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COMPLETE SPECIFICATION

Title of Invention:

Inductive power pick-up coils

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INDUCTIVE POWER PICK-UP COILS

TECHNICAL FIELD OF THE INVENTION

This invention relates to the field of inductive power transfer for loosely coupled combinations and in particular to means to enhance the collection of said power at the receiving side.

BACKGROUND

Inductive power transfer is capable of providing electric power across a significant space to often moving apparatus without a physical connection for the electricity (such as sliding or rolling contacts). It can be carried out at low or high frequencies, in a loosely or a tightly coupled configuration, and with or without magnetically permeable materials.

We have described such a system in our US Patent 5,293,308 (and in the corresponding International application filed as PCT/GB92/0220).

Advantages of the preferred loosely coupled inductive power transfer means over various tightly coupled transfer arrangements include that:

(a) Effective transfer is possible across a larger space, thus the primary and the secondary need not be constrained in space to move within such close limits.

(b) The larger area results in a lower peak power density or a less tightly focused field to carry power, which is less hazardous and places less stress on components or on incidental objects within the flux field.

(c) The pick-up coil need not surround the primary conductor so a system can be constructed in which a flat receiving surface containing secondary windings may be brought near another flat surface containing one or more embedded transmitting (primary) conductors, so permitting much freedom of movement for vehicles over a roadway, for example.

(d) Useful power control means applied to the secondary side may be implemented by shorting the secondary coil (which is generally a resonant inductor) without material effect on currents in the primary side. A shorted secondary coil has little effect on primary current flow, so unaffected primary current can reach another consumer further from a power supply.

Exploiting the above advantages of loosely coupled inductive power transfer systems to utilise IPT in an optimised way uncovers the inherent disadvantages between loosely and tightly coupled systems, mainly that the available power may be limited and that secondary pick-up coils are large, expensive, have unnecessary ohmic resistance, and have large magnetic fields of their own when in use. Means to make the transfer process more effective across wider gaps are required and therefore there is a need to enhance the ability of secondary windings to collect as much of the available flux as possible.

DEFINITIONS

IPT is used as an abbreviation for "inductive power transfer".

A **tightly coupled** pair of inductors exhibit a close correspondence or ratio between current in one and in the other. Substantially all of the magnetic flux generated by current in one inductor is coupled to the second inductor. An example is the relationship between windings in a power transformer. Thus a shorted turn in a typical power transformer secondary causes large and usually damaging currents to flow in the primary winding.

A **loosely coupled** pair of inductors do not exhibit a close correspondence. Only a portion of the flux emanating from the primary conductor passes through the secondary conductor. Changes in the induced current in the secondary inductor has only a small

effect in the primary inductor.

A primary winding is one which generally acts as a source of magnetic flux, some of the flux intersecting the windings of a secondary winding which then passes the power onwards for consumption. The direction of power transfer is of course reversible. In this specification we use the names primary and secondary to refer to the usual direction of power flow.

OBJECT

It is an object of the present invention to provide an improved means for the transfer of electric power across a gap by inductive means, or one which will at least provide the public with a useful choice.

STATEMENT OF THE INVENTION

In one aspect the invention provides an inductive power pick-up means comprising a plurality of pick-up coils mounted on a movable support said coils being spaced apart from one another, each coil being adapted to pick-up inductive power from a primary conductor so that each coil can act as a secondary conductor when located relative to a said primary conductor, and control means capable of identifying from time to time the pickup coil or coils in best alignment with a said primary conductor, said control means including switching means capable of switching "on" the identified pickup coil or coils which are best sited to collect inductive power from a said primary conductor, and to render functionally inactive the coil or coils (if any) which are remote from a said primary conductor.

Preferably the control means is capable of determining from time to time the short-circuit current available at each pickup coil.

Preferably the control means has means to measure the rate of voltage increase that occurs when the coil is released from a shorted state.

More preferably the control means maintains those coils which are not loaded, or only partly loaded, in a short-circuited state.

Preferably each pick-up coil is mounted on a ferromagnetic flux concentrator adapted for capturing flux lines and feeding them through the core of a said pickup coil.

In another aspect the invention provides a core for collecting magnetic flux from a space and concentrating the flux through a secondary winding of a loosely coupled inductive power transfer system; the core comprising an elongate mass of magnetically permeable material having a length, a width, and a height, and having low losses at the operating frequency.

Preferably the magnetic permeability of the magnetic core is relatively high, so that in use the magnetic core serves as a concentrator or collector of at least some of the flux generated by a primary conductor of the inductive power transfer system.

A preferred permeability is 1000 or greater - where air is 1.

Preferably the magnetic core is flexible or at least capable of undergoing distortion without permanent loss of function.

In a related aspect the core is composed of a ferrite material, provided as a modular array comprising at least four fingers of material, each finger having at least one shaped side, the fingers being laid side by side along the length of the elongate mass in an array with these shaped sides held in close contact with each other by a compliant force exerting a compression force along the length of the array, so that the permeability of the array is substantially similar to that of an equivalent single mass of the ferrite material.

Preferably the shaped sides are flat, although alternatively other mating shapes may be used.

Preferably the flatness of the flat sides is such that, if two clean strips are brought together, the magnetic permeability of the strips in contact is not substantially lower than that of the bulk ferrite material.

Alternatively the ferrite material of the core may be made up of modules having shapes other than rectangles.

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