit system, as well as the mode of their operation, will be readily understood, but many questions touching upon the practical working of the system will suggest themselves to those interested in it as a commercial enterprise: Will the conduit become filled with dirt or with snow? Can the necessary insulation of the underground wires be maintained? Will the car have sufficient traction? What will happen if the car runs off the track? All these objections have been anticipated, and it is found that the satisfactory operation of the conduit road built by the Bentley-Knight Company at Allegheny City, Penn., demonstrates that they are groundless. This road, which is known as the Observatory Hill Passenger Railway, is about four miles in length, the conduit being employed for about one-fourth of this distance, and it has been in continuous operation since the first day of January, 1888. There are thirty-four curves on the line, not including turnouts and switches. The maximum grade is $9\frac{39}{40}$ feet in 100 feet, on a length of 400 feet, and this is on a reversed curve (radii 100 and 200 feet). The sharpest curve has a forty-foot radius on five-per-cent grade. Greater natural difficulties than these can scarcely be found on any street-railway in existence, and hence the successful working of the road during the severe snows and ice of the last winter is perhaps the best guaranty of the practicability of the system. Other conduit-roads are now under process of construction by the same company, noticeable among which are one of over three miles in length, contracted for by the West End Railway Company of Boston, and the Fulton Street Road of New York City. The progress of these roads will be watched with interest.

That for the West End Company in Boston is just completed, and will be put into operation in a few weeks, and thoroughly tested.

PHILOSOPHY AND SPECIALTIES.

ON Saturday evening, Dec. 8, the annual address of the retiring president of the Philosophical Society of Washington, Col. Garrick Mallery, U.S.A., was delivered before a very large audience, composed not only of the members of the Philosophical Society, but of those of the Anthropological, Biological, Chemical, Geographic, and Woman's Anthropological Societies, whose attendance had been