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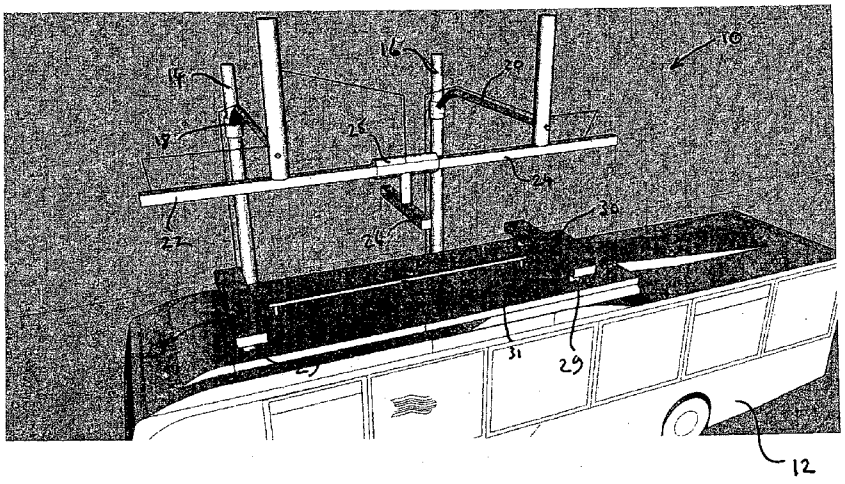
FIG 1



(57) Abstract: An overhead charging arrangement (10) for a vehicle comprises first, second and third elongate charging conductors (22, 24, 26) for making contact with respective first, second and third receiving conductors (28, 30, 32) on the vehicle, the first and second charging conductors (22, 24) being arranged in-line one behind the other, and insulated from one another, and the third charging conductor (26) being disposed between the first and second charging conductors (22, 24), the third charging conductor (26) being transverse to the first and second charging conductors (22, 24).

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OVERHEAD CHARGING ARRANGEMENT FOR A VEHICLE

The present invention relates to an overhead charging arrangement for a vehicle, and particularly but not exclusively to an overhead charging arrangement for charging an energy storage device of a passenger vehicle such as a bus, trolley-bus or tram.

BACKGROUND TO THE INVENTION

At present, vehicles, such as electric vehicles, have energy storage devices, for example, batteries or super-capacitors, which are recharged periodically by way of charging stations which the vehicle travels to so that it can be connected to a power source such as the mains electricity supply. Some vehicles may operate using an electro-mechanical device such as an energy storage flywheel and again, the vehicle travels to a charging station and is attached to the charging station so that the energy storage device is re-charged from an electrical supply.

Vehicles that use energy storage devices include, for example, trolley-buses or trams, which have a spring loaded electrical connection mechanism called a pantograph on the roof of the vehicle. The pantograph can be lifted up and extended so that the pantograph comes into contact with and is held in contact with an electrical power supply. Once the energy storage device is charged, the pantograph is lowered, contact with the electrical supply line is broken and then the driver can move off.

A known device is described in US 3955657, which discloses a single pantograph on the roof of a vehicle for making a first connection and a metal plate in a road for making a second connection. The fact that the metal plate is positioned in a road means that the plate may be contaminated by dirt or oil, which may reduce the effectiveness of charging because of poor electrical contact. Furthermore, the fact that the plate is embedded in the road means that there are difficulties in operation if the road needs to be resurfaced because the plate will need to be removed, which means that the charging station would not be operational for a period of time.

US 5651434 discloses a charging station which has parallel arms which are carried by a rotatable part of a pylon so that the charging connectors can be swung over into

position relative to a vehicle to facilitate charging when the vehicle is in place. The system is positioned in a first, non-operative mode with the arms to the side of the road, and moved to an operative mode, such that the arms overhang the road. The arms are then separated in a longitudinal direction, with reference to the longitudinal direction of the vehicle, in a V formation. Once the arms are separated, power conductors are drawn between each arm. Finally a pantograph having contact plates is raised to contact with the conductors, to receive a charge. This system requires very accurate positioning of the vehicle to ensure connection is made between the contact plates of the pantograph and the conductors. The position of the vehicle relative to the conductors is greatly determined by the distance between each respective arm and the length of conductor extending therebetween.

US 4158802 discloses a system which has a pair of spring loaded electrodes that are lowered from an overhead supply and connect with connectors on a vehicle. The electrodes are arranged in parallel and are positioned transverse to the longitudinal axis of the vehicle. The use of this system has disadvantages in that it requires accurate positioning of the vehicle, to ensure the electrodes connect with the connectors on the vehicle.

In the applicant's earlier application, namely PCT/GB2010/051978, there is disclosed an improved vehicle charging station, which seeks to mitigate these problems. The vehicle charging station is provided with a pair of conductors, arranged on supports and positioned to contact with corresponding charge receiving members. The arrangement provides an improved vehicle charging station, in that the overall area in which the conductors can contact a respective charge receiving member is greatly increased. This advantage allows for a reduction in the accuracy of the positional alignment of the vehicle, relative to the vehicle charging station, by the driver.

When charging a vehicle, it is known to provide a "pilot" connection for allowing communication between the charger and the vehicle being charged. However, providing a pilot connection increases the overall number of connections to a vehicle, making rapid automatic connection of a charger more difficult.

It is an object of the invention to provide a further improved overhead charging arrangement for a vehicle.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided an overhead charging arrangement for a vehicle comprising first, second and third elongate charging conductors for making contact with respective first, second and third receiving conductors on the vehicle, the first and second charging conductors being arranged in-line one behind the other, and insulated from one another, and the third charging conductor being disposed between the first and second charging conductors, the third charging conductor being perpendicular to the first and second charging conductors.

Advantageously, the positioning of the charging conductors provides for a large stopping target for a vehicle. Furthermore, the use of three conductors provides for an equi-potential connection from the chassis of the vehicle to the earth connection of the charging station. This facilitates correct measurement of the insulative resistance from the high voltage positive and negative to both the vehicle chassis and the charging station. This is an important safety feature.

The first and second charging conductors may be separated from one another by an insulator. The insulator may be of any suitable insulating material, that is, a non-electrically conductive material. Alternatively, the insulator may be provided in the form of an air gap.

A fourth elongate charging conductor may be provided for making contact with a fourth receiving conductor on the vehicle, the fourth charging conductor being disposed in-line with the third charging conductor.

The fourth charging conductor may provide a "pilot connection" to control the charging process. The pilot connection allows for communication between the vehicle and the charging station, in order that the charging may be adjusted to most effectively condition the battery of the vehicle. The pilot connection increases the

safety of the charging process, since it provides a path for continuity testing of the ground contact and verifying the connection of the power transfer contacts. The pilot connection can be used to control when charging starts and stops, so that charging takes place when and only when the vehicle is in a condition to safely receive charge. Charging can be controlled from the vehicle in order to prolong the life of the battery.

The third and fourth charging conductors may together be disposed along a line which is transverse to the first and second charging conductors. An insulator may be provided between the third and fourth conductors

The above-described arrangement of four charging conductors has similar benefits in terms of vehicle positioning to the alternative arrangement of three charging conductors. The fourth charging conductor allows for a pilot connection, whilst still providing a connection which is easy to effect. The vehicle may be driven under a charging gantry, and parked in an approximate location for receiving charge. Due to the arrangement of the elongate connectors, very precise parking is unnecessary. This saves time, which is especially important where the vehicle must be charged quickly to keep to a timetable (e.g. when the vehicle is a public bus).

The centre of the line formed by the third and fourth charging conductors may be positioned at a point substantially in-line with the first and second charging conductors, each of the third and fourth charging conductors extending the same distance perpendicularly from the first and second charging conductors.

The conductors may be arranged on support means such that the charging conductors can connect with and contact receiving conductors on the vehicle which is to receive a charge. It is preferred that the charging conductors can be positioned to align with the roof of the vehicle. However, should the vehicle have receiving conductors on another position on the vehicle, for example on the side of the vehicle, the charging conductors may be provided in an alternative location on the support means. For example, the support means may have movable arms which allow the conductors to be lowered or swung into a position that is in proximity to the receiving conductors on the vehicle.

It is envisaged that the support means may comprise of a single support member having a single arm for holding the first and second conductors. Alternatively, the support means may comprise a plurality of support members. In one arrangement there may be a plurality of arms connected together at a central point, each arm extending from a respective support member. In another arrangement, each support member may be provided with a respective arm, each arm holding a respective conductor. The support members may be in the form of vertical stanchions, for example, substantially circular poles. Where the support means includes more than one support member, the support members may be spaced apart at the road side.

The spacing apart of each arm may be varied to provide for a range of vehicle lengths. An adjustment mechanism may be provided for varying the spacing apart of the arms.

The conductors may be electrically isolated from the support means.

The third, and where provided, fourth charging conductors may be held on a separate support member from the first and second charging conductors, and may be suspended by a respective arm. Alternatively, the third and fourth conductors may be positioned about the connection between the first and second conductors. Such positioning may be about the insulator between the first and second charging conductors. Such an arrangement is advantageous in allowing for the position of the vehicle relative to the system to be varied, when the vehicle is positioned ready to receive a charge. Having the third conductor arranged perpendicular to the first and second conductors further increases the flexibility of positioning the vehicle as it allows for the sideways position of the vehicle to be varied. The sideways position is in relation to each side of the vehicle when it is viewed from the front, which is where the driver usually sits. Where a fourth conductor is provided, and the third and fourth conductors are transverse of the first and second conductors, maximum flexibility in terms of sideways positioning is maintained.

The third and, where provided, fourth charging conductors may usefully be positioned below the first and second conductors. Advantageously, this provides for a system whereby the third conductor, which may be an earth, and the fourth conductor, which may be a pilot connection, contact their respective receiving conductors before the

first and second charging conductors make contact. In this way, it is impossible for any electrical power to be transferred until the system is earthed and, where provided, a pilot connection is made. In this configuration it is also not possible for the first and second charging conductors to accidentally contact the receiving conductors which are associated with the third or fourth charging conductors.

The arms of the support means may have a positioning mechanism for moving the arms between a first position substantially adjacent the support members and a second position substantially spaced to one side of the support members, in a substantially horizontal plane. The arms may move in an arc, and may substantially rotate through 90 degrees from the first position to the second position and back again, as required

It is further envisaged that the conductors are provided with a positioning mechanism such that they can be raised or lowered between a non-contact position and a contact position. This provides for the lifting or lowering of the charging conductors.

The charging arrangement may further be provided with a positioning mechanism for raising or lowering each arm. Such an arrangement provides for additional positioning of the arrangement relative to the vehicle to be charged.

The overhead charging arrangement may be provided with both of the above positioning mechanisms for allowing for the raising or lowering, and the moving to the side of the conductors. This is advantageous in that the conductors can be positioned so as to not present a hazard to tall vehicles in the roadway when the system is not in use. Alternatively, if a vehicle has a low or high roofline, then the conductors may be lowered or raised accordingly.

The system may conveniently be provided with any one of the above mentioned positioning mechanisms, for allowing the raising or lowering and the moving to the side of the charging conductors, and/or the raising or lowering of the arms. In one arrangement, the arms are movable about and relative to the support members, and the charging conductors are movable in a vertical direction. This configuration provides maximum flexibility of the system for providing a charge to a vehicle.

The charging arrangement may further comprise a charge receiving arrangement including a receiving conductor corresponding with each charging conductor. The charge receiving arrangement may comprise first, second and third receiving conductors, and may further comprise a fourth receiving conductor. Each receiving conductor is arranged to contact a respective charging conductor.

The receiving conductors may be of any suitable shape for contacting a respective charging conductor, but preferably the receiving conductors are substantially elongate. Advantageously, such a configuration provides a large target area for the charging conductors and receiving conductors to align and make contact.

In a preferred arrangement, the charge receiving arrangement comprises first and second receiving conductors aligned perpendicular to the longitudinal axis of the vehicle and a third receiving conductor aligned parallel to the longitudinal axis of the vehicle. A fourth receiving conductor may be provided, and may be aligned parallel to the longitudinal axis of the vehicle and to the third receiving conductor. The third and fourth receiving conductors may be positioned at either side of the vehicle centreline. The third conductor may be a certain distance to one side of the vehicle centreline, and the fourth conductor may be the same distance to the other side of the vehicle centreline.

Where three receiving conductors are provided, they may be arranged in an insulated "H" arrangement. The transverse receiving conductors may connect with axially aligned charging conductors and the axially aligned receiving conductors may contact with the transverse supply conductors.

Where a fourth receiving conductor is provided, the receiving conductors may be arranged substantially as four sides of a rectangle. The receiving conductors perpendicular to the longitudinal axis of the vehicle may connect with axially aligned charging conductors, and the axially aligned receiving conductors may contact with the perpendicular charging conductors. This configuration utilises the length and width of a vehicle for mounting receiving conductors and maximises the chance of a successful, safe energy transfer.

It is further envisaged that the charge receiving arrangement may be provided with a positioning mechanism such that it can be raised or lowered between a non-contact position and a contact position. Alternatively, one or more of the receiving conductors may be provided with a positioning mechanism such that they can be raised or lowered independently between a non-contact position and a contact position.

The non-contact and contact positions relate to positions in which connection is made, or not, between a charging conductor and its respective receiving conductor. The non-contact position is a position where the charging conductor is positioned substantially at a distance spaced from its receiving conductor so as to not make contact and so that the vehicle does not receive a charge. The contact position is a position where the charging conductor is positioned substantially in contact with a respective receiving conductor, such that contact is made and electricity may be conducted.

According to a second aspect of the invention there is provided an overhead charging arrangement for a vehicle comprising first, second and third elongate charging conductors for making contact with respective first, second and third receiving conductors on the vehicle, the first and second charging conductors being arranged parallel to one another, and insulated from one another, and the third charging conductor being disposed perpendicular to the first and second conductors.

The first and second charging conductors are arranged parallel to one another and may be positioned parallel to the longitudinal axis of the vehicle. The longitudinal axis of the vehicle can be defined as the axis extending from the front (where the driver usually sits) to the back of the vehicle.

In other words, the second aspect of the invention defines the reverse arrangement to the first aspect, that is, the arrangement of charging conductors in the first aspect is similar to the arrangement of receiving conductors in the second aspect, and the arrangement of receiving conductors in the first aspect is similar to the arrangement of charging conductors in the second aspect.

As in the first aspect of the invention, a fourth charging conductor may be provided. Where a fourth conductor is provided, it may be parallel with the third charging conductor.

Each one of the first and second charging conductors is separated from the other by an insulator. The insulator may be of any suitable insulating material. In a preferred arrangement, the insulator is of an insulating element made of a non-conducting material. Alternatively, the conductor may be provided in the form of an air gap.

The charging conductors may be arranged on support means such that the charging conductors can connect with and contact receiving conductors on the vehicle which is to receive a charge. It is preferred that the charging conductors can be positioned to align with the roof of the vehicle. However, should the vehicle have receiving conductors on another position on the vehicle, for example on the side of the vehicle, the conductors may be provided in an alternative position on the support. For example, the support may have movable arms that allow the conductors to be lowered or swung into a position that is in proximity to the receiving conductors.

It is envisaged that a single support means may be provided with at least one arm for holding the first and second charging conductors. In a particularly useful configuration, the system is provided with support means having a single arm, the single arm supporting the first and second charging conductors. The single arm may support the charging conductors in any suitable way for allowing the charging conductors to make contact with the vehicle. Conveniently, and to maximise the contact area, the arm supports the first and second charging conductors about a central position. The central position is about the centre longitudinal axis of each charging conductor. Again this provides the advantage of allowing for a variation in the positioning of the vehicle when it is to receive a charge. The single support may conveniently include a vertical stanchion, for example a substantially circular pole at the road side.

The charging conductors are isolated from the supports. It is possible that there may be a row of supports, each holding a pair of charging conductors which could charge

multiple sets of batteries, for example if a vehicle has more than one battery that needs to be charged.

The third and, where provided, the fourth charging conductors may be held on separate support means and may be suspended by a respective arm.

Alternatively the third and fourth charging conductors may be suspended from one end of the first and second charging conductors from an insulator. This arrangement is advantageous in allowing for the position of the vehicle relative to the charging arrangement to be varied when the vehicle is positioned ready to receive a charge. Having the third and fourth charging conductors arranged perpendicular to the first and second charging conductors further increases the flexibility of positioning the vehicle as it allows for the sideways position of the vehicle to be varied. The sideways position is in relation to each side of the vehicle when it is viewed from the front, which is where the driver usually sits.

The third and fourth charging conductors may usefully be positioned below the first and second conductors. Advantageously, this provides for a system whereby the third charging conductor, which may be an earth, and the fourth charging conductor, which may be a pilot connection, may contact their respective receiving conductors first, thus ensuring no contact between the first and second charging conductors and their respective receiving conductors is made until the system is earthed and the pilot connection, if provided, is made. In this configuration, it is not possible for the first and second charging conductors to accidentally contact the receiving conductors associated with the third and fourth charging conductors.

The support means may further include any number of arms for suspending the charging conductors.

In this configuration, it is preferred that the system comprises a single support means, the single support means having a single arm for suspending the first and second charging conductors about their centre.

The arm of the support means may further have a positioning mechanism for moving the arm between a first position substantially adjacent the support means to a second position substantially spaced to one side of the support means, in a substantially horizontal plane. The arm may move in an arc, and may substantially rotate through 90 degrees from the first position to the second position and back again, as required.

It is further envisaged that the charging conductors are provided with a positioning mechanism such that they can be raised or lowered between a non-contact position and a contact position. For example, the arm or arms may move vertically up or down. This provides for the lifting or lowering of the charging conductors.

In one arrangement the overhead charging arrangement may be provided with both of the above positioning mechanisms for allowing for the raising or lowering, or the moving to the side of the charging conductors. This is advantageous in that the charging conductors can be positioned so as to not present a hazard to tall vehicles in the roadway when the system is not in use. Alternatively, if a vehicle has a low or high roofline, then the charging conductors may be lowered or raised accordingly.

The system may conveniently be provided with any one of the above mentioned positioning mechanisms. In one arrangement, the system is provided with each one of the above-mentioned positioning systems, that is, the arm being movable about and relative to the support means, and the charging conductors being movable in a vertical direction. This configuration provides maximum flexibility of the system for providing a charge to a vehicle.

The charging arrangement may further comprise a charge receiving arrangement including a plurality of receiving conductors. The charge receiving arrangement may comprise first, second, third and fourth receiving conductors. It is envisaged that each receiving conductor is arranged to contact a respective charging conductor.

In one arrangement, the receiving conductors are of any suitable shape for contacting a respective charging conductor. The receiving conductors may be substantially elongate. Advantageously, such a configuration provides a large target area for the charging conductors and receiving conductors to align and make contact.

In one arrangement, the charge receiving arrangement comprises first and second receiving conductors aligned perpendicular to the longitudinal axis of the vehicle and a third charge receiving conductor aligned parallel to the longitudinal axis of the vehicle.

Where a fourth receiving conductor is provided, it may run parallel with the third receiving conductor, the third and fourth receiving conductors being spaced from either side of a centreline of the vehicle.

Conveniently the receiving conductors are arranged in an insulated "T" arrangement. The perpendicular receiving conductors may connect with axially aligned charging conductors and the axially aligned receiving conductors may contact with the transverse charging conductors. This configuration utilises the length and width of a vehicle for mounting charge receiving members and maximises the chance of a successful, safe energy transfer.

Where a fourth receiving conductor is provided, the fourth charge receiving conductor may run parallel with the third receiving conductor, the receiving conductors being arranged in an insulated "Π" arrangement.

This configuration of the overhead charging arrangement reduces the components required by the system, decreasing the servicing requirements of the components, which may become worn through use.

It is further envisaged that the charge receiving arrangement may be provided with a positioning mechanism such that it can be raised or lowered between a non-contact position and a contact position. Alternatively, one or more of the charge receiving members may be provided with a positioning mechanism such that it can be raised or lowered independently between a non-contact position and a contact position.

According to a third aspect of the present invention there is provided an overhead charging arrangement for a vehicle comprising a plurality of charging conductors for contacting respective receiving conductors on the vehicle, the charging conductors

being movable between a non-contact position and a contact position, at least one of the charging conductors making contact with its respective receiving conductor before the other charging conductors in the movement from a non-contact position to a contact position, the rate of movement of the other conductors being slowed subsequent to the at least one conductor making contact.

It is envisaged that the overhead charging arrangement is provided with means to move the conductors between a non-contact position and a contact position, where at least one of the conductors makes contact with a charge receiving member before the other conductors make contact with the other respective charge receiving members.

It is further envisaged that the overhead charging arrangement may be provided with means to slow the subsequent conductors, once the at least one of the conductors has made contact with a charge receiving member. The at least one of the conductors may be provided with any suitable means for slowing the subsequent conductors. The at least one of the conductors may be provided with a spring held in a housing, which can be compressed once contact is made between the at least one of the conductors and its respective charge receiving member. The means to slow the subsequent conductors may further be provided with damping means, such as a dash pot. Alternatively the means to slow the subsequent conductors may be a piston and cylinder arrangement or the like. Alternatively still, the means to slow the subsequent conductors may be controlled by position sensors which control the rate of descent of the subsequent conductors using one or more electric motors.

It is envisaged that the first charging conductors to come into contact with the vehicle will be the ground conductor and, where provided, the pilot conductor. Once the ground and pilot are connected, the high voltage positive and negative contacts are lowered slowly onto the vehicle.

The invention is advantageous in that it provides a larger target area for contact between the conductors and the charge receiving members. This allows a driver to approach the overhead charging arrangement such that, when the vehicle moves into position the driver has some leeway in positioning the vehicle and there does not need to be precise alignment of conductors and charge receiving members. The structural

arrangement of longitudinally arranged receiving conductors provides for a large target area along the vehicle and potentially the entire length of the vehicle (for example a bus) if positioned at the front and rear of the vehicle. Similarly if the charge receiving members or conductor(s) extend the entire width from one side to the other side of the vehicle, the stopping target area is large in that it is the entire width of the vehicle. Combined together this arrangement provides for a very large stopping area making it easier for the vehicle operator/driver to connect properly with the charging arrangement. The three conductors also provide for an earth connection, thus making charging safe.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:

Figure 1 shows a perspective view of a charging arrangement according to the first aspect of the invention;

Figure 2 shows a side perspective view of the charging arrangement of Figure 1 with the earth or third elongate conductor making connection with the third charge receiving member on the bus;

Figure 3 shows a side perspective view of the charging arrangement of Figure 1, with all 3 elongate conductors making contact with respective charge receiving members on the bus;

Figure 4 shows a perspective view of a charging arrangement according to the second aspect of the invention; and

Figure 5 shows an alternative charging arrangement according to the first aspect of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

With reference to Figures 1 to 3, an overhead charging arrangement according to the first aspect of the invention is indicated generally at 10. A vehicle in the form of a bus 12 is shown alongside an overhead charging arrangement 10 and has receiving conductors mounted on its roof.

The overhead charging arrangement 10 comprises two upright support members or stanchions 14, 16 which may be mounted at the side of a road. Support arms 18, 20 are mounted to and cantilevered out from the respective support members 14, 16. The support members 14 and 16, in cooperation with the support arms 18 and 20, provide for the overhead charging arrangement 10 to be positioned directly over the bus 12, when a charge is to be received.

First and second charging conductors 22 and 24 carrying positive and negative supplies from insulated supply cables are mounted on the support arms 18, 20. The charging conductors 22, 24 are straight conductive members which are connected together by a connector 25, which is an insulator and separates the ends of the charging conductors. The charging conductors 22, 24 are connected with their central axes in-line one behind the other.

A third charging conductor 26 is mounted to the underside of the connector 25 and is also a straight elongate conductor. The third charging conductor is an electrical earth and is connected to ground by an insulated cable. The alignment of the central axis of the third charging conductor is transverse or at 90 degrees to the central longitudinal axes of the first and second charging conductors 22, 24. The third charging conductor 26 is also mounted to the connector on a compressible strut, which acts as a spring mass damper, explained further below.

The arms 18, 20 are movable on the support members 14, 16 both vertically along the support members and/or horizontally, by rotation of the arms. In Figures 1 to 3 the arms are shown in front of the support members 14,16, in a position for charging, but they may be rotated about the support member and moved to one side of the support

members. The arms may rotate through nearly 90 degrees from the central position as shown in the Figures, to either side of the support members, when not in use.

A charge receiving arrangement is disposed on a vehicle, a bus 12 as shown, and includes first and second receiving conductors 28 and 30. The first and second receiving conductors 28, 30 are aligned transverse to the longitudinal axis of the vehicle 12, and are mounted to the roof of the vehicle 12. Insulators 29 insulate the first and second receiving conductors 28, 30 from the roof of the vehicle 12.

A third receiving conductor 32 is also disposed on and mounted to the roof of the vehicle 12. The third receiving conductor 32 is aligned parallel to the longitudinal axis of the vehicle 12. Mounting blocks 31, which are conductors, connect the third receiving conductor 32 to the roof of the vehicle 12. The third receiving conductor 32 has an overall height less than the height of the first and second receiving conductors 28, 30. As such, the third receiving conductor 32, when mounted to the roof of the vehicle 12, is positioned lower than the first and second receiving conductors 28, 30 to ensure that the first and second charging conductors 22, 24 do not accidentally contact the third receiving conductors 32.

As shown in Figure 1, first and second receiving conductors 28, 30 extend across the width of the roof of the vehicle 12 and are spaced apart along the length of the vehicle 12. The third receiving conductor 32 is positioned centrally on the vehicle and aligned axially between the first and second receiving conductors 28, 30. A gap is provided between the first, second and third receiving conductors 28, 30, 32, to insulate each receiving conductor from the others. In an alternative configuration, the receiving conductors 28, 30, 32 may be connected to each other by an insulator. The insulator may be of any insulating material, that is, a non-electrically conductive material.

With reference to Figure 1, the overhead charging arrangement 10 is shown in a non-contact position, above the vehicle 12 which is to receive a charge. In operation, the overhead charging arrangement 10 is lowered into a first position above the roof of the vehicle which is to receive a charge. The overhead charging arrangement 10 is lowered by lowering support arms 18, 20 on support members 14, 16.

Next, the charging conductors 22, 24, 26 are lowered into position above the roof of the vehicle 12, until the third charging conductor 26 contacts the third receiving conductor 32, as shown in Figure 2, to arrive at a first contact position. The third charging conductor 26 provides an equi-potential connection from the earth connection (the third receiving conductor 32) of the vehicle 12 to the earth connection of the overhead charging station 10, to earth the vehicle 12 before the first and second charging conductors 22, 24 contact the first and second receiving conductors 28, 30. Once the third charging conductor 26 has contacted the third receiving conductor 32, the overhead charging arrangement 10, is further lowered by either lowering support arms 18, 20 on support members 14, 16, or by lowering the first and second charging conductors 22, 24. The contact of the third charging conductor 26 slows the descent of the first and second charging conductors 22, 24, by means of the spring/mass damper arranged in the mounting. The slowing of the first and second charging conductors 22, 24 may also be controlled by position sensors which control the rate of descent of the subsequent charging conductors using one or more electric motors.

Alternatively, the receiving conductors 28, 30, 32 may be provided on means for raising and lowering the charge receiving arrangement such that each receiving conductor 28, 30, 32 contacts with a respective charging conductor.

Figure 3 shows the overhead charging arrangement 10 in a second contact position once the first, second and third charging conductors 22, 24, 26 have contacted first, second and third receiving conductors 28, 30, 32. The third charging conductor 26 is retracted into a compressed position and is spring loaded against the contact of the third receiving conductor 32.

With reference to Figure 4, an overhead charging arrangement according to the second aspect of the invention is indicated generally at 110. A vehicle in the form of a bus 112 is shown alongside an overhead charging arrangement 110 and has receiving conductors mounted on its roof.

The overhead charging arrangement 110 comprises an upright support member 40 which may be mounted at the side of a road. A cantilevered support arm 42 is mounted to the support 40. The support member 40, in cooperation with the support

arm 42, provides for the overhead charging arrangement 110 to be positioned directly over the bus 112, when a charge is to be received. The free end of the support arm 42 is connected to a central member 44, which carries a support beam 46 mounted to its lower end. Support beam 46 is substantially perpendicular to the first and second charging conductors 122, 124 and spaces apart the charging conductors. Support beam 46, mounted on central member 44, is positioned substantially centrally about the length of the first and second charging conductors 122, 124. The first and second charging conductors 122, 124, carrying positive and negative supplies from insulated supply cables, are mounted on support beam 46, which is an insulator, with their central axes parallel to one another and are positioned parallel to the longitudinal axis of the vehicle 112.

A rear support arm 48 further connects together the first and second charging conductors 122, 124. The rear support arm 48 is an insulator and is positioned substantially at the rear, that is the distal end of the connectors from the front of the vehicle, of the charging conductors 122, 124. The rear support arm 48 is substantially transverse to the charging conductors 122, 124, or perpendicular to the longitudinal axis of the vehicle 112. A connector 50 is mounted aligned with the longitudinal axis of the vehicle 112, and is positioned about the centre of rear support arm 48. Connector 50 is elongate and extends from the rear of the first and second conductors 122, 124, towards the rear of the vehicle 112. A lower central member 52 is connected to and extends downwardly from connector 50. Lower central member 52 is positioned along the longitudinal axis of the connector 50, and may be mounted in any position along the longitudinal axis of the connector 50, thus accounting for any variation in the spatial positioning of the third conductor 126, relative to the first and second receiving conductors 128, 130. This ensures no contact is made between the third charging conductor 126 and the first and second receiving conductors 128, 130.

A straight elongate third charging conductor 126 is mounted to the lower central member 52, which may comprise a compressible strut which acts as a spring mass damper. The spring/mass damper or position sensor in cooperation with an electric motor provides for the slowing of the third charging conductor 126, when the charging conductor 126 is lowered and brought into contact with the third receiving conductor 132. The spring/mass damper, or position sensor and motor arrangement, in

cooperation with the slowing of the third charging conductor 126, provides for the slowing of the first and second charging conductors 122, 124, when the system is lowered into position. The third charging conductor 126 is mounted transverse to the connector 50, or to the first and second charging conductors 122, 124. The third charging conductor is an electrical earth and is connected to ground by an insulated cable.

The support arm 42 is movable on the support member 40 both vertically along the support members and/or horizontally, by rotation of the arm.

A charge receiving arrangement is disposed on a vehicle, a bus 112 as shown, and includes first and second receiving conductors 128 and 130. The first and second receiving conductors 128, 130 are aligned transverse to the longitudinal axis of the vehicle 112, and are mounted to the roof of the vehicle 12. Insulators 129 insulate the first and second receiving conductors 128, 130 from the roof of the vehicle 112.

A third receiving conductor 132 is also disposed on and mounted to the roof of the vehicle 112. The third receiving conductor 132 is aligned parallel to the longitudinal axis of the vehicle 112. Mounting blocks 131, which are conductors, connect the third receiving conductor 132 to the roof of the vehicle 112. The third receiving conductor 132 has an overall height less than the height of the first and second receiving conductors 128, 130. As such, the third receiving conductor 132, when mounted to the roof of the vehicle 112, is positioned lower than the first and second receiving conductors 128, 130 to ensure that the first and second charging conductors 122, 124 do not accidentally contact the third receiving conductor 132.

As shown in the Figure, first and second receiving conductors 128, 130 extend across the width of the roof of the vehicle 112 and are spaced apart about the central longitudinal axis of the vehicle 112. The third receiving conductor 132 is aligned centrally and parallel to the longitudinal axis of the vehicle 112. A gap or insulator separates the first, second and third receiving conductors 128, 130, 132, to insulate each receiving conductor from the other.

In an alternative configuration, the receiving conductors 128, 130, 132 may be connected to each other by an insulator. The insulator may be of any insulating material, that is, a non-electrically conductive material. The insulator may be provided in the form of an air gap.

The receiving conductors 128, 130, 132 may be provided on means for raising and lowering the charge receiving arrangement such that each receiving conductor 128, 130, 132 contacts with a respective charging conductor.

It will be appreciated that the spatial arrangements of charging conductors and receiving conductors can be interchanged in both of the above described charging arrangements. For example, in the first arrangement, the first and second receiving conductors may lie axially in-line, one behind the other on the vehicle and the third receiving conductor may lie transverse to the first and second receiving conductors. The charging conductors are similarly interchanged, that is with the first and second charging conductors parallel and spaced apart (transverse to the vehicle axis during charging) and the third charging conductor between the first and second charging conductors (aligned with the vehicle axis during charging).

Referring now to Figure 5, an alternative embodiment of a charging arrangement according to the first aspect of the invention is shown generally at 210. Similar to charging arrangement 10, charging arrangement 210 includes first and second in-line elongate charging conductors 222, 224, and an insulating connector 225 disposed between the first and second charging conductors 222, 224.

In this embodiment, a third charging conductor 226 and a fourth charging conductor 227 depend from the insulating connector 225. The third and fourth charging conductors 226, 227 are substantially elongate and run perpendicular to the first and second charging conductors 222, 224. The third charging conductor 226 extends away from the first and second charging conductors 222, 224 to one side and the fourth charging conductor 227 extends away from the first and second charging conductors 222, 224 to the other side. Together, the third and fourth charging conductors 226, 227 run transverse of the first and second charging conductors 222, 224.

The third and fourth charging conductors 226, 227 may be used to provide respectively a ground connection and a pilot connection.

Also shown in Figure 5, a bus 212 includes receiving conductors on its roof. The arrangement of receiving conductors is similar to the arrangement of receiving conductors on bus 12, including first and second receiving conductors 228, 230 at either end of the bus, each of the first and second receiving conductors 228, 230 running substantially perpendicular to the longitudinal axis of the bus.

Third and fourth receiving conductors 232, 233 run parallel with the longitudinal axis of the bus 212, to either side of the centreline of the bus. The overall height of the third and fourth receiving conductors 232, 233 is less than the height of the first and second receiving conductors 228, 230.

In use, the first, second, third and fourth charging conductors 222, 224, 226, 227 are brought downwards to contact respectively the first, second, third and fourth receiving conductors 228, 230 232, 233. The third and fourth conductors will contact first, and a damper arrangement within the insulating connector 225 then slows the rate of descent of the second and third charging conductors. With the vehicle positioned correctly, it is impossible for the first and second charging conductors 222, 224 to unintentionally contact the third and fourth receiving conductors 232, 233 due to the difference in heights between the first and second and the third and fourth receiving conductors.

All of the above described arrangements provide large vehicle target areas for successful connection and low impact connection of the charging conductors due to the reduced impact speed achieved by the earth connecting first, with damping. Electrical supply to the charging conductors is provided conventionally by insulated cables and the earth and pilot connections provide added safety. The charging conductors are insulated from one another by air or insulating material and similarly the receiving conductors are insulated from one another by air or insulating material.

CLAIMS

1. An overhead charging arrangement for a vehicle comprising first, second and third elongate charging conductors for making contact with respective first, second and third receiving conductors on the vehicle, the first and second charging conductors being arranged in-line one behind the other, and insulated from one another, and the third charging conductor being disposed between the first and second charging conductors, the third charging conductor being perpendicular to the first and second charging conductors.

2. An overhead charging arrangement as claimed in claim 1, in which a fourth elongate charging conductor is provided for making contact with a fourth receiving conductor on the vehicle, the fourth charging conductor being disposed in-line with the third charging conductor.

3. An overhead charging arrangement as claimed in claim 2, in which the fourth charging conductor provides a pilot connection to control the charging process.

4. An overhead charging arrangement as claimed in claim 2 or claim 3, in which the third and fourth charging conductors are together disposed along a line which is transverse of the first and second charging conductors.

5. An overhead charging arrangement as claimed in claim 4, in which the centre of the line formed by the third and fourth charging conductors is positioned at a point substantially in-line with the first and second charging conductors, each of the third and fourth charging conductors extending the same distance perpendicularly from the first and second charging conductors.

6. An overhead charging arrangement for a vehicle as claimed in any of the preceding claims, in which the overhead charging arrangement further comprises support means for supporting the first and second charging

conductors, for positioning the charging conductors relative to the vehicle which is to receive a charge.

7. An overhead charging arrangement for a vehicle as claimed in claim 6, in which each one of the charging conductors is held on separate support means.

8. An overhead charging arrangement for a vehicle as claimed in claim 7, in which there is provided an insulated connector between the first and second charging conductors, a support depending from the insulated connector and the third conductor being mounted to the support.

9. An overhead charging arrangement for a vehicle as claimed in claim 8, when dependent on any of claims 2 to 5, in which the fourth conductor is mounted to the support.

10. An overhead charging arrangement for a vehicle as claimed in any one of claims 6 to 9, in which the support means includes a first arm and a second arm, the first and second charging conductors being suspended from the first and second arms, the first arm supporting the first charging conductor and the second arm supporting the second charging conductor.

11. An overhead charging arrangement for a vehicle as claimed in claim 10, in which the first and second arms are movable.

12. An overhead charging arrangement for a vehicle as claimed in claim 11, in which the first and second arms are movable in tandem in a substantially horizontal plane, for moving the charging conductors between a first position substantially adjacent the support means and a second position substantially spaced to one side of the support means.

13. An overhead charging arrangement for a vehicle as claimed in any one of the preceding claims, in which the charging conductors can be raised or lowered between a non-contact position and a contact position.

14. An overhead charging arrangement for a vehicle as claimed in any one of the preceding claims, in which the overhead charging arrangement further comprises a charge receiving arrangement, the charge receiving arrangement comprising first, second and third receiving conductors.

15. An overhead charging arrangement for a vehicle as claimed in claim 14, when dependent on any of claims 2 to 5, in which the charge receiving arrangement further comprises a fourth receiving conductor.

16. An overhead charging arrangement for a vehicle as claimed in claim 14 or claim 15, in which the first, second and third receiving conductors are elongate.

17. An overhead charging arrangement for a vehicle as claimed in claim 16, when dependent on claim 15, in which the fourth receiving conductor is elongate.

18. An overhead charging arrangement for a vehicle as claimed in claim 16, in which the first and second receiving conductors are transverse to the third receiving conductor.

19. An overhead charging arrangement for a vehicle as claimed in claim 17, in which the third and fourth receiving conductors are transverse to the first and second receiving conductors.

20. An overhead charging arrangement for a vehicle as claimed in claim 16 or claim 18, in which the first and second receiving conductors are spaced apart from the third receiving conductor.

21. An overhead charging arrangement for a vehicle as claimed in claim 20, when dependent on claim 15, in which the fourth charging conductor is spaced from the first and second receiving conductors.

22. An overhead charging arrangement for a vehicle as claimed in any one of claims 14 to 21, in which the charging conductors each contact a respective receiving conductor.

23. An overhead charging arrangement for a vehicle as claimed in claim 22, in which the first and second charging conductors contact the first and second receiving conductors, and the third charging conductor contacts the third receiving conductor.

24. An overhead charging arrangement as claimed in claim 23, when dependent on any of claims 2 to 5, in which the fourth charging conductor contacts the fourth receiving conductor.

25. The overhead charging arrangement for a vehicle as claimed in any one of claims 14 to 24, in which the charge receiving arrangement is on a vehicle.

26. An overhead charging arrangement for a vehicle as claimed in any of claims 14 to 25, in which the charge receiving arrangement can be raised or lowered between a non-contact position and a contact position.

27. An overhead charging arrangement for a vehicle as claimed in any of claims 14 to 26, in which one or more of the receiving conductors can be raised or lowered independently between a non-contact position and a contact position.

28. An overhead charging arrangement for a vehicle comprising first, second and third elongate charging conductors for making contact with respective first, second and third receiving conductors on the vehicle, the first and second charging conductors being arranged parallel to one another, and insulated from

one another, and the third charging conductor being disposed transverse to the first and second conductors.

29. An overhead charging arrangement for a vehicle as claimed in claim 28, in which a fourth charging conductor is provided.

30. An overhead charging arrangement for a vehicle as claimed in claim 29, in which the fourth charging conductor is parallel with the third charging conductor.

31. An overhead charging arrangement for a vehicle as claimed in any of claims 28 to 30, in which the overhead charging arrangement further comprises support means for supporting the first and second charging conductors, for positioning the charging conductors relative to the vehicle which is to receive a charge.

32. An overhead charging arrangement for a vehicle as claimed in claim 31, in which the support means includes at least one arm, the charging conductors being suspended from and supported by the at least one arm.

33. An overhead charging arrangement for a vehicle as claimed in claim 32, in which the at least one arm is movable.

34. An overhead charging arrangement for a vehicle as claimed in claim 33, in which the arm is movable in a substantially horizontal plane, for moving the charging conductors between a first position substantially adjacent the support means and a second position substantially spaced to one side of the support means.

35. An overhead charging arrangement for a vehicle as claimed in any of claims 28 to 34, in which the conductors can be raised or lowered between a non-contact position and a contact position.

36. An overhead charging arrangement for a vehicle as claimed in any of claims 28 to 34, the overhead charging arrangement further comprising a charge receiving arrangement, the charge receiving arrangement comprising first, second and third receiving conductors.

37. An overhead charging arrangement for a vehicle as claimed in claim 36, when dependent on claim 29 or claim 30, in which the charge receiving arrangement further comprises a fourth receiving conductor.

38. An overhead charging arrangement for a vehicle as claimed in claim 36 or claim 37, in which the first, second and third receiving conductors are elongate.

39. An overhead charging arrangement for a vehicle as claimed in claim 38, when dependent on claim 37, in which the fourth receiving conductor is elongate.

40. An overhead charging arrangement for a vehicle as claimed in claim 38 or claim 39, in which the first and second receiving conductors are perpendicular to the third receiving conductor.

41. An overhead charging arrangement for a vehicle as claimed in claim 40, when dependent on claim 39, in which the first and second receiving conductors are perpendicular to the fourth receiving conductor.

42. An overhead charging arrangement for a vehicle as claimed in any of claims 38 to 41, in which the first and second receiving conductors are spaced apart from the third receiving conductor.

43. An overhead charging arrangement for a vehicle as claimed in claim 42, when dependent on claim 39 or 41, in which the first and second receiving conductors are spaced apart from the fourth receiving conductor.

44. An overhead charging arrangement for a vehicle as claimed in any one of claims 36 to 43, in which the charging conductors contact respective receiving conductors.

45. An overhead charging arrangement for a vehicle as claimed in claim 44, in which the first and second charging conductors contact the first and second receiving conductors, and the third charging conductor contacts the third receiving conductor.

46. An overhead charging arrangement for a vehicle as claimed in claim 45, when dependent on any of claims 37, 39, 41 or 43, in which the fourth charging conductor contacts the fourth receiving conductor.

47. An overhead charging arrangement for a vehicle as claimed in any one of claims 36 to 41, in which the charge receiving arrangement is on a vehicle.

48. An overhead charging arrangement for a vehicle as claimed in any of the preceding claims, in which the charge receiving arrangement can be raised or lowered between a non-contact position and a contact position.

49. An overhead charging arrangement for a vehicle as claimed in any of the preceding claims, in which one or more of the receiving conductors can be raised or lowered independently between a non-contact position and a contact position.

50. An overhead charging arrangement for a vehicle comprising a plurality of charging conductors for contacting receiving conductors on the vehicle, the charging conductors being movable between a non-contact position and a contact position, at least one of the charging conductors making contact with a respective receiving conductor before the other charging conductors in the movement from a non-contact position to a contact position, the rate of

movement of the other charging conductors being slowed subsequent to the at least one charging conductor making contact.

51. An overhead charging arrangement for a vehicle according to claim 45, wherein the movement of the at least one charging conductor between a non-contact position and a contact position and contact between the at least one charging conductor and its respect receiving conductor is independent of the movement of the other charging conductors between a non-contact position and a contact position.

52. An overhead charging arrangement for a vehicle as substantially described herein with reference to and as illustrated in Figures 1 to 3, 4 and 5 of the accompanying drawings.

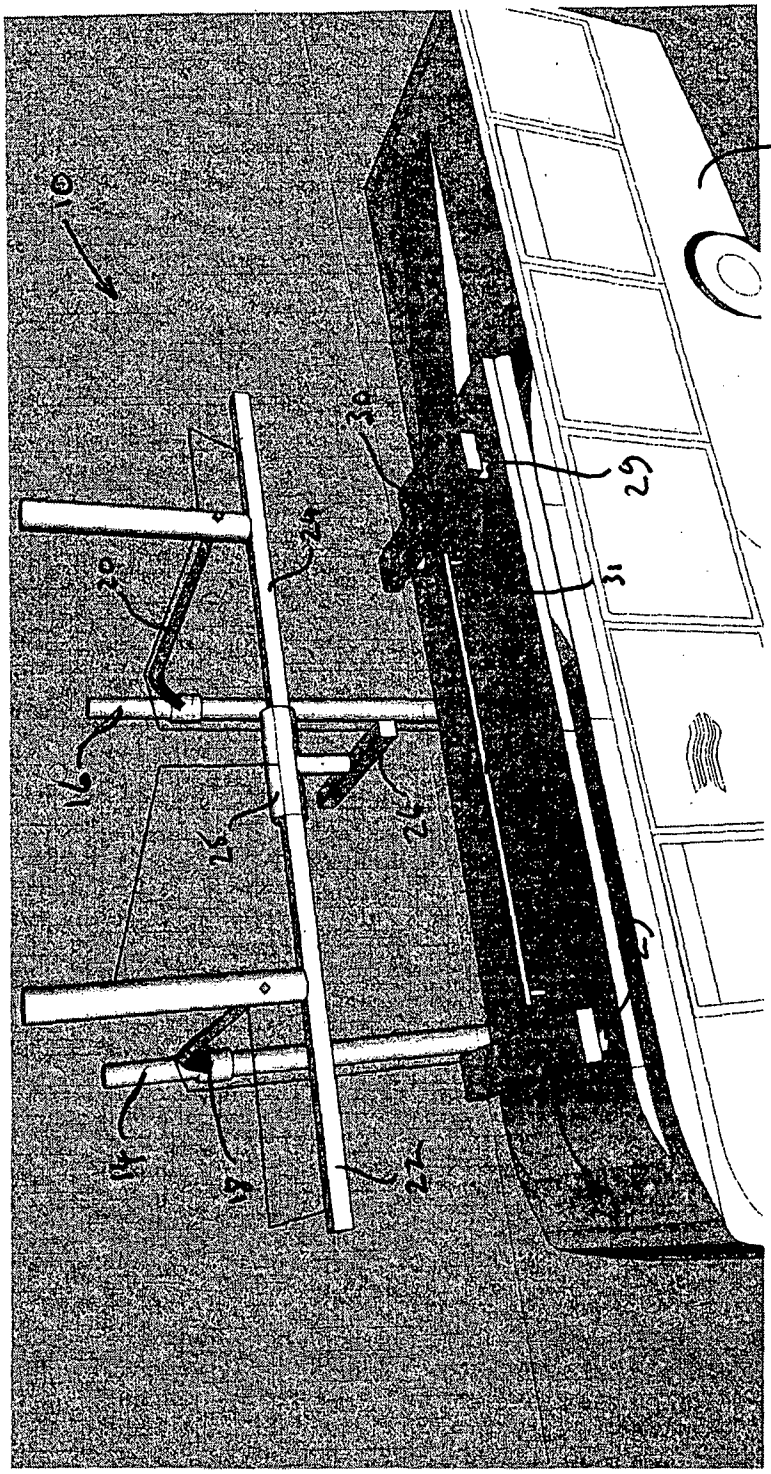

FIG 1

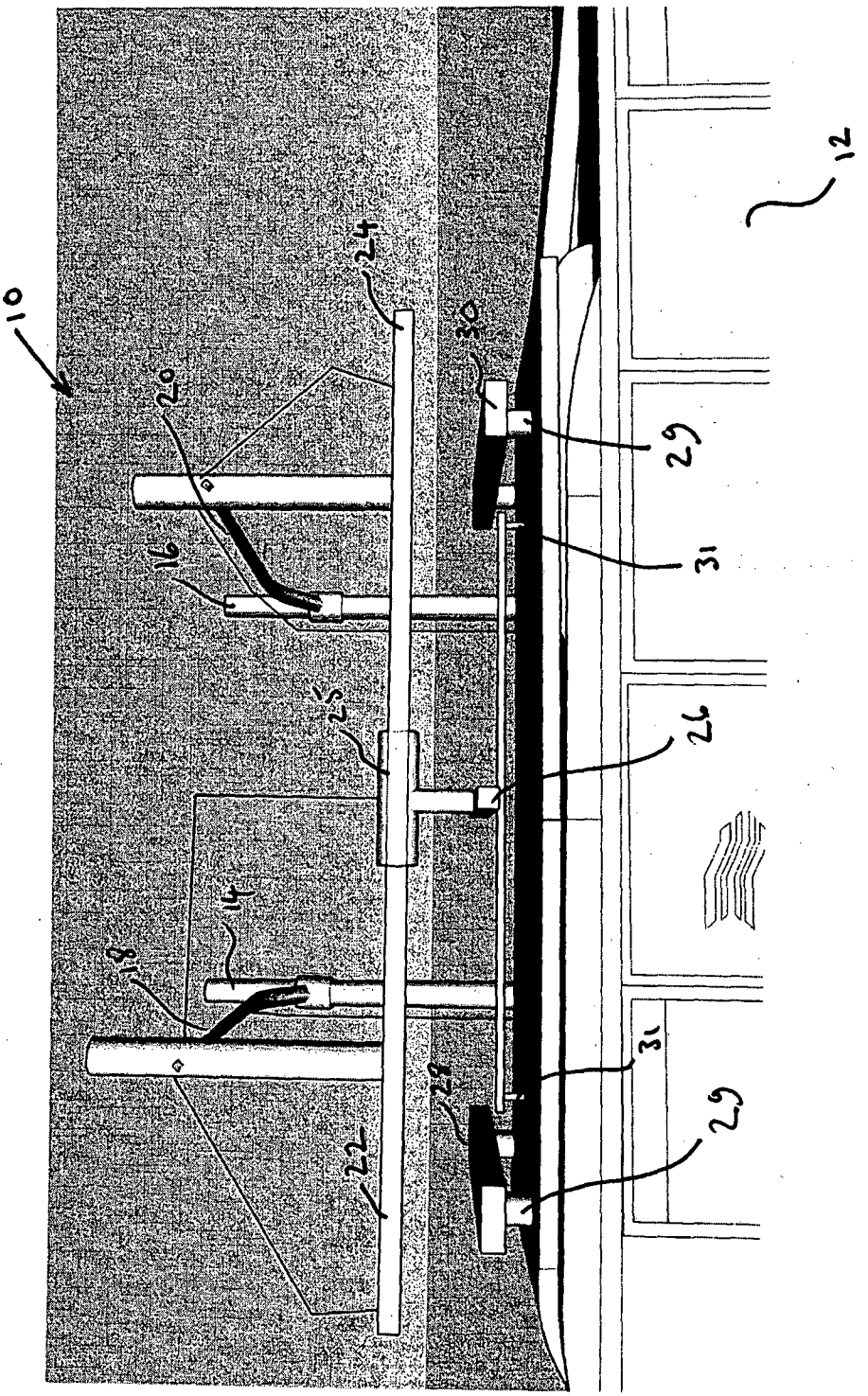

FIG 2.

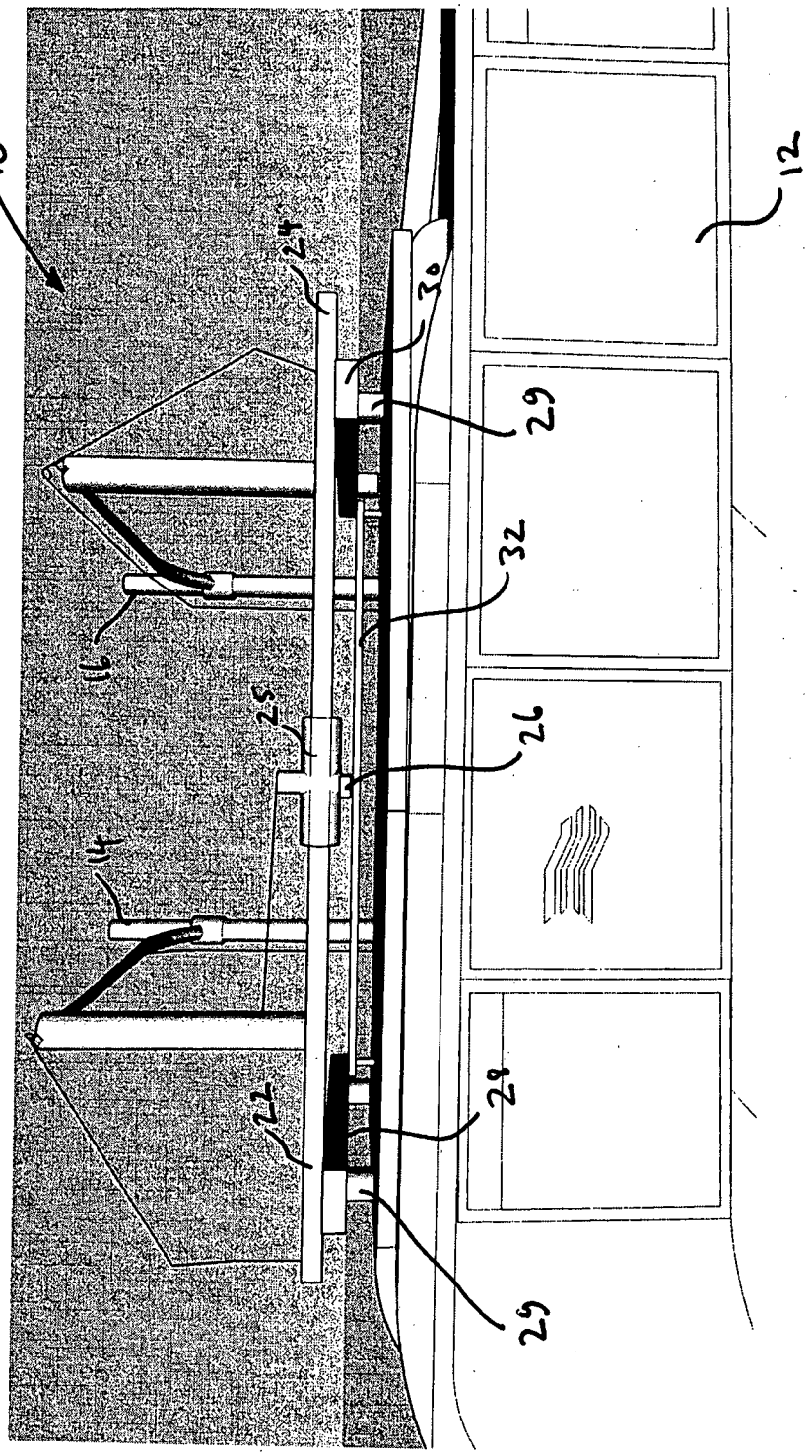

FIG 3

Figure 4

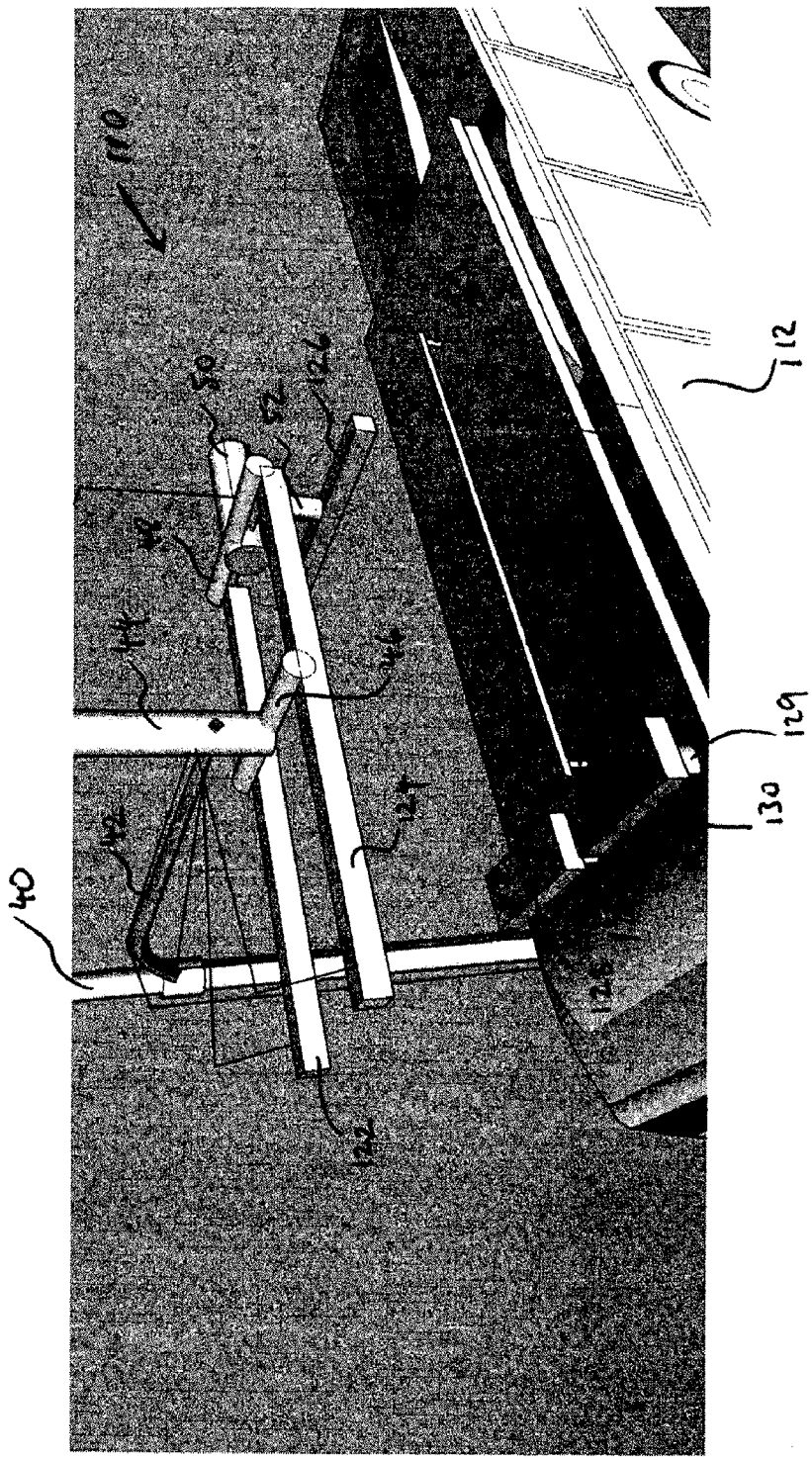

Figure 5