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Filed July 31, 1940

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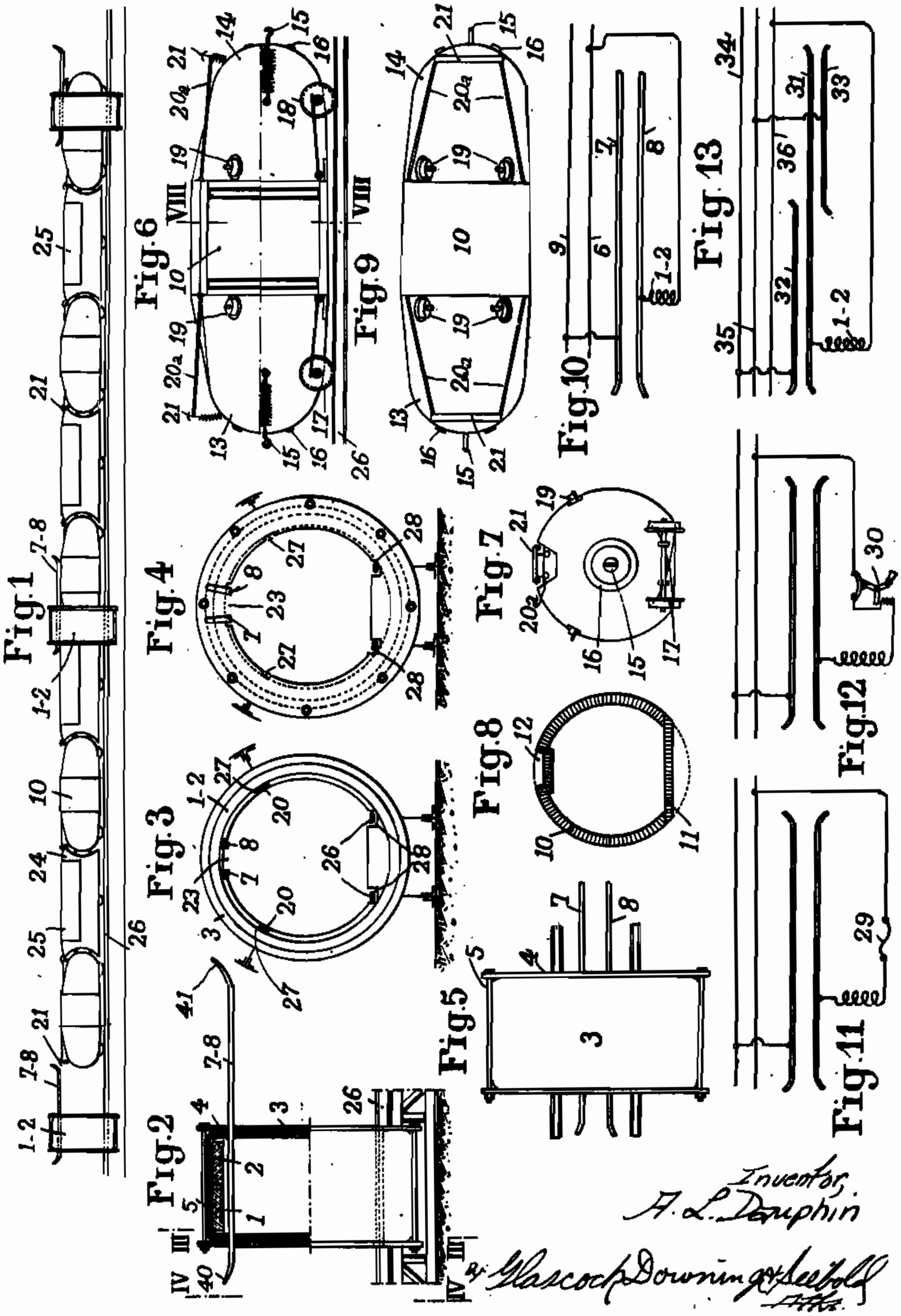
2 Sheets-Sheet 1



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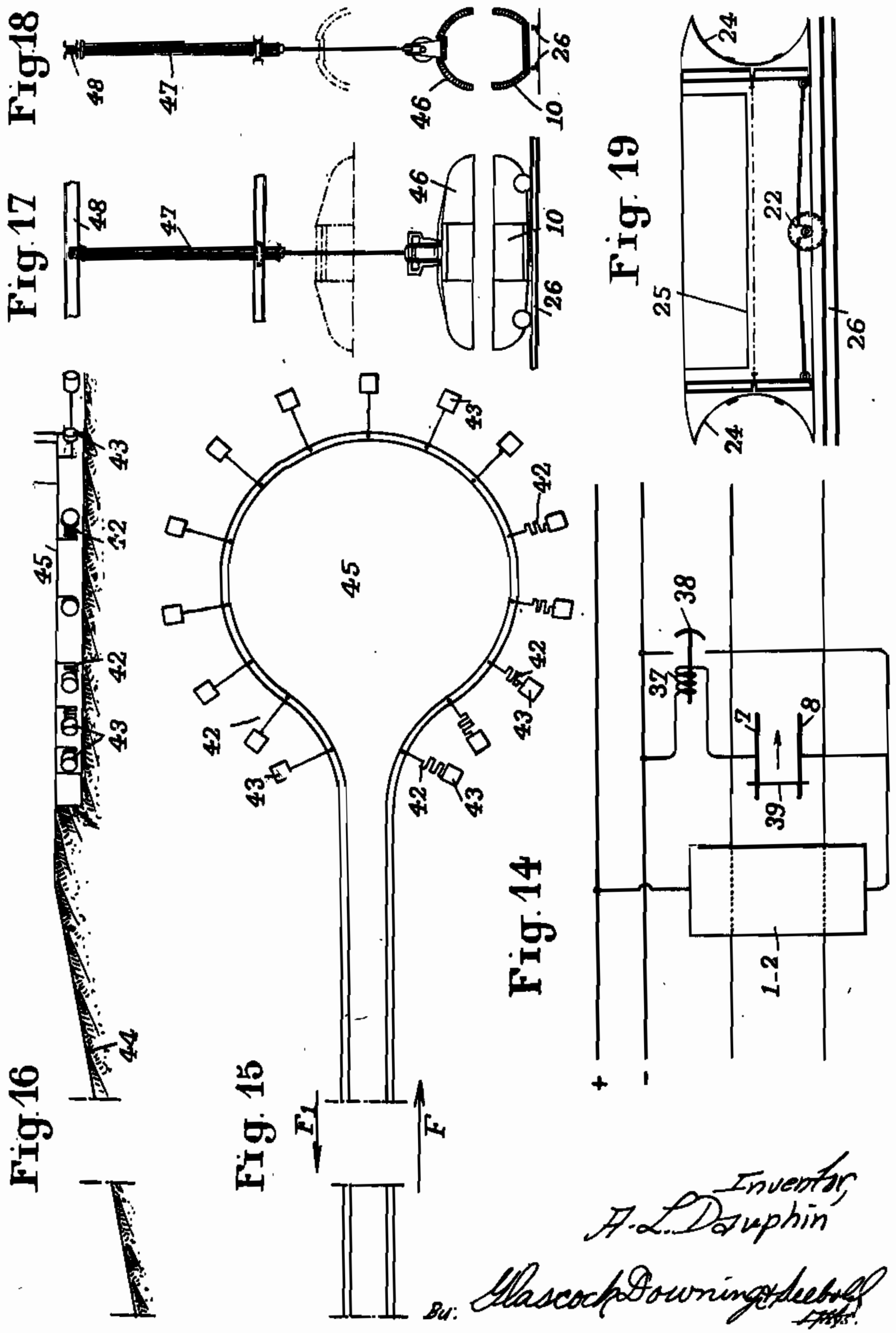


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# ALIEN PROPERTY CUSTODIAN

## ELECTROMAGNETIC TRANSPORT DEVICE

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This invention relates to an electromagnetic transport device, more particularly intended for the rapid transport over any distance of light freight and especially mail, by electromagnetic propulsion.

The problem of the rapid transport of the mail is as yet only imperfectly solved. The most rapid means (aeroplanes) cannot ensure a constant flow and always necessitate a transfer from the point of arrival to the distribution centre.

The pneumatic tube system employed in large towns where the network is dense, easily superintended and of small capacity, is not applicable to long distances or to large diameters.

The electromagnetic propelling device patented by the applicant is perfectly adaptable to the solution of this problem by means of a certain number of improvements.

However, it follows that the construction must be different according to whether it is a question of transporting light mail at a very high speed (50 to 100 meters/sec.) and over very great distances, or of transporting heavy and bulky loads (standard mail bags) for a short distance such as from an aerodrome to a distribution centre and at low speeds (20 to 25 meters/sec.).

The first application necessitates a tight tube which can be placed in a trench or in a duct or even in the open air. It necessitates magnetically controlled automatic switch points, good contacts without material contact with the movable bodies, an automatic block system etc., all these arrangements being obtained by the present invention.

The principle of the system which is known in itself is as follows:

If a magnetic core is assumed to be about to pass into a solenoid, and if the said core itself by its movement causes a current to be passed through the solenoid, it will be attracted with an increasing force up to the point where the magnetic circuit with the outer framework is closed and the attraction will disappear.

However, if in arriving at this point (taking into account the self-inductance of the winding) the core itself by its movement cuts off the current through the solenoid, it will continue in its course owing to inertia, assuming it to be suitably guided.

If a second solenoid is met under the same conditions a fresh impulse may be imparted to the core.

According to the energy and the frequency of these impulses, taking into account the passive resistances, it will acquire an accelerated movement or a continuous movement.

The case can now be considered where instead of a single magnetic core there is a train composed of any number of cores which are magnetically separate but mechanically coupled.

If this train passes through a series of suitably spaced solenoids the impulses will succeed one another so as to constitute a practically continuous drive and the train can move at any speed determined by the power expended on the one hand, by the passive resistance, on the other hand, and in a subordinate way by the switching conditions, time constant of the solenoids, etc.

It follows that according to the particular conditions of application and for the purpose of reducing the initial cost, solenoids which are more widely spaced and of greater power can be used, thus utilizing the momentum of the train, to ensure the drive by a succession of spaced impulses. The algebraic sum of the driving impulses and the resistances to motion must, of course, be positive at any moment.

The device according to the invention comprises in combination suitable solenoids of suitable dimensions provided with switching apparatus and locomotor elements which themselves constitute, and through the auxiliary transport members with which they can be combined, a core for the solenoids the latter being suitably arranged on a suitable supporting and guiding track which also comprises suitable magnetic braking and safety devices, preferably operating automatically, with the object of obtaining a high-speed transport assembly permitting a considerable traffic.

The accompanying drawings show the construction according to the invention of a device intended to be used for the transport of mail bags between given stations.

In the drawings:

Fig. 1 is a view of an assembly of a train used according to the invention;

Fig. 2 is a half section with half external view of a solenoid mounted on the track;

Fig. 3 is a vertical section of Fig. 2 along the line III—III.

Fig. 4 is an end view of Fig. 2 along the line IV—IV of Fig. 2;

Fig. 5 is a plan of Fig. 2;

Fig. 6 is an elevation with partial section of a locomotor element,

Fig. 7 is an end view partly broken away;

Fig. 8 is a section along the line VIII—VIII of Fig. 6;

Fig. 9 is a plan view of Fig. 6;

Fig. 10 is a diagram of the electrical connections of each solenoid;

Figs. 11, 12, 13 show modifications of Fig. 10,

Fig. 14 is a diagrammatic view of a cut-out located in the connections of the coil,

Figs. 15, 16 are diagrammatic views showing a plan view and a longitudinal section respectively of a station,

Figs. 17, 18 are a longitudinal elevation and a cross-section respectively of a locomotor in an opened position;

Fig. 19 is an elevation of a transport vehicle intended to be inserted between locomotors according to Fig. 6.

The complete device comprises three principal elements which are the solenoids, the switching apparatus and the locomotors, and accessory elements such as the track, the transport trolleys and the safety devices.

Each solenoid (Figs. 2 to 5) consists of an annular winding of a diameter suitable for the calibre of the device. This winding can consist of a single coil or, as in the preferred embodiment shown in Fig. 2, several coil sections (two in number in said embodiment) such as 1 and 2 connected in series and suitably insulated conforming to the dimensions of the assembly. The simple or multiple coil is enclosed in a laminated magnetic framework forming a casing and assembled by bronze members such as 4 and 5; said framework receives the track elements 26.

The area of the section of iron of the said magnetic framework is such that the iron is not saturated in any case. Under these conditions the surfaces of the armatures are surfaces of magnetic level in which the lines of force must normally terminate.

As the driving reaction acts on the magnetic framework the assembly is calculated mechanically in proportion to these reactions:

As clearly shown in the Figures 2 to 5 of the drawings, the whole is concentrated and constructed to reduce to a minimum the dispersion of the lines of force in accordance with the known processes.

The internal diameter of the magnetic ring is determined so as to reduce the air gap to a minimum when the magnetic circuit is closed by the core of the locomotor, which is described hereafter this necessitating a very accurate guiding obtained as indicated hereinafter in the description relating to the track.

The iron plates are suitably notched as by 23, 27, 28 to allow free passage for the switch rails 7, 8, guide rails 20 and bearing rails 26 respectively. In order that the said rails do not form a magnetic short-circuit, said rails will comprise sections of rail constructed of non-magnetic metal. It would also be possible to use steel rails by providing by notching air gaps which are appreciably greater than the normal air gap, according to the conditions of construction.

In view of their mass, the surface of dispersion and the extremely short time during which a current passes (of the order of 100th of a second) the question of overheating in normal service does not arise. In case of accidents causing the circuit to be closed for a considerable time the circuit is automatically broken by a fuse 29 (Fig. 11) or by a cut-out 30 (Fig. 12) having a retarded action.

As relatively high currents are used the question of switching is of considerable importance and conditions the operation of the device insofar as practical operation continues.

Thus in a system comprising a train of 3,000 kgs. driven at a speed of 25 meters/sec. the peak current may reach 300 amperes at 600 volts. As this current is instantaneous (of the order of 100th of a second) the questions of self-inductance, time constant of the windings and the breaking of the current, give rise to problems the solution of which constitutes one of the characteristics of the invention.

This solution is theoretical and practical and is obtained as follows:

One of the ends of the winding of each of the solenoids 1, 2 is directly connected to one of the supply lines, for example 6 (Fig. 10). At any suitable point of the inner circumference of each solenoid, preferably at the upper part, are placed two rail elements for switching shown at 7 and 8 in Figs. 2–4. These rails are constructed of a metal which is non-magnetic and which is a good conductor of electricity, such as for example copper, bronze or other material, and are separated by a distance which is sufficient to avoid the formation of arcs between the said rails in view of the supply voltage adopted.

One of the rails, for example 7, is directly connected to the other supply line 8, the other rail 8 being connected to the second end of the winding 1, 2, as shown in Fig. 10.

It can therefore be seen that in order to energize the solenoid 1—2 it is necessary and sufficient for the circuit between the two rails 7—8 to be closed by means of a special part carried by the movable body. Among other advantages this arrangement has the advantage that no part of the train (with the exception of the insulated slider which is described below) serves as a conductor for the current and neither the rails nor the earth form part of the circuit, thus excluding all risk of fire breaking out in the transported freight.

Each of the solenoids is connected up only through the medium of the protecting and cut-out devices such as 29 (Fig. 11) and 30 (Fig. 12) by means of which a solenoid can be disconnected for repairs without interrupting the traffic.

In order to make the most use of the solenoid it is important that the useful current intensity, that is to say the intensity at the moment when the magnetic core passes into the magnetic field, is the maximum intensity provided for while taking into account solely the ohmic resistance of the winding.

As it is here a question of instantaneous currents the winding has a considerable self-inductance which slows up the passage of the current and this "time constant" has an appreciable value which may reach several hundredths of a second. It is therefore important for the switch rails to be suitably extended in order that the slider of the movable body shall close the circuit before the core passes into the solenoid.

The length of this extension is determined by the time constant of the windings and the speed at which the movable body is propelled. An insufficient length will reduce the magneto-motive action and an exaggerated length will reduce the output of energy and will be capable of causing an unnecessary overheating.

The breaking in an inductive circuit of an instantaneous current of such strength presents considerable difficulties in an apparatus where the current is very frequently interrupted unless relays are employed the complication and sensitiveness of which will appreciably reduce the advantages of the device.

In order to avoid these disadvantages the magnetic circuits are dimensioned so that at any moment of the total closing of the magnetic circuit (core centred in the solenoid) the back electromotive force due to the movement considerably reduces the current strength. In this way in the example cited above, when the peak current strength is of the order of 300 amperes the current on breaking the circuit is only 15 amperes.

However, by way of supplementary precaution the ends of the switch rails are provided with points 40—40, 41—41 (Figs. 2, 5) graphite or equivalent material forming a spark arrestor for the double purpose of avoiding the over-voltages which are harmful to the windings and of allowing an easy maintenance without changing the assembly of the rail.

The abovementioned arrangement is applied to double track conveyors operating in some sort of closed circuit, but the device is equally applicable to "shuttle" services run with single track conveyors.

In this case there are three switch rails (Fig. 13) the central rail 31 connected to the solenoid 1—2 and to the supply line 36 being of double length, in order to ensure the advance contact in both directions of running. The side rails 32—33 carried in front and at the rear are each connected to a different supply line 34—35 respectively which can be connected up from the central plant.

In order to reverse the direction of a train it is therefore sufficient to change the slider and to connect one or the other of the supply lines 34—35 to the generator not shown in the drawing.

The device comprises propelling solenoids and also braking solenoids intended to slow up the speed of the train on arrival at a station.

The switching conditions are here quite different since the magneto-motive action must have effect only when the magnetic circuit is closed and the current must be broken during the opening of the magnetic circuit.

The efficiency of the solenoid is then extremely reduced since the maximum self-inductance during the passing of the current considerably reduces the current strength used, and since the circuit is broken at a peak current without any counter action due to the back electro-motive force. As this counter action is moreover inversely proportional to the speed of the train it will entirely disappear when the train is stationary.

This disadvantage is overcome by the following device (Fig. 14). The switch rails 7, 8 are arranged and dimensioned so that the circuit is closed through the winding 1—2 when the core is centred therein but at the same time a current is passed through the coil 37 of a cut-out 38 and the latter closes, the resistance and the self-inductance of the operating coil 37 of the cut-out 38 being negligible relatively to those of the solenoid 1—2. Under these conditions the passing of a current through the solenoid 1—2 is not influenced by the delay in the closing of the cut-out this being indispensable.

On the contrary, at the end of the outward course of the core the cut-out 38 will open only after the slider 39 has left the switch rails 7—8 and under these conditions the slider 39 will not have to break any current since it will be short-circuited by the cut-out 38 when it leaves the rails 7—8.

The peak current during the outward course at low speeds (less than 10 meters/sec.) could appreciably exceed the allowable instantaneous overload for the generators. Non-inductive resistances 42 (Figs. 15, 16) are therefore provided in series with the braking solenoids 43, these resistances being determined in accordance with the characteristics of the solenoids.

Normally the braking will be assisted by passing up a slope 44 (Fig. 16) in the direction of arrow F, it being assumed that every station such as 45 (Figs. 15, 16) is at a higher level than the track, and in the same way starting up will take place on descending the slope 44 in the direction of arrow $F_1$ in order that the train will arrive at the first solenoids with a speed of at least 5 meters/sec. However, this arrangement is not essential to the operation of the device but appreciably facilitates its operation.

The locomotor is one of the two essential parts of the device since it is this part which ensures the driving of the train assembly when it receives the magneto-motive action of the solenoid and at the same time it has to make the driving contacts.

Every locomotor comprises a magnetic ring 10 (Figs. 6 and 8) consisting of two radially arranged iron plates (parallel to the lines of force). This ring which is preferably of a general cylindrical shape, can have flat portions, such as 11 (Fig. 8), for the passage of the points, and recesses, such as 12 (Figs. 7, 8), for housing the switch rails.

The external diameter of this ring is directly proportional to the internal diameter of the solenoid (Figs. 2 to 4) in order to maintain the air gap provided for. The length of the ring is the least equal to that of the solenoid measured between the outer plates of the cheeks 3.

The ring 10 is mounted on a suitable frame of a light non-magnetic metal extended by streamlined portions 13, 14, likewise of light non-magnetic metal and of suitable shape. Spring hooks 15 and bearings rings 16 allow the various elements to be connected up to form a train.

The locomotor comprises two bogies 17 and 18 mounted resiliently but with a small amount of play and guiding is completed by four rollers 19 (Figs. 6 and 9) which bear on guide rails 20 (Fig. 3).

The rollers are placed above the horizontal diameter at an angle which is determined by the profile of the line in order to balance the mean resultant of the reactions due to curves in both perpendicular planes.

The locomotor can be opened for loading for instance by raising the entire upper casing 46 which raising may be operated by means of a pulley block 47 of any desired construction, and which may be for instance a pneumatic pulley block, secured on a convenient frame 48. It would also be possible to open said locomotor in any other way, for instance, by opening trap doors (not shown in the drawings) in the streamlined portion, according to the nature and dimensions of the freight to be transported.

The locomotor carries at its upper part contact sliders each comprising a resilient parallelogram 20ᵃ (Figs. 6 and 7) which has at its end two joined straight bars 21 which are suitably insulated from the body. These bars of a metal which is a good conductor close the circuit between the switch rails. Thus a current cannot in any case pass through the locomotor.

When the train has to travel in both directions (single track or point terminus) there are two sliders 21 one at each end of the locomotor, as shown in Fig. 6, a mechanical locking gear not shown in the drawing preventing them from being raised at the same time.

In the case of a double track and loop terminus as in Figs. 16, 17, the train always travels in the same direction and a single slider is sufficient.

It follows that as the sliders are located on the streamlined portion the latter is suitably arranged to allow a very small clearance.

A suitable curvature of the ends of the switch rails 7, 8 and of the contact bar 21 of the slider allows a contact to be made without shock at the speed under consideration.

Trolleys 25 are interposed between the locomotors at the rate of $n-1$ trolleys for $n$ locomotors. The length is determined by the freight to be transported and at the same time by the spacing between the solenoids and can be variable according to whether the train runs with continuous drive or with discontinuous drive.

They are constructed of a light metal, for example of the shape shown in Fig. 19, supported if necessary by one or two bogies 22, and shaped at their ends at 24 so as to fit exactly the ends of the locomotors.

The train thus forms a cylinder scarcely undulated and without any break of continuity, ensuring the minimum of resistance to its motion and carried by the track 26.

The trolleys can have a diameter less than that of the locomotors in order to escape the switch rails.

The track assembly consisting of rails, points, etc. . . . does not differ at all from the present railway material. Its spacing is mainly equal to the radius of the magnetic cylinder but it can differ therefrom without disadvantage according to the conditions of stability. The rails are supported by the elements of the trussed girder which itself constitutes the "tube."

At the terminus the track can either describe a loop (Figs. 15 and 16) of radius proportional to the length of the trains (loop terminus) or the two tracks can be joined to form a single track (point terminus) according to the extent of the traffic provided for.

It follows that the trains cannot be manoeuvred at a station under the action of the solenoids. This manoeuvring can be effected by means of suitable auxiliary motors which will be of any convenient type and conveniently arranged at the end stations.

In the case of multiple lines comprising main tracks and additional or secondary tracks, a security device will be preferably arranged, said device comprising a convenient block system protecting every junction, for instance by means of additional contacts controlling by the aid of relays solenoids which act upon rolling trains by blocking same or otherwise.

The several manoeuvres will be controlled for instance from a central station, for instance by means of emissions of modulated current or having a special frequency, or by means of interrupted current according to a determined rythm, said rythm being for instance determined by indications given for instance by a perforated film which unrolls at a speed corresponding to the speed of trains.

Any other device may, of course, be used for the same purpose.

The invention is applicable to the rapid transport of any suitable matter or substance and more particularly mails, and the transport can be effected either on the surface or underground. The track can be constructed in any suitable manner.

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