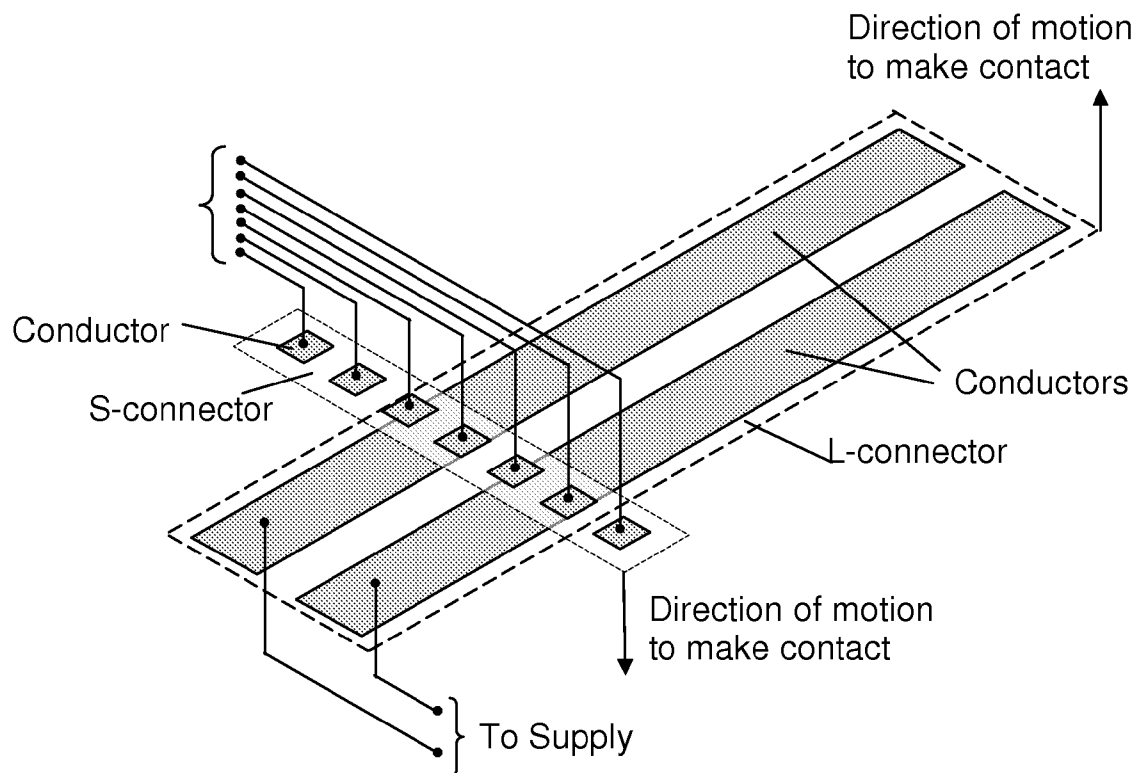




US 20090011616A1

(19) **United States**(12) **Patent Application Publication**
Patwardhan(10) **Pub. No.: US 2009/0011616 A1**(43) **Pub. Date: Jan. 8, 2009**(54) **WIDELY DEPLOYABLE CHARGING SYSTEM
FOR VEHICLES**(76) Inventor: **Satyajit Patwardhan**, Fremont, CA
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FREMONT, CA 94539 (US)(21) Appl. No.: **12/168,137**(22) Filed: **Jul. 6, 2008****Related U.S. Application Data**(60) Provisional application No. 60/947,954, filed on Jul. 4,
2007.**Publication Classification**(51) **Int. Cl.**
H01R 4/28 (2006.01)(52) **U.S. Cl. 439/34**(57) **ABSTRACT**

A mechanical, electrical and telecommunication system to electrically connect a vehicle to an electricity source to transfer energy to the vehicle is presented. In one rendition the system has a stationary portion on the road or infrastructure side, and a moving member on the vehicle. The system is designed to tolerate misalignments of a parked vehicle with respect to the parking stall. The infrastructure or road side component of the system being mechanically static is designed rugged and therefore is widely deployable. The system along with moving member is fail-safe and poses no threat to humans, the vehicle being charged or the vehicles sharing the road. An important component of the system is a pair of rigid, insulating strips with a series of conductors on each of them, placed at approximately right angles to each other. One of the strips is mounted on the infrastructure or road side and the other on the vehicle. The two strips cover the lateral and longitudinal misalignment of the parked vehicle. As long as the two strips have an overlap, the connection can be made by the conductors in the overlap region. The system is designed to operate only in the active presence and active desire of a vehicle to connect to the infrastructure or road side stationary part.



L and S connectors.

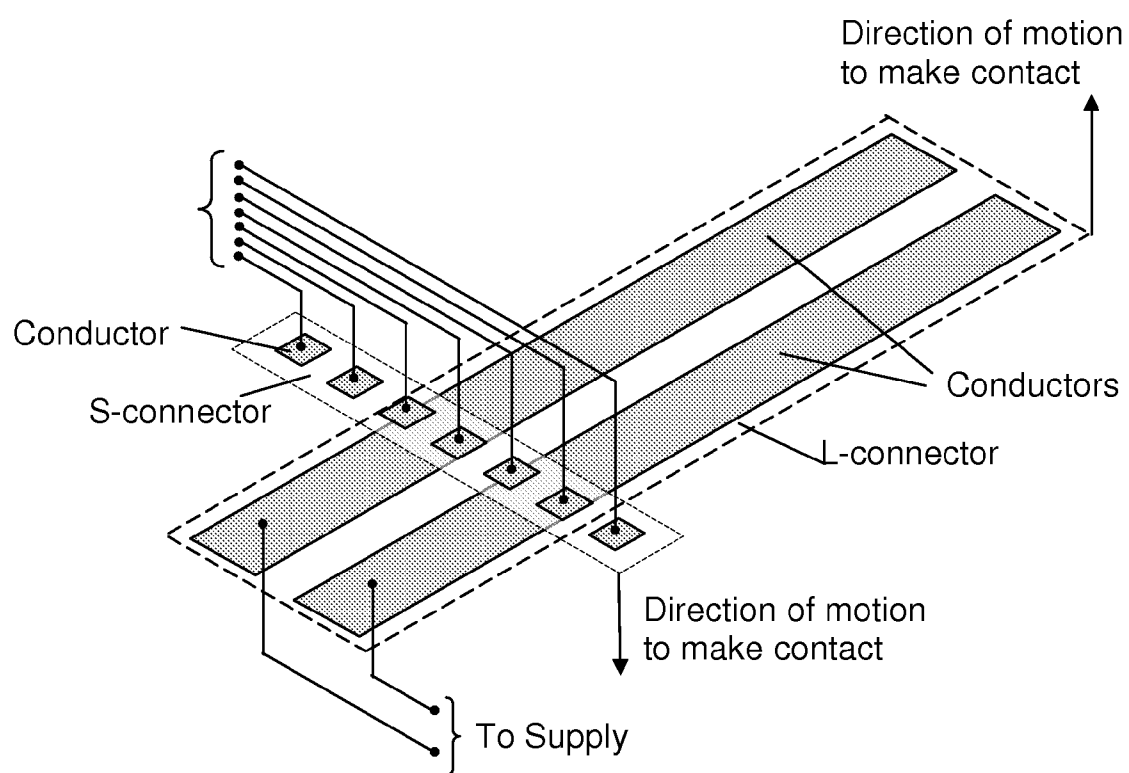


Figure 1: L and S connectors.

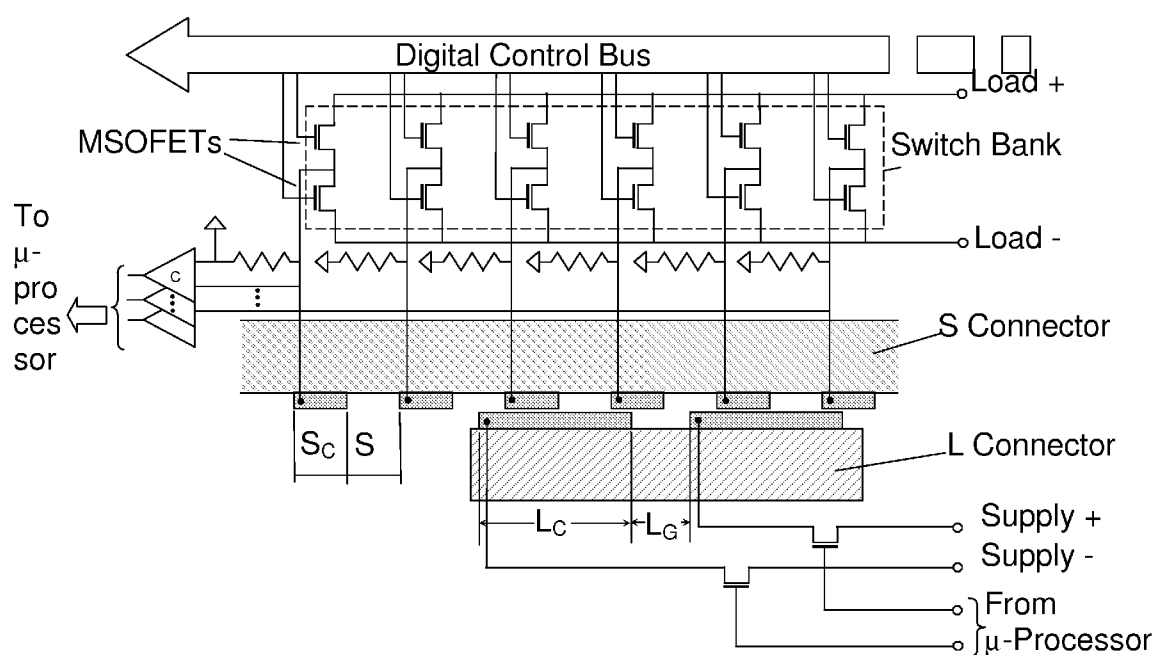


Figure 2: Electrical connections and geometry definition.

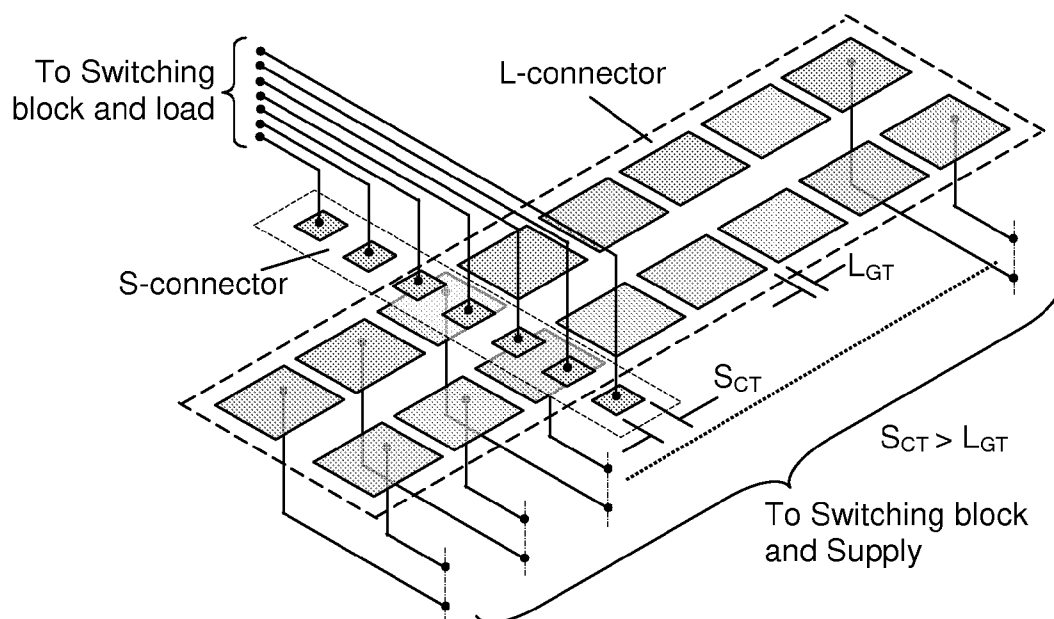


Figure 3: Splitting the L-connector conductors.

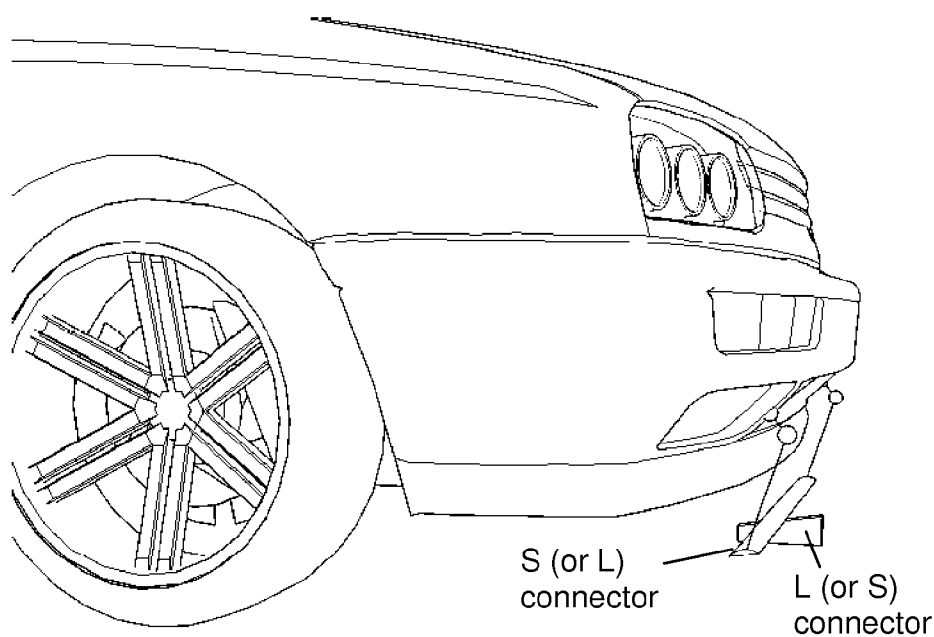


Figure 4: Front underside mounting.

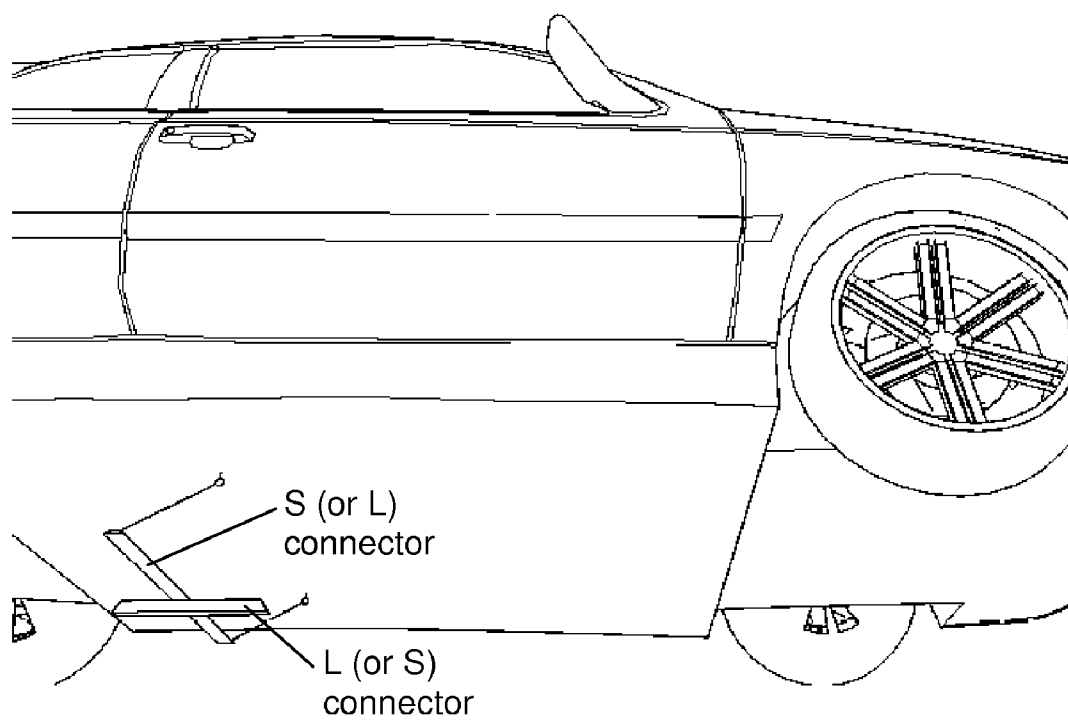


Figure 5: Underside mounting.

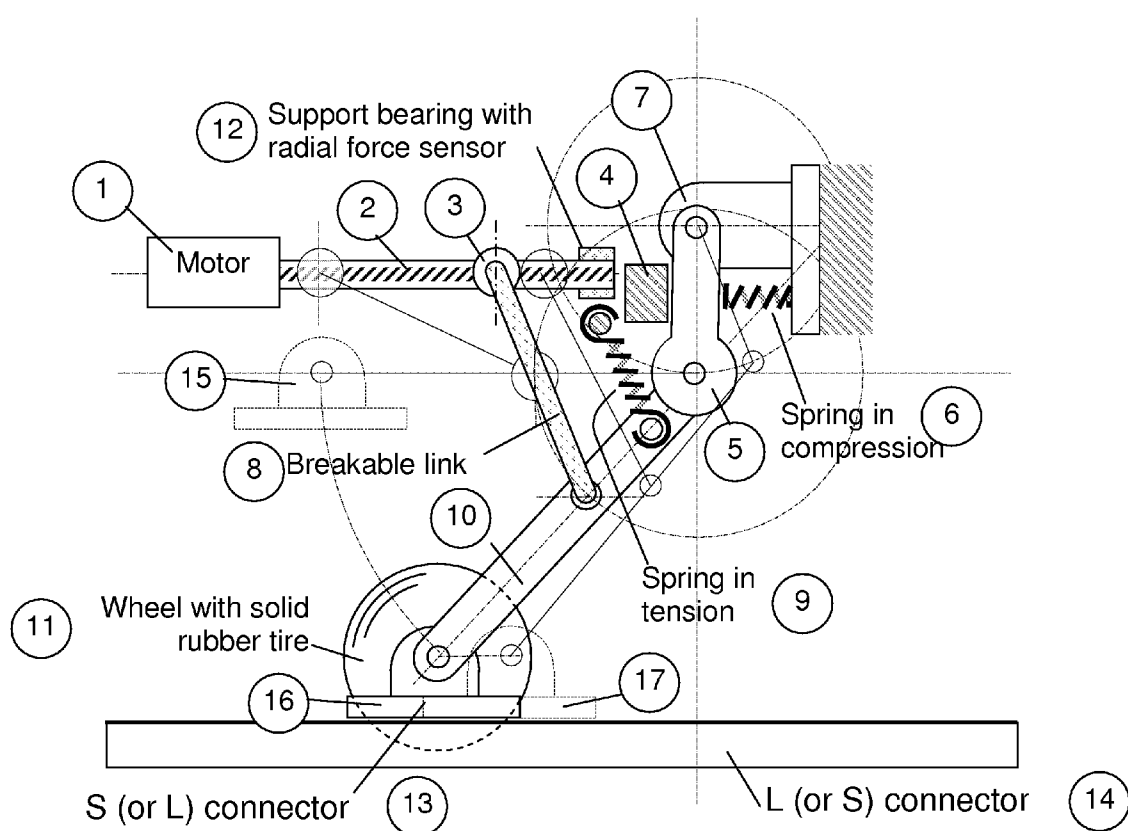


Figure 6: Actuating Mechanism.

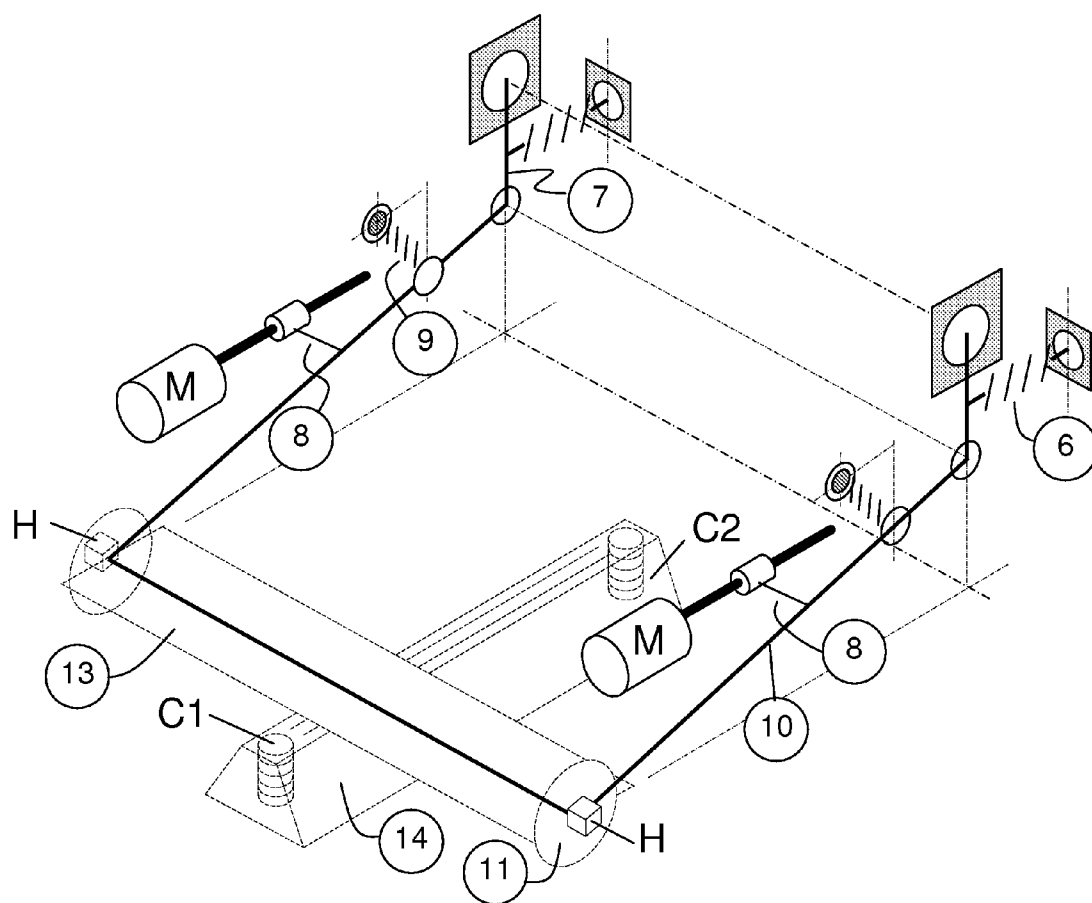


Figure 8: Mechanical system: Configuration 2.

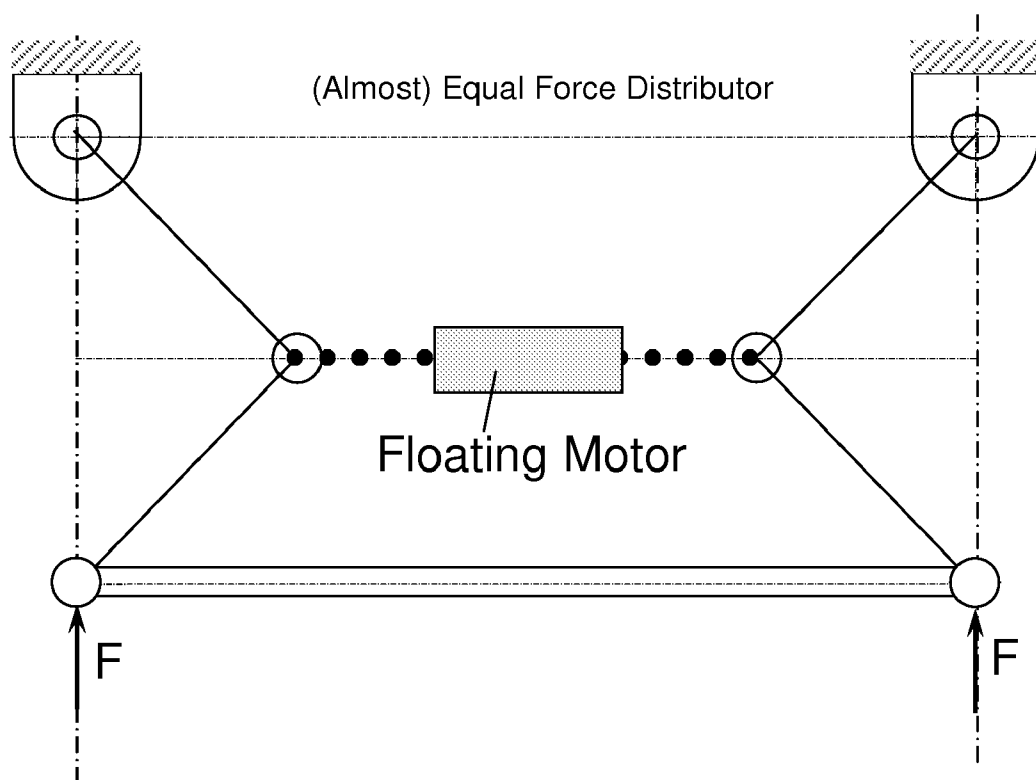


Figure 9: Equal force distributor replacement mechanism for link 10.

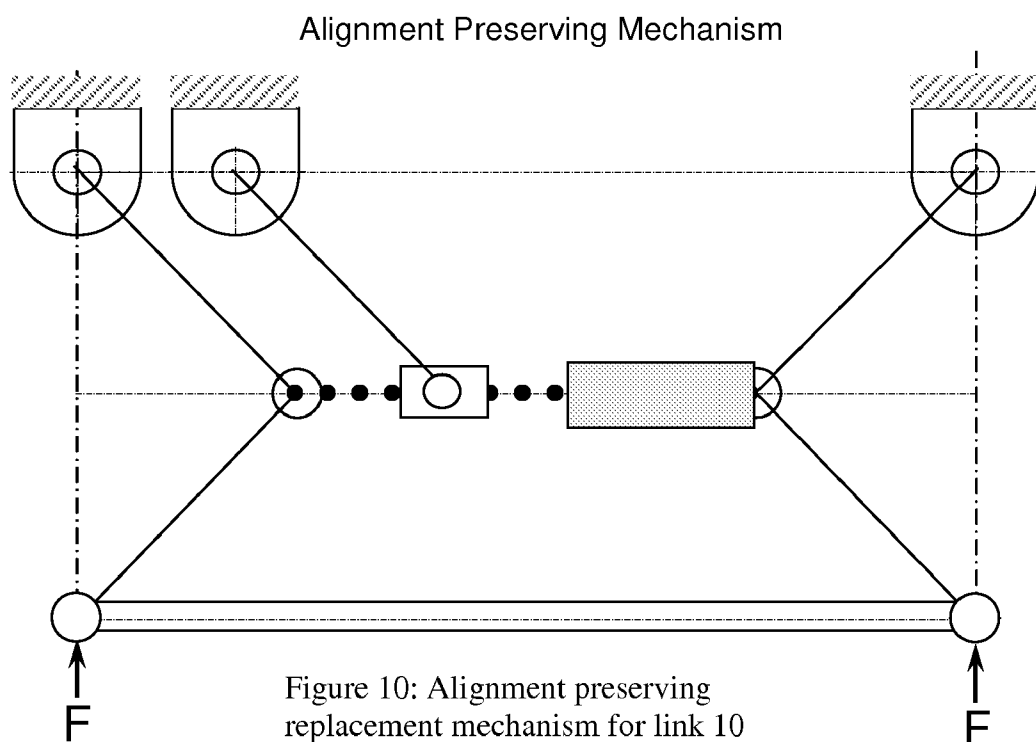
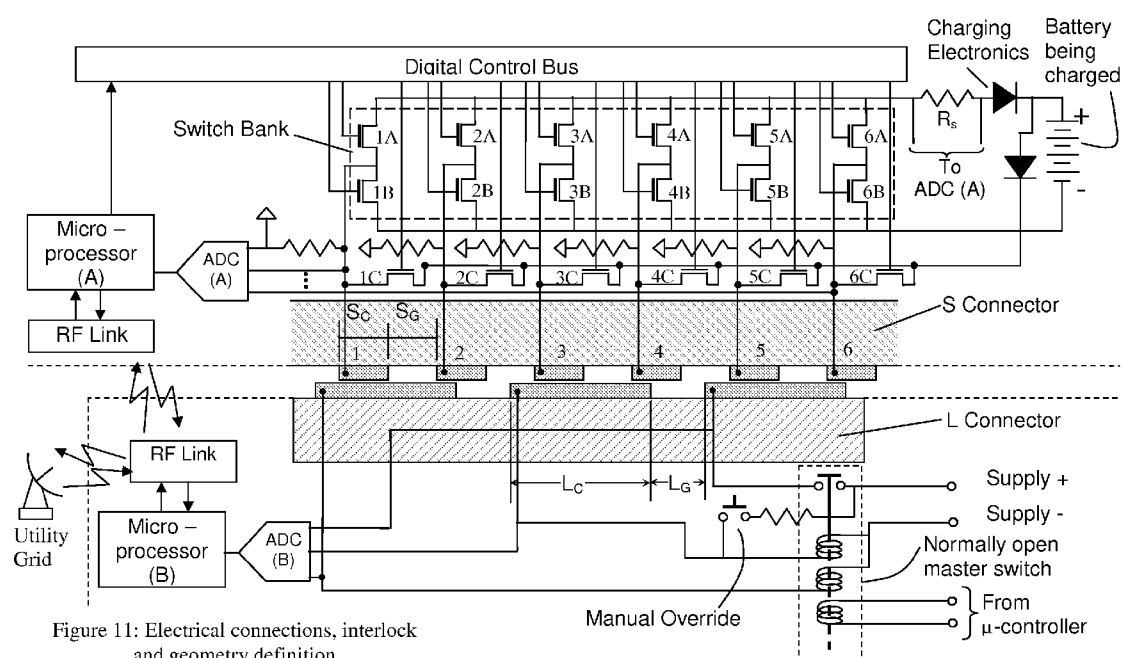


Figure 10: Alignment preserving replacement mechanism for link 10



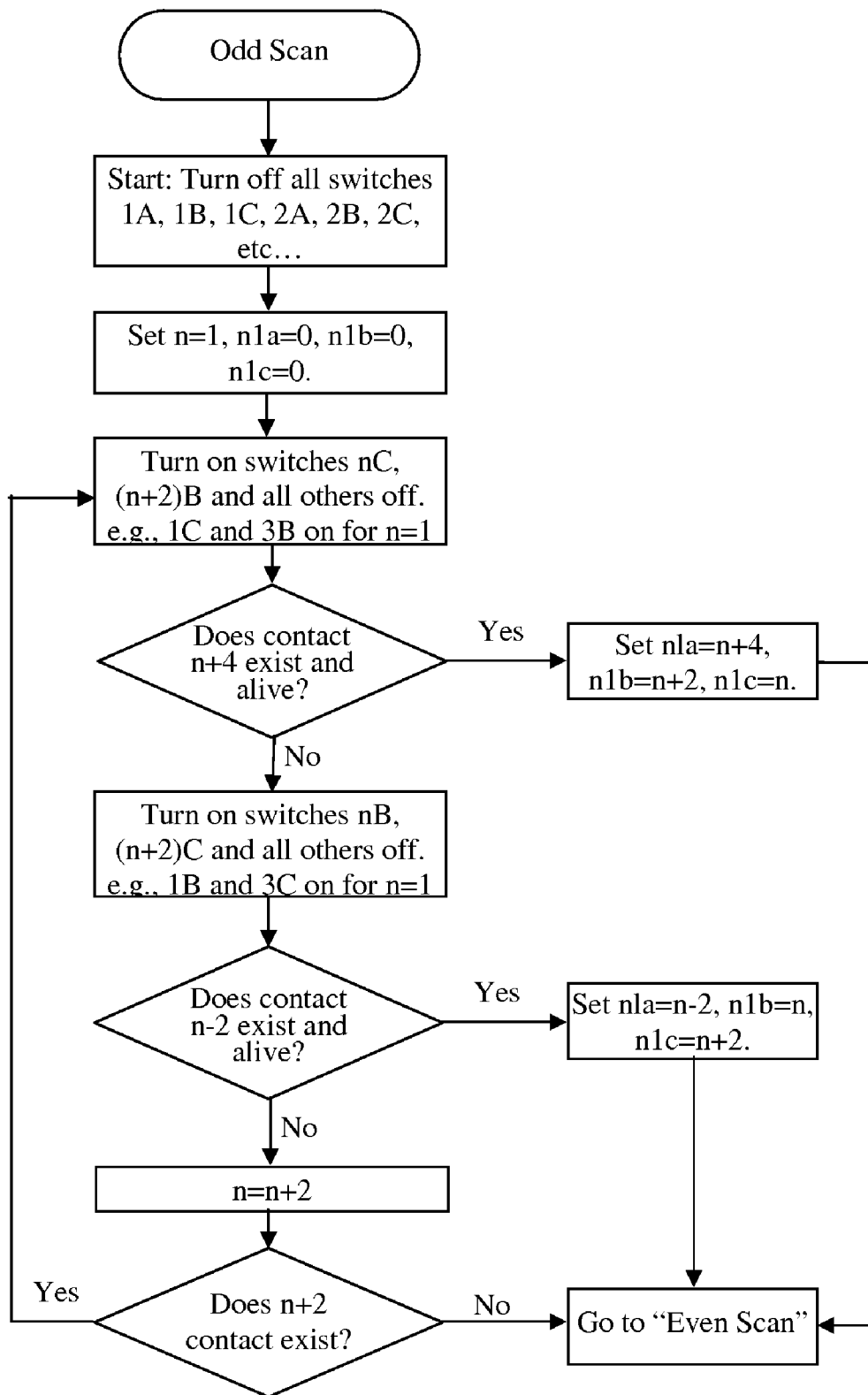


Figure 12: Steps to select contacting conductors, executing on microprocessor A.

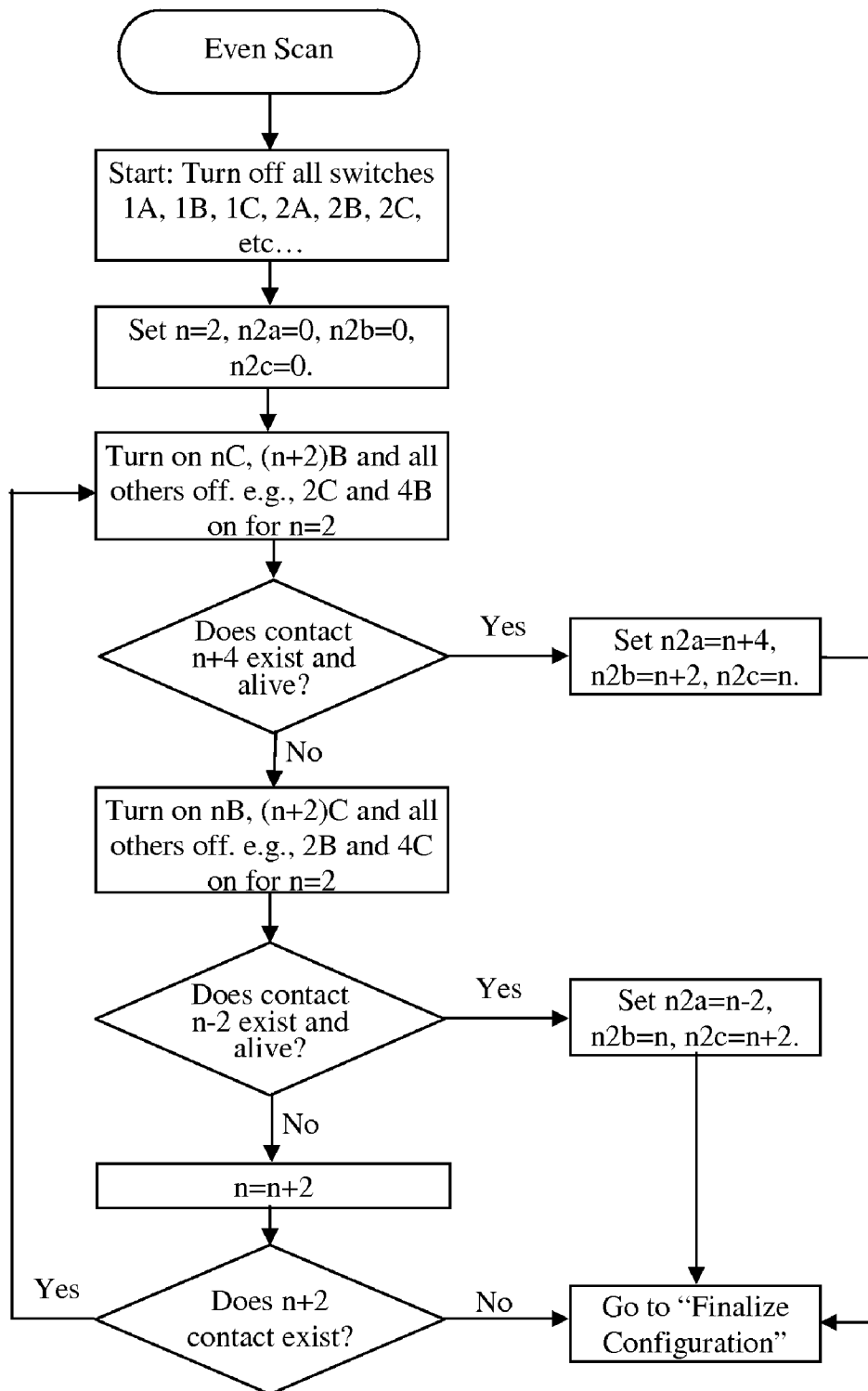


Figure 13 Steps to select contacting conductors, executing on microprocessor A.

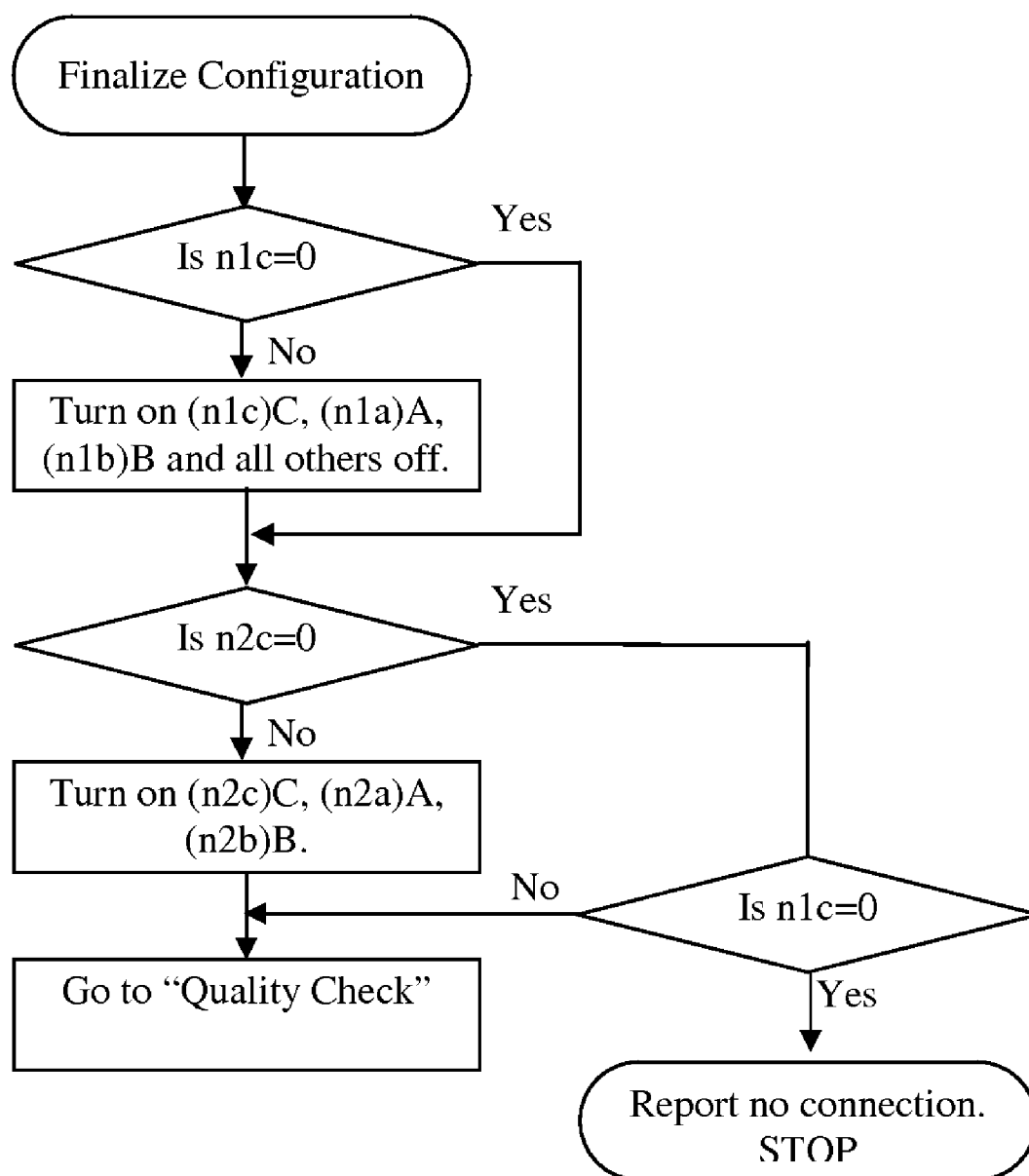


Figure 14 Steps to select contacting conductors, executing on microprocessor A.

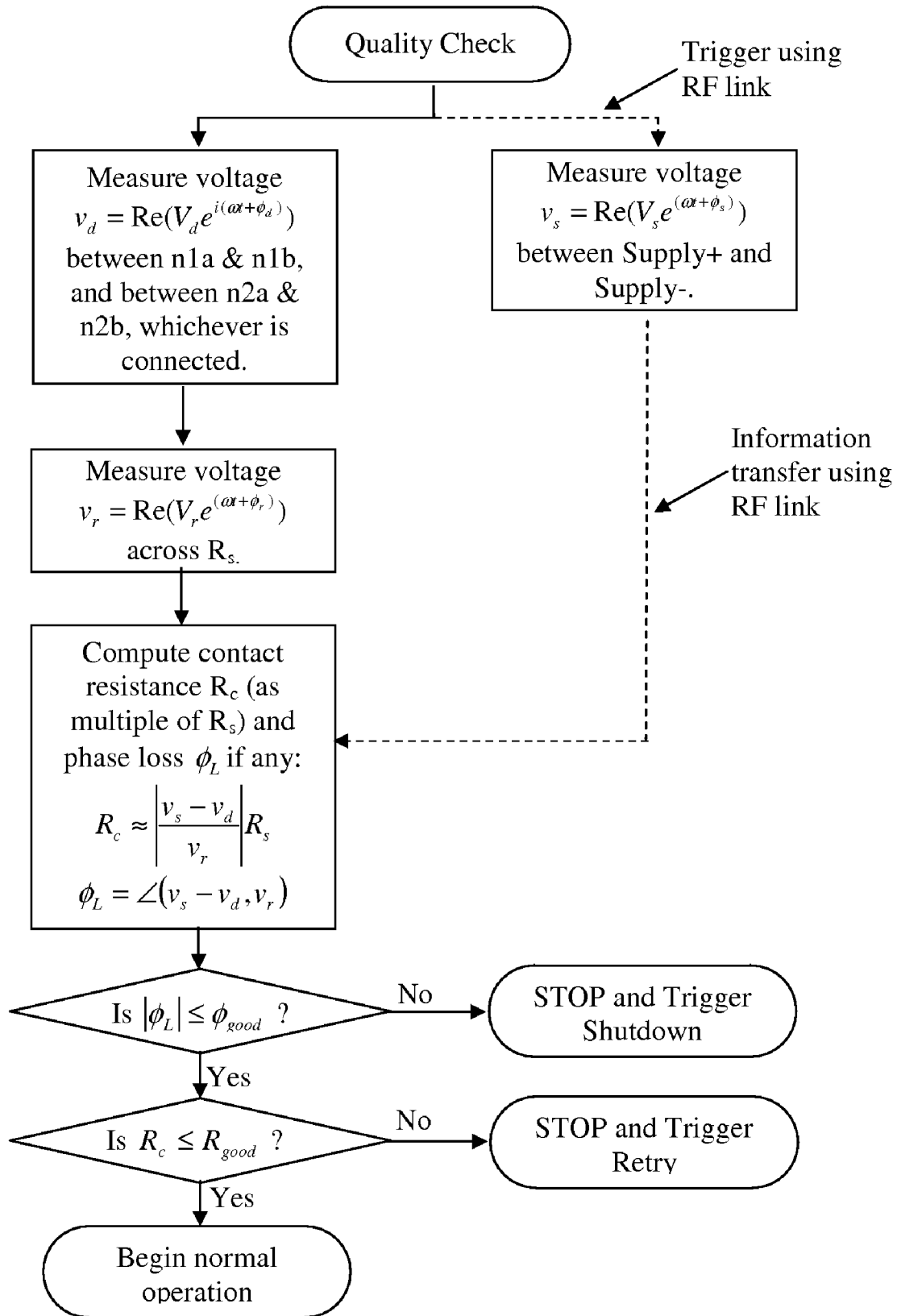


Figure 15: Connection quality check.

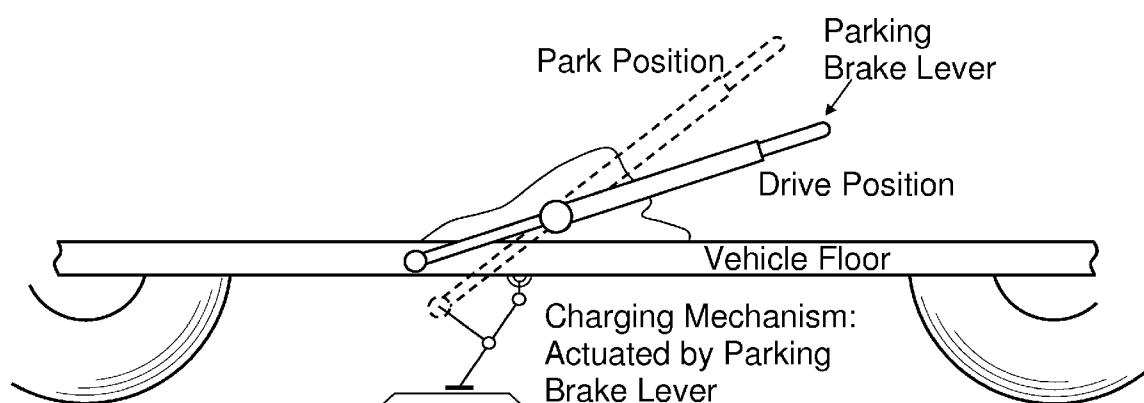


Figure 16: Using parking brake or similar lever for charging mechanism actuation.

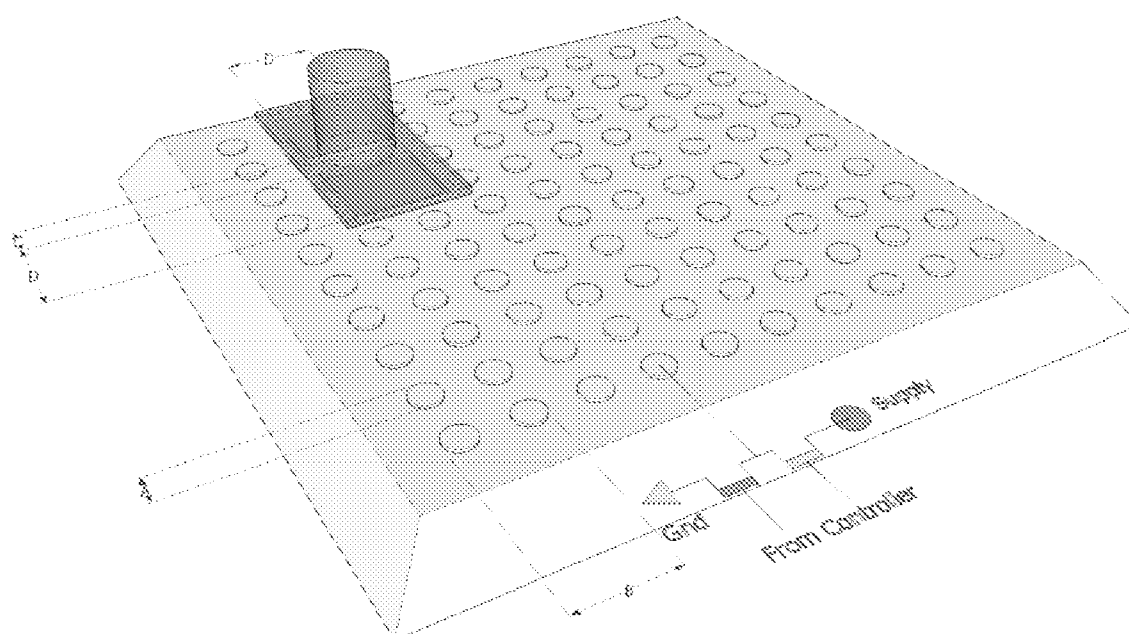


Figure 17: L and S connector (Grid style)

WIDELY DEPLOYABLE CHARGING SYSTEM FOR VEHICLES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority over U.S. Provisional Patent Application 60/947,954, filed Jul. 4, 2007, titled "Widely deployable charging system for vehicles", which is incorporated herein by reference in its entirety.

DESCRIPTION OF DRAWINGS

- [0002] FIG. 1: L and S connectors.
- [0003] FIG. 2: Electrical connections and geometry definition.
- [0004] FIG. 3: Splitting the L-connector conductors.
- [0005] FIG. 4: Front underside mounting.
- [0006] FIG. 5: Underside mounting.
- [0007] FIG. 6: Actuating Mechanism.
- [0008] FIG. 7: Mechanical system: Configuration 1.
- [0009] FIG. 8: Mechanical system: Configuration 2.
- [0010] FIG. 9: Equal force distributor replacement mechanism for link 10.
- [0011] FIG. 10: Alignment preserving replacement mechanism for link 10
- [0012] FIG. 11: Electrical connections, interlock and geometry definition
- [0013] FIG. 12: Steps to select contacting conductors, executing on microprocessor A.
- [0014] FIG. 13 Steps to select contacting conductors, executing on microprocessor A.
- [0015] FIG. 14 Steps to select contacting conductors, executing on microprocessor A.
- [0016] FIG. 15: Connection quality check.
- [0017] FIG. 16: Using parking brake or similar lever for charging mechanism actuation.
- [0018] FIG. 17: L and S connector (Grid style)

BACKGROUND AND PRIOR ART

[0019] After reviewing over 150 patents from the class 320.109, class 439.10 and class 439.34, it is deemed that this invention is unique and new over the prior art.

[0020] The problem of transferring electrical energy to moving vehicles has received substantial attention in the transportation and material handling community. Consequently there is a rich array of technologies available in the prior art. The prior art can be broadly classified into following categories:

[0021] Cable with connectors or pedals: (U.S. Pat. No. 6,185,501) All such systems involve manual connection and disconnection of vehicle to the infrastructure. Apart from the fact that these systems do not offer automation, they do have safety issues arising from a potentially complex tangle of wires to be managed as well as possibilities of accidental drive off by a forgetful driver while the vehicle is still tethered to charging outlet.

[0022] Large scale inductive transfer: (U.S. Pat. No. 5,573,090). These systems involve oversized primary induction coils embedded under parking spot. Large dimensions are intended to cover the vehicle parking misalignments. Such systems suffer from the excessive inductive energy wastage and involve complex infrastructure modifications that are unsuitable for modern personal use vehicles.

[0023] Overhead pantographs: (RE29994, U.S. Pat. No. 3,955,657, U.S. Pat. No. 5,651,434) All such systems are bulky intrusive configurations that need involved installation and maintenance of overhead bus bars. These systems also involve single energy transfer channel due to the cross bars with single conductors. The second connectivity channel is taken from underground connection. This leaves no room for additional channels for energy transfer interlocks, which are crucial from the operational safety viewpoint.

[0024] Electromagnetic radiation coupling: (U.S. Pat. No. 7,068,991, U.S. Pat. No. 6,792,259, U.S. Pat. No. 6,114,834, U.S. Pat. No. 5,982,139) A handful of patents refer to a narrow radiation beam emanating from an infrastructure device and hitting energy receiving devices on the roof of vehicles. Such systems still need a fair amount of manual alignment, but most importantly have very limited energy transfer rates for a safe level of radiation.

[0025] Conical/compliant receptacles: (U.S. Pat. No. 7,02,3177, U.S. Pat. No. 6,614,204, U.S. Pat. No. 5,850,135, U.S. Pat. No. 5,696,367, U.S. Pat. No. 5,498,948, U.S. Pat. No. 5,272,431) These systems offer a limited tolerance to vehicle to parking stall misalignments. The operator is still expected to home into the receiving or compliant zone of the receptacle and stop just in time not to push against the infrastructure. In addition to expecting specific behavior from drivers, an accidental poor alignments as well as fast approach pose collision threat and will degraded the operation and reliability of such systems.

[0026] Active location seeking robotic arms/trolleys: (U.S. Pat. No. 6,85,9010, U.S. Pat. No. 5,821,731, U.S. Pat. No. 5,703,461, U.S. Pat. No. 5,696,367, U.S. Pat. No. 5,654,621, U.S. Pat. No. 5,646,500, U.S. Pat. No. 5,617,003, U.S. Pat. No. 5,461,298, U.S. Pat. No. 5,272,431) There are many variants of these systems depending on the sensing scheme used as well as actuation schemes used. Such systems are relatively complex and depend on reliability of several sensors and motion control loops. A miss-calibrated/drifted system could pose a spectrum of problems ranging from scratching the shiny paint of vehicle to simply not being able to connect the vehicle. Apart from the intrusive nature of the robotic arms, both the trolleys as well as robotic systems are susceptible to vandalism in open infrastructure applications.

[0027] Physical and virtual guiding systems for homing: (U.S. Pat. No. 6,525,510, U.S. Pat. No. 5,850,135, U.S. Pat. No. 5,461,298, U.S. Pat. No. 5,341,083, U.S. Pat. No. 4,496,896) The first category of these systems either employ mechanical guides for vehicle tires, forcing the vehicle to a relatively precise location for the automatic connector to mate with now precisely located vehicle side counterpart. Some other systems involve passive guidance to the drives, either based on a sensor pair, a dashboard or infrastructure based display device or through grid markings on the pavement. Such systems are either large footprint and tend to be bulky, or are imprecise (passive guidance) and need further connectivity assistance from conical, compliant or active search components.

[0028] Contactor arrays: Such systems have multiple connectors placed on infrastructure that will end up connecting with relatively few contactors on the vehicle side and vice versa. The vehicle to parking stall misalignment is compensated by multiple conductors. This patent generally falls in this category of devices. Specifically: U.S. Pat. No. 6,307,347 describes a pair of two dimensional grids, each grid being permanently dedicated for one channel of connectivity. This

not only increases the number of connectors (proportional to l^2) per channel of connectivity, but also needs each grid big enough to tolerate the vehicle misalignment specs. Thus making the total # of connectors to $n \times l^2$, where n is # of connectivity channels and l is the grid's linear dimension, which has to be bigger than vehicle parking tolerance in one dimension.

[0029] U.S. Pat. No. 5,651,434 has two overhead cables and the vehicle has a pantograph with two contactors insulated from each other. Due to the one to one correspondence between the infrastructure side and vehicle side contactors, this arrangement necessitates the two cables as well as the two pantograph connectors be separated laterally by the worst case lateral misalignment specs of the vehicle plus the lateral dimension of the pantograph contactors, making it a bulky system, which is difficult to extend beyond two connectivity channels, a prime safety requirement from ground fault detection viewpoint. U.S. Pat. No. 5,523,666 has features similar to contactor array structures; however it still depends on the mating pair of contactors to be brought together by active positioning. Again the one to one correspondence between the infrastructure and vehicle side connectors means relatively precise alignment at least in one direction, between the corresponding connectors is required. This alignment in the U.S. Pat. No. 5,523,666 is made by active positioning of the infrastructure rails and suffers from the consequent disadvantages of an active positioning system.

[0030] U.S. Pat. No. 5,252,078 is very similar to U.S. Pat. No. 5,523,666, except the relatively positioning of the mating connectors is achieved by passive compliant members. Both U.S. Pat. No. 5,252,078 and U.S. Pat. No. 5,523,666 suffer from the disadvantages of a system requiring precise alignment—whether passive or active, as well as carry potential for damage and reduced reliability and safety due to drivers accidentally driving into the system.

[0031] U.S. Pat. No. 4,158,802 is an overhead contactor system with one to one contactor correspondence between vehicle and infrastructure. Consequently suffers from either precise positioning or too large contactor spacing and size. As described, this system is also bulky and needs involved installation.

[0032] U.S. Pat. No. 4,850,879 is a front bumper variation of U.S. Pat. No. 6,307,347. Both, U.S. Pat. No. 4,850,879 as well as U.S. Pat. No. 6,307,347 describe conductor arrays that have contiguous domains of conductors that are electrically connected to each other and represent one single large conductor.

[0033] Corresponding to one conductor (or a group of conductors that are electrically connected to each other) on ground, there is one and only one conductor on the vehicle that the ground conductor is permitted to pair with. All inventions based on one to one conductor pairing necessitate large individual conductors (or group of conductors) or accurate positioning. In case of U.S. Pat. No. 4,850,879, former is true. Additionally, U.S. Pat. No. 4,850,879 can be damaged due to accidental driving in.

DETAILED DESCRIPTION OF THE INVENTION

[0034] A mechanical, electrical and telecommunication arrangement to transfer electrical energy to a vehicle is described in this invention. At the core of the system (see FIG. 1) is a pair of linear arrays of conductive elements insulated from each other. A specific rendition where one of the arrays is a 1×7 array (labeled as S-Connector) and the other is a 2×1 labeled L connector is shown in the FIG. 1. One of the con-

nectors (either S or L connector) is placed on the infrastructure side and the other on a vehicle. When the array on the vehicle is in the proximity of the array on the ground, such that the two have an overlap, one or both of the arrays are moved towards each other. This causes the array elements—labeled as “conductors”, to mate and form an electrical contact in the overlap region. Depending on the relative position of the vehicle in the parking stall, an arbitrary group of conductors from S connector may come in contact with an equally arbitrary group of conductors from L-connector. A series of switches connected to each of the contactors, in cooperation with a microprocessor select the contactors in the overlap region for use in the energy transfer process. Notice that the lengths of the array and their relative orientation to each other allows for a tolerance in the accuracy of parking a vehicle. In fact the length of each of the S and L connectors is the amount of allowable parking tolerance in lateral and longitudinal direction, and is a direct design variable to cover the parking inaccuracies in the respective directions. The following paragraph describes further design procedure to ensure reliable contact between the elements of two arrays upon contacting each other. In the description, it is assumed that the intention is to establish two electrical conductive paths between array “S connector” and array “L connector”. These will be referred to as + and – paths. In this example shown in FIG. 1, one of the conductors on the “L conductor” has polarity – and the other has polarity + in terms of its electrical potential.

[0035] In order to ensure a guaranteed contact of correct polarity, the geometry of the conductors on the S and L connectors has to follow certain geometric constraints. Assuming the conductor dimensions are as shown in FIG. 2, the constraints are:

1	$S_C + S_G < L_C$	Ensures that a L conductor contacts at least one S conductor fully.
2	$S_C < L_G$	Ensures that S conductor does not short neighboring L conductors.
3	$S_C + 2S_G > L_C$	Ensures that L conductor does not short 3 neighboring S conductors.
4	$2S_C + 2S_G = L_C + L_G$	Ensures that + and – connections end up with same geometry.

Note that one solution to these constraints is: $S_G = S_C$, $L_C = (3 - x) S_C$, $L_G = (1 + x) S_C$, where x is number between 0 and 1.

[0036] Note that one solution to these constraints is:

[0037] $S_G = S_C$, $L_C = (3 - x) S_C$, $L_G = (1 + x) S_C$, where x is number between 0 and 1.

[0038] Once the connectors are brought to mate with each other, a microprocessor reads the potential on each of the S-connector conductors (see FIG. 2). Using these measurements, the microprocessor can figure out the specific conductors on the S-connector that have mated with conductors on L connector as well as their polarity. In turn the microprocessor switches on the appropriate MOSFETs from the Switch Bank, to ensure correct electrical polarity to appear at the Load + and Load – terminals in FIG. 2.

[0039] As a further safety modification, the conductors on the L-connector can be divided into smaller pieces as shown in FIG. 3. Once the contact is made, a switching bank (not shown) similar to the one shown in FIG. 2, is used to power up only the mating L-connector conductors. This ensures that

unused and possibly exposed L-connector conductors carry no electrical potential. This improves safety and eliminates accidental short circuits.

[0040] It should be noted that the voltages used across the mating connectors can be any low voltages such as 12 or 24V. Electronic pre and post processing will be used to down and up convert the low interface voltages to any desired input/output voltages. This is to further enhance safety and reduce operational hazard.

[0041] There are several locations on the vehicle for mounting the movable connector (either S or L). FIG. 4 and FIG. 5 show two such examples. Both of these examples show the infrastructure side connector mounted on the pavement. One can think of many alternate locations and mechanisms with or without pavement mount.

[0042] Among other alternatives is a configuration with roadside connector mounted on an actuator and vehicle side connector being mounted rigidly on the vehicle.

[0043] The motion involved to mate the connectors, is a simple one dimensional motion and can be accomplished by many different mechanical arrangements. FIG. 6 shows an actuating mechanism to mate the two connectors. Specifically, the motor 1—mounted on vehicle actuates a feed screw 2. The other end of the feed screw is mounted on bearings 12, which is also attached to the vehicle. This bearing can sense the vertical bearing force. The link 8 is connected to the feed screw 2 by a feed nut 3. The link 8 further connects up with link 10 with a pin. One end of link 10 is pivoted on link 5 and the other end carries a solid rubber tire 11 and one of the connectors—either S or L. The link 5 is pivoted to vehicle using member 7. The tension spring 9 is anchored to vehicle at one end exerts an upward pull on the member 10 by being in tension at the position shown. The compression spring 6 normally pushes member 5 against the stop 4. The stop 4 is attached to the vehicle. The mechanism stays in its retracted position 15 when the vehicle is in motion. After the vehicle is parked and ready for charge, a microprocessor runs the motor 1 and first brings the mechanism in to position 16 in which the connector 13 (S or L) just touches the connector 14 (L or S). During this motion, the link 5 continues to be pushed by spring 6 against stop 4. The motor 1 then moves further and the connector 13 moves from position 16 to 17. During this motion, the link 5 moves against the spring 6. The motor continues to push till a certain force is measured at the bearings 12. The bearing force sensor is optional. Same information can be sensed by monitoring the motor current. The last part of the motion from position 16 to 17 causes the conductors to slide against each other with a sizable interface force, thus ensuring a good quality contact by cleaning the debris and any oxide film that may have formed.

[0044] In the case when the mechanism in FIG. 6 is in its extended position (i.e. connector 13 in position 17), and a passenger enters the vehicle, thus compressing the vehicle suspension springs by a few inches. Such motion will be well tolerated by the mechanism in FIG. 6 by further compressing the spring 6. The allowable stroke of the spring 6 should be designed appropriately to accommodate the vehicle suspension compliance.

[0045] The mechanism is able to operate with a wide range of initial separation between connector 13 and 14. The link 10 will extend till it encounters the reaction from the conductor 14. At that point— independent of the angular deployment of link 10, the conductors will start sliding against spring 6.

[0046] The overall mechanical system can be configured in many ways. Two examples are shown in FIG. 7 and FIG. 8. The Configuration #1 (FIG. 7) uses only one motor for actuation and exerts almost equal forces on the two (right and left) copies of the link 10. The Configuration #2 (FIG. 8) uses two independent copies of the actuating mechanism. After the connectors 13 and 14 have made their initial contact, the location (along the connector 13) of the contact point will be sensed through a capacitive proximity sensor (not shown) and appropriate forces are applied to the two copies of the link 10, such that the moments of these forces are balanced about the contact point. The force computations being done by the microprocessor after the contact point sensing. Alternatively the two forces will be applied such that the connector 13 swings through some small positive and negative angle, while monitoring the quality of the connection using a small dummy potential applied to the connector 14. Once a good quality connection is sensed, the force proportion on the two actuators will be frozen for subsequent motion.

[0047] FIG. 7 and FIG. 8 also show energized coils (or permanent magnets) C1, C2 and magnetometers H. The magnetic field emanating from energized coils (or magnets) C1 and C2 will be sensed by magnetometer H. The sensed magnetic field will be converted to relative position between connector 14 and 13. This information will be provided to user via a user interface. This information will be used as an optional feedback to the user during parking. Depending on the specific design, the magnetic field from C1 and C2, as sensed by the magnetometers H, will be distinguished by polarity or timing.

[0048] Fail safe features: In the normal circumstances, an electronic interlocking with the ignition key of the vehicle will be employed to ensure that the mechanism is fully retracted before the vehicle starts to move. However, in case of malfunction, there are two level fail safe features incorporated in the mechanism. The first feature is the soft rubber wheel 11, which will smoothly rotate upon touching the road, thus causing no harm to the drivability of the vehicle. In case the mechanism is stuck in a position such that a large portion of road forces are being borne by the rubber tire 11, the second feature kicks in. The breakable link 8 will break up under the road forces that are transmitted to it via wheel 11 and link 10. Once broken, the spring 9 will pull the linkage 10 up to its retracted position or close to it. Alternatively, the pin connecting the link 8 and lead nut 3 can be a breakable link to achieve a similar fault protection.

[0049] In an alternative mechanism, the motor 1, the feed screw 2 and the feed nut 3 will be eliminated. The link 8 will be replaced by mechanisms such as shown in FIG. 9 and FIG. 10. The mechanism in FIG. 9 is an equal force distribution mechanism in which the two copies of the link 10 will be pushed down with almost equal force. The mechanism in FIG. 10 is an alignment preserving mechanism in which the connector 13 will be kept parallel to its original position.

[0050] In an alternative mechanism, the motor 1, the feed screw 2 and feed nut 3 will be replaced by a pneumatic cylinder. Further the air supply can be centrally or locally heated. The heated air will be intentionally leaked out of the pneumatic cylinder periodically to melt away any accumulated snow or frozen moisture in cold weather. The periodic hot air bursts will also help clear away any normal debris that may have accumulated on the actuating mechanism. As an

additional cold weather protection, optional heating elements can be embedded in the conducting arrays to ensure all surface moisture is melted away.

[0051] Once the mechanical motion is completed, the contactor selection process begins. One example of such algorithm is presented in FIG. 12, FIG. 13 and FIG. 14. This is followed by a connection quality check described in FIG. 15. Finally a communication with the utility grid is established to optimize charging process parameters, such as rate and time of charging to realize cheapest energy costs or any other goal set by the user. Specific details of such transaction are not intended to be part of this invention.

[0052] Some of the additional features for reliability improvement are:

[0053] 1. A set of wipers on the leading edge of the connector 13, arranged such that they end up wiping the relevant portion of the connector 14 as the two connectors approach during mating.

[0054] 2. A dust cover to cover the retracted position of the connector 13 and its moving linkage.

[0055] 3. A circuit design to ensure that the exposed conductors of connector 13 and 14 are kept at a negative potential, so that they get protected from degrading by the cathodic protection.

[0056] 4. A circuit design to ensure that the vehicle tires are kept at a negative potential, so that they get protected from degrading by the cathodic protection.

Unique Features of the Invention and their Market Value

[0057] 1. No need for precise vehicle positioning. Normal parking accuracy using the usual painted parking stall markings will be sufficient to make a successful contact.

[0058] 2. Static and movable parts of the connector are configurable. In one configuration, static connector is on the infrastructure side, enabling wide scale deployment. In other configuration, the static connector is on the vehicle, minimizing changes required on the vehicle.

[0059] 3. No tangle of wires or mechanical arms emanating to/from a group of vehicles being charged.

[0060] 4. Self cleaning of the contact surfaces by sliding motion across each other before the electrical potential is established. This ensures high quality of contact.

[0061] 5. Elimination of sparking by a microprocessor that switches on the electrical potential only after ensuring that a quality connection has been established.

[0062] 6. Low voltage across interfacing conductors ensuring human safety.

[0063] 7. Only relevant conductors are turned on after ensuring a good contact using a small dummy voltage to test the connection quality. This keeps the conductors normally de-energized to further reduce human hazard.

[0064] 8. Individually switched multiple conductors enable pinpointed energizing of relevant conductors for safe operation and shutdown during detected short circuits from accidental nails or other metal debris landing on the conductor. The energized section of the connector will always be first swept for debris and then covered by the mating connector.

1. An electrical energy transfer system for transferring energy across two objects within specified range of relative position with respect to each other, which comprises of:

a. Two, arrays of insulated, independent conductive elements—with elements disposed along a surface, such

that one or more elements of the first array are intended to mate with one or more elements of the second array.

b. The geometry of the conductive element arrays and the conductive elements themselves is such that any arbitrarily selected overlap region of the two arrays can establish plurality of independent conductive paths across the two arrays.

c. A mechanism to attach—henceforth referred as attaching mechanism or a mechanism to move—henceforth referred as actuating mechanism to attach each of the two arrays to the two objects and to move one or both of the arrays closer to each other and into their mating position, such that one or more conductive elements of one array overlap with and connect to one or more conductive elements of the second array.

d. A set of switches to selectively connect each of the conductive element to other electrical circuits, which may include, but not limited to electrical power source, electrical power drain, electrical energy monitoring circuits, etc.

2. System of claim 1, with one or more of the four combined dimensions of the two arrays—in their mating position, to be parallel to and at least as long as the permissible positioning misalignments of the two objects.

3. System of claim 1, with the elements of the conductive element arrays disposed along a curved surface.

4. System of claim 1, with the elements of the conductive element arrays disposed along a flat surface.

5. System of claim 1 with one or more of the conductive arrays comprising of a linear array of elements.

6. System of claim 1 where with one or more of the conductive element arrays with spring loaded elements to allow movement of individual elements relative to the array.

7. System of claim 1 with actuation mechanism tolerant of accepting a wide range of initial separation between the two arrays.

8. System of claim 1 with actuation mechanism with at least one breakable member and spring loaded linkage to initiate retraction and keep the mechanism retracted under a fault condition in a way that will pose no hazard to the surrounding.

9. System of claim 1 with actuation mechanism enforcing relative sliding of contacting elements from the two arrays after mating.

10. System of claim 1 with actuation mechanism—in its mated position to be tolerant to relative motion between the objects.

11. System of claim 1, with conductive elements such that

a. The said switches are normally-open-electrical-switches.

b. The other electrical circuits include voltage monitoring devices.

c. It has a sequencing device on one or both of the arrays to first sequence through a series of switching patterns on the switches described in (a), while monitoring the voltages pattern on the individual contactor elements.

d. It has a decision making device to select—based on the voltages monitored in the sequence (c), a switching pattern on switches described in (a) to supply/receive electrical energy to/from only those contactors on the two arrays that are in connection with each other.

12. System of claim 1 with one or more of the following additional sub-systems:

- a. A communication means to communicate data across the two objects.
 - b. A Protection device to switch off electrical energy source during a fault condition.
 - c. A communication device to communicate to energy supplier infrastructure to either process billing information or negotiate optimal energy transfer scheme.
- 13.** System comprising of a combination of systems described in claim 1, claim 2, claim 3, claim 4, claim 5, claim 6, claim 7, claim 8, claim 9, claim 10, claim 11 and claim 12.
- 14.** System of claim 13 with two conductive channels that are used for electrical power.
- 15.** System of claim 13 with three conductive channels as follows:
- a. one channel for live power sourced from the first object.
 - b. second channel for ground connection across first and second object.
 - c. third channel for live power sourced from second object to first object.
- 16.** System of claim 15 in which the power sourced from second object to the first object is used to close a normally open master switch on the first object which establishes the power sourced from the first object.
- 17.** System of claim 16 with the said master switch whose de-energized state is disconnected state.
- 18.** System of claim 13 with a force sensor in the actuating mechanism to monitor required actuation force and detect the establishment of contact between elements of arrays when the actuation force reaches a certain threshold.

19. System of claim 13, with ability to monitor voltage and current across contacting array elements to monitor electrical quality of contact.

20. System of claim 13, with the first object being ground and the second object being a transportation vehicle.

21. System of claim 20, with actuating mechanism on the vehicle side and actuated by the motion of parking brake lever.

22. System of claim 20 such that the decision to move the arrays closer or farther is linked to the gear shift lever of the vehicle so as to ensure full retracted mechanism when the vehicle is in drive mode.

23. System of claim 20 such that the decision to move the arrays closer or farther is linked to the parking brake lever of the vehicle so as to ensure full retracted mechanism when the vehicle parking brake is disengaged.

24. System of claim 20 with actuating mechanism on the vehicle side whose retracted position keeps the vehicle side conductor array such that it is not extending out of the vehicle body in a way to cause damage to road, self or other vehicles while moving or stationary.

25. System of claim 20 with pneumatically powered actuating mechanism.

26. System of claim 20 with electric heating coils embedded in the arrays to melt away frozen moisture in cold climates.

27. System of claim 20 with heated air blowing over the stationary part to clear away debris as well as to melt and clear away frozen moisture in colder climates.

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