coiling the springs, by any suitable fixed steam-engine or other prime-motor, are to be provided, rotary motion being communicated by shafts under the roadway to vertical spindles and geared wheels, which being thrown into temporary connection, for the purpose, with the spring-barrel, will coil the springs until the requisite tension power is obtained. The means of effecting this temporary connection of the prime-motor with the carriage-mechanism may obviously be varied, without affecting the principle of thus providing stored-up power, self-contained, whereby the car may be automatically propelled Adequate brake power is also provided so as not only to control and arrest, when requisite, the spring-power, but to hold it in complete suspension when the car is stationary: and furthermore, an arrangement of clutches is interposed between the spring-barrels and the driving-wheels, whereby the uncoiling motion of the springs, which is constant in one direction only, may be transformed into an ultimate variable rotary motion, given out in opposite directions as needed, for reversing the direction of propulsion of the car.

In the accompanying engravings fig 1 represents an ordinary tramway car in side elevation, fitted up with this self-propelling appliance, and showing the mechanism for winding up the coiled springs applied thereto. In fig. 2 is shown an inverted view or plan of the underside of the car-framing and mechanism; the sectional plan of the spring-barrels or drums and gear connected therewith appearing in fig. 3; while fig. 4 demonstrates in elevation, as applied to such a tramway carriage, the mechanical arrangement proposed for employment in winding up the springs.

Fixed horizontally and transversely beneath the carriage flooring and situated at about the centre of its length, are two series or groups of hollow drums or spring barrels, A, A1, fitted on to sleeve-shafts, carried on fixed axles, B, B1; in each group there are five barrels, but any less or greater number of barrels may be employed, as may be convenient and requisite Simultaneous operation of all the springs in both groups may be secured an l maintained; or, on the other hand, action may be limited to the springs of one series only; the arrangement and details being as follows.

A winding-shaft, C, is fixed in bearings in the cheeks or side plates, D, fitted to the underside of the carriage-framing, which carry also the drum-axles, B, B1. On the shaft, C, is keyed a pinion, *c*, geared into a spurwheel, *a*, affixed to the spring-barrel, 1, the first of group A. The spring-barrels, 1 and 2, are loosely mounted on a sleeve on shaft B, and severally connected thereto by means of coiled springs, whereof the coil for the barrel 2 is in the reverse direction to that for the barrel 1; the barrels 3 and 4 are similarly carried by, and reversely connected to another and independent sleeve on the same axle. Connection between the barrels 2 and 3 is effected by a pin, *b*, at the periphery of the barrels, which thus acts alternately as a driver, to transmit the coiling power from the prime-motor, passing through spring-barrel, 1, or *vice versa*, to give out the power of tension stored up in the coiled-springs, when acting in their turn as prime-motor. A similar pin, *b*, also connects spring-barrels 4 and 5, whereof the latter is mounted on and connected with a separate sleeve, and carries a spur-wheel, *a1*, engaging in another like spur-wheel, *a2*, affixed to the spring-barrel, 6, the first of the second group or series, A1, carried on the axle, B1; the arrangement and connection of the spring-barrels, 6, 7, 8, 9, and 10, constituting the second group are precisely similar; and the last barrel, 10, of the series is provided with a spur-wheel, *e2*, engaging into the intermediate gearing actuating the driving-wheels.

Centrally located between B and B1 is a supplementary axle, E, also carried in the side-plates, D, and serving to carry a loose pinion, *e*, engaging in the spur-wheels, *e1*, *e2*, which are respectively mounted on shafts, B and B1, so as to run loose; the wheel, *e1*, is connected with the spring-barrel 1, by means of a pawl and ratchet, just as in the case of *e2*, and 10. Friction-brakes, *h*, thrown in and out of action by brake-rods, H, H1, extending forwards and backwards to the opposite ends of the car, and by lever handles, and operated by bevel-gearing, as shown in fig 2—are fitted on the peripheries of the spring-barrels 1 and 10, so as to act as detents for the prevention of the running down or uncoiling of the springs of both groups, when in action; or otherwise, when released, to permit them to exercise their tension-power

The counter shaft, F, carried in bearings in side-plates, D, serves to transmit the spring-power and rotary motion to the axle C, of the driving-wheels, by the medium of spur-gearing, *f*, *f1*, *f2*. Upon this driving axle are two pinions, *g*, loosely mounted, and having clutch-teeth on their boxes, formed to receive respectively the teeth of a pair of clutches, *g1*, sliding on feathers on the shaft G, and actuated by the clutch-rods, *g2* These constitute the reversing gear, for forward motion, the pinion into which the wheel, *f1*, gears, is thrown into action, the transmission of power being direct, for reversal to backward motion, the spur-wheel, *f2*, is put in action, driving an idle pinion *g3*, gearing into the adjacent pinion, *g*, and running loosely on a shaft, *g4*, having its bearings in radius rods, *g5* respectively pendent from shafts, P, G, and thus transmitting opposite rotation to G. It will be understood that the terms "backward" and "forward" are only relative, and that motion may be imparted to the car in either direction indifferently.

In case the barrels, 1 and 10, are both released from the friction-brakes, *h*, both groups of springs exert their power through their respective spur-wheels, *e1*, *e2*, upon the pinion, *f*. If, however, the brake be put in action on the barrel, 10, only, the tension-power of group, A1, is transmitted back by spur-wheels, *a2*, *a1*, in aid of group, A, and the spur-wheel, *e*, by the pinion, *e*, and *e2*, now acting as an idle-wheel drives the pinion, *f*; on the other hand, if the barrel, 1, be held by the brake, and 10 be free, the action of the springs is transmitted in the reverse direction to the wheel *e2*, which thus receives and transmits the whole combined propelling power.

The winding-up of the spring-barrels is effected, as explained, by engine power, located at suitable intervals along the track, as may be convenient for the run, or at special stopping places. In fig 4 the stationary engine, 1, and fly-wheel, K, drives by belt the pulley, L, fixed on horizontal shaft, M, carried in bearings, enclosed in a metallic tube or casing, beneath the roadway, and extending across the tramway track, close alongside whereof a covered box, N, is sunk in the roadway, enclosing a chain-wheel, O, affixed on the shaft, N. The endless pitch-chain, P, passes round O, and a second chain-wheel, Q, carried on a pair of radius arms, R, supported on M. The axle of Q is fitted with a sleeve so shaped as to connect with the winding-axle, C, of the tramway car, and thus give the requisite motion thereto. On the arrival of a car at any station requiring to have its spring-tension renewed, the chain-wheel, Q, is raised into position, connected with the shaft, C, and the spring-barrels are wound up by the engine, which being done, Q is disconnected, and depressed into its original position. A friction-coupling or other like appliance may be introduced at any suitable and convenient part of the apparatus, to prevent over-winding.

The crucial point of the whole system clearly relates to the size and power of the springs, the arrangement adopted, of connecting together the springs alternately by their arbours and peripheries, practically unites all the separate springs of the two groups into one continuous coil, exerting the power of each individual member of the series (supposed of equal strength), but exerting that power through a proportionately longer period The power and duration of the springs must be adequate for the maintenance of the requisite maximum (though limited) speed for a period or journey of sufficient length.

Now it has been computed that the actual tractive force, requisite to overcome the resistance of a tramway car weighing gross 5 tons, is 60 lb. on the driving wheels, corresponding to 720 lb. on the periphery of the spring barrel; 24 lb. and 288 lb. respectively correspond to a gross weight of 2 tons; and in like proportions for intermediate weights. So far as previous experience goes, a spring 6 lb. in weight, exerting a direct pressure of 105 lb., may be taken to represent the maximum in size and power of such steel springs. Under the stimulus applied by M. Leveaux's researches, the steel manufacturers of Sheffield, by special and improved plant, annealing ovens and appliances, have turned out springs 50 to 60 feet long, capable when duly coiled of exerting a pressure of 800 lb. to 900 lb. without permanent set. In France also, still driving bands, with great elasticity, are made 100 yards in length, so that the question of the possibility of obtaining springs of the requisite size and power is practically solved.

Having satisfactorily tested the principle in a working model, to one-sixth scale, on a small temporary tramway of considerable length, M Leveaux has had all the necessary mechanism and appliances made by a well-known firm of en-