The superconductor loops 55 which are carried by the pontoons 50 extending from the sides of the train are formed of a suitable Type II superconductor material, such as niobium-titanium wire, which is cooled close to absolute zero (4° K.) so as to virtually eliminate its electric resistivity. At such low temperature a very large flow of current, for example 300,000 amperes can be circulated through each of the closed or "shorted" superconductor coils 55 for periods up to a year or more, with virtually no I^2R power loss. These large currents generate the powerful magnetic field required for the suspension of the 30-ton vehicle.

An illustrative construction of superconducting loops 55 is shown in the cross-sectional view of FIG. 1A. In order to maintain the conductive material at the extremely low temperature required for superconductivity phenomena, it is necessary that the conductor be cooled continuously and be well insulated against heat loss. In the construction of FIG. 1A the superconducting cable conductor 55*a* may be about 2" in diameter with a hollow core portion through which a central pipe 57*a* circulates a suitable low-temperature cooling agent, such as liquid helium at a temperature of 4° K.

In order to prevent heat leakage to the conductor from the ambient environment (300° K.), a multi-layer wrap of superinsulation 59 is provided around the cable 55*a*. A suitable superinsulation, having a heat conductivity of only 10^{-5} B.t.u./hr.=ft.^{2}=°F./ft., comprises alternating layers of Fiberglas paper and aluminum foil with approximately 35 layers to the inch. Of course alternative superinsulators may also be adapted to this application.

Low heat conductivity is achieved by first reducing the gas pressure in the multi-layer insulation 59 to less than 1 micron, by freezing out all gases except helium, and by then excluding helium from multi-layer insulation 59, by means of vacuum-tight inner and outer sealing jackets 56 and 58, respectively. Suitable radial supports, of relatively small area and formed of structural material having poor thermal conductivity, e.g., high-density plastic, are employed to center cable 55*a* within multi-layer insulation 59. Superconductor cable structure 55 is completed by an outer metallic shielding jacket 51, abount 4" in diameter. Jacket 51 reduces eddy current losses and serves the important fail-safe function of temporarily maintaining current flow in the cable 55*a*, by inductor action, if insulation 59 fails and allows the cable temperature to rise above near absolute zero, the critical range of superconductivity.

Calculations indicate that, for a 100-foot train, the total heat leak from the ambient environment into all the superconducting train magnets 55 could be held down to about 10 watts with the aforementioned cable construction. The necessary refrigeration for removing this leakage heat energy and maintaining the superconductor cable 55*a* at the requisite low temperature could be suitably accomplished by means of a small pump and ten-kilowatt refrigerator unit 53 carried on the train (FIG. 1) and circulating the liquid helium through a pipe supply system 57. Alternatively, the circulating liquid helium supply for the train loops 55 could be replenished periodically at train station stops, since it is estimated that, with the excellent superinsulation provided, only a few liters of helium liquid per hour would be consumed. The heated helium gas residue could then be reliquefied in a suitable external refrigerator for reuse at a later time.

Track loops 60 could also be constructed as shown in FIG. 1A, if it is desired to reduce the transitional speeds to a few miles per hour.

FIGS. 2–4 are a series of schematic views illustrating an arrangement for a track loop array interacting with the superconducting train loops for providing vertical lift of the train by electromagnetic action according to the teachings of the present invention. A typical body section of one car of the train 30 is schematically represented at 35 having respective left and right pontoon elements 50L and 50R, each carrying an associated pair of superconducting loops 55.

Circulating D.C. currents, on the order of 300,000-ampere magnitudes, are originally set up in each of the train superconductor loops 55 by the use of an external power supply, which may thereafter be disconnected. There are several well-known techniques for establishing the superconductor current flow, such as the use of an auxiliary transformer and switching circuit in the induction pumping method described in an article by H. Van Beelen et al., "Flux Pumps and Superconducting Solenoids," appearing in Physica, vol. 31, page 413 et seq. (1965).

In order to maximize the inductive coupling effect between the train loops and the track lift loops it is preferable to have the circulating current flow in alternate directions in adjacent pairs of train loops on each side of the train. Thus, as shown in the top view of FIG. 4, and assuming that the train travels in the direction shown by arrow *a*, the leading loops of a pair of train loops 55 on each side of the train section 35 have their respective currents flowing in a counterclockwise direction. With this arrangement, as a section of the train body passes by a stationary-point on the side of the roadbed, a magnetic flux field of great magnitude, produced by the 300,000-plus ampere circulating current, is first established on each side of the track by the passage of the leading train loop. Thereafter, at a rate dependent upon the speed of the train, a rapid polarity reversal results, so as to produce at the reference location a flux field of equal magnitude but opposite phase direction, due to the passage of the succeeding train loop in which current circulates in the opposite direction. This rapid change of magnetic flux sequentially induces corresponding currents in a spaced series of shorted track loops 61 which are vertically arranged and longitudinally aligned on respective sides of the roadbed supported by the track structure 70.

These lift track loops 61, as well as the later described arrays of track loops for providing horizontal stability and damping, are preferably formed of a suitable non-magnetic metal conductor, such as a one-inch diameter aluminum conductor constructed of multiple insulated turns of wire to reduce eddy current effects. The longitudinal length of the individual track loops 61 is short relative to the corresponding dimension of the train loop and the track loops are spaced closely together so as to maximize the inductive interaction on which the train suspension depends.

The peak amplitude of the current induced in the lift track loops 61 may be on the order of 5,000 amperes per loop for the train loop currents assumed. This induced current in the track loops 61 generates an associated magnetic field which interacts with the primary field of the train loops to provide vertical lift of the vehicle. This electromagnetic coupling between the train and track loops produces a suspension which is vertically stable about an equilibrium position *e* located slightly beneath the horizontal centerline *h* of the vertically-arranged track loops 61 (see FIG. 3). If the train should move down from the equilibrium position towards the track bed 25, the magnetic coupling between the track and train loops becomes tighter, thereby increasing track current. Both of these effects combine to produce a monotically increasing lift force as the height of the train body 35 above the roadbed 25 decreases. The magnitude of the magnetic lift force depends on three principal factors: train loop current, the induced current in the track loops, and the distance separating them. Calculations indicate that, with the assumed train and track characteristics previously stated, magnetic restoring forces are generated which are of such strength that a three-inch displacement below the centerline *h* will generate a magnetic restoring force approximately equal to the total weight of the train.