c) A guide arm is coaxially arranged with respect to the cable reel and adapted to be pivotally movable by
COMMONWEALTH OF AUSTRALIA
Patents Act 1952-1969

CONVENTION APPLICATION FOR A PATENT

METALLGESELLSCHAFT AKTIENGESELLSCHAFT; PAUL VAHLE
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of Reuterweg 14, D 6000 Frankfurt/Main 1, Westicker
Strasse 52, D-6708-Kamen and Siemensstrasse 1, D-4448
Emshuren, Federal Republic of Germany, respectively

hereby apply for the grant of a Patent for an invention entitled:

TRACKLESS, CENTER-PIVOT-STEERED UNDERGROUND VEHICLE
DRIVEN BY AN ELECTRIC MOTOR

which is described in the accompanying complete specification. This application is a
Convention application and is based on the application numbered
P35 03 225.1
for a patent or similar protection made in Federal Republic of Germany
on 31st January 1985

Our address for service is Messrs. Edwd. Waters & Sons, Patent Attorneys,
50 Queen Street, Melbourne, Victoria, Australia.

DATED this 29th day of January 1986

LEON GESELLSCHAFT AKTIENGESELLSCHAFT,
PAUL VAHLE GMBH & CO. KG and
MASCHINENFABRIK HERMANN PAUS GMBH

lodged at Sub-Office

3 J JAN 1986
Melbourne

Rayne McMaster
Reg'd. Patent Attorney
IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT OR PATENT OF ADDITION

In support of the Convention Application made by 

METALLGESELLSCHAFT AKTIENGESELLSCHAFT, PAUL VAHLE GMBH & CO. KG and MASCHINENFABRIK HERMANN PAUS GMBH

(hereinafter referred to as the applicant) for a Patent

for an invention entitled: TRACKLESS, CENTER-PIVOT-STEERED UNDERGROUND VEHICLE DRIVEN BY AN ELECTRIC MOTOR

I, WILLI HILMANN, on behalf of PAUL VAHLE GMBH & CO. KG, Westicker Strasse 52, D 4708 Kamen, I, HERMANN PAUS on behalf of MASCHINENFABRIK HERMANN PAUS GMBH, Siemensstrasse 1, D 4448 Emsburen, and We, WOLFGANG SCHNEIDER, ANNELIESE GASTEYER, on behalf of METALLGESELLSCHAFT AKTIENGESELLSCHAFT, Reuterweg 14, D 6000 Frankfurt/Main 1

Germany

...do solemnly and sincerely declare as follows:

1. That I am authorised by the applicant for the patent to make this declaration on their behalf.

2. The basic application as defined by Section 141 of the Act was made in Federal Republic of Germany on the 31st day of January 1985 by PAUL VAHLE GMBH & CO. KG.

3. WILLY HILMANN, Ostkamp 8, D 4708 Kamen, HERMANN PAUS, Heideweg 5, D 4448 Emsburen, and EBERHARD DREWS, Am Gradeberg 13, D 5940 Lennestadt 17, Germany

...are the actual inventor of the invention and the facts upon which the applicants are entitled to make the application are as follow:

The assignee of the inventors and has subsequently assigned a partial interest in the invention to METALLGESELLSCHAFT AKTIENGESELLSCHAFT and MASCHINENFABRIK HERMANN PAUS GMBH.

4. The basic application referred to in paragraph 2 of this Declaration was the first application made in a Convention country in respect of the invention the subject of the application.

DECLARED at Frankfurt/Main, West Germany this 24th day of February 1986.

Paul Vahe Gmbh & Co. Kg

[Signature]

To: THE COMMISSIONER OF PATENTS

[Signature] (Wolfgang Schneider) (Anneliese Gasteiger)
DOCUMENTS LODGED WITH THIS APPLICATION ARE UNSUITABLE FOR REPRODUCTION AND MAY BE INSPECTED AT THE PATENT OFFICE A.C.T.
A trackless, center-pivot-steered underground vehicle having a tractor section, which is driven by an electric motor, which is powered via a sliding contact line, a current collector device, which is movable along said line, and a supply cable, which is electrically and mechanically connected to said current collector device, and adapted to be unwound from a reel against a restoring force, characterized by the following features in combination:

a) the supply cable is connected to the current collector device by a slip ring member, which is rotatable about a vertical axle;

b) a helically winding cable reel is mounted on the tractor section and rotatable about a vertical axle, which is provided with a slip ring member;

with the current collector car 212 ensures that the
c) a guide arm is coaxially arranged with respect to the cable reel and adapted to be pivotally movable by hydraulic means;

d) a hydrostatic axial piston transmission is coupled to a three-phase a.c. motor.
COMMONWEALTH OF AUSTRALIA
PATENTS ACT 1952-60

COMPLETE SPECIFICATION
(ORIGINAL)

Application Number: 52860/86.

Complete Specification Lodged:

Priority:

Related Art:

Name of Applicant: METALLGESELLSCHAFT AKTIENGESELLSCHAFT, PAUL VAHLE GMBH & CO. KG and MASCHINENFABRIK HERMANN PAUS GMBH

Address of Applicant: Reuterweg 14, D 6000 Frankfurt/Main 1; Westicker Strasse 52, D 4708 Kamen and Siemensstrasse 1, D 4448 Emsburen, Federal Republic of Germany, respectively

Actual Inventor: WILLI HILLMANN, HERMANN PAUS and EBERHARD DREWS

Address for Service: EDWD. WATER2 & SONS, 50 QUEEN STREET, MELBOURNE, AUSTRALIA, 3000.

Complete Specification for the Invention titled:

TRACKLESS ENTER-PIVOT-STEERED UNDERGROUND VEHICLE DRIVEN BY ELECTRIC MOTOR

The following statement is a full description of this invention, including the best method of performing it known to US.
This invention relates to a trackless, center-pivot-steered underground vehicle having a tractor section, which is driven by an electric motor, which is powered via a sliding contact line, a current collector device, which is movable along said line, and a supply cable, which is electrically and mechanically connected to said current collector device and adapted to be unwound from a reel against a restoring force.

The bulk material recovered in ore or salt mines is mainly hauled from the working spaces to the surface by self-propelled trackless vehicles consisting particularly of center-pivot-steered dumpers. Such vehicles are usually driven by diesel engines although the use of diesel engines for driving the hauling vehicles results in a high pollution of the underground air. For this reason
it is known to use railbound underground vehicles, which are supplied with electric power via a contact wire extending along the road or from replaceable batteries.

"CIM Reporter", Vol. 7, No. 2, of May 4, 1981, discloses a center-pivot-steered underground vehicle which is provided with an electric motor and powered from a supply system consisting of a sliding contact line, a current collector and a cable reel. The cable is self-tensioning and the vehicle can move along and transversely to the sliding contact line. The cable reel is a random-winding reel, which is rotatably mounted on a horizontal axle and disposed in front of the vehicle.

German Patent Publication 25 17 836 discloses means for transmitting electric power by means of a cable from a stationary installation to a vehicle, which may be trackless and is provided with a cable reel unit having a vertical axle on which two concentric drums are rotatably mounted one over the other. In one embodiment the reel unit is connected to a movable current collector, which moves along a conductor rail system. The power supply cable consisting, e.g., of a ribbon cable, and a rope are wound in mutually opposite sense on respective reels. During transverse movements of the vehicle under the rail system the two drums rotating in mutually opposite senses are intended to prevent an undesired twisting of...
and interference between the cable and the rope. That known vehicle has several disadvantages and does not meet the requirement that it should be virtually freely movable and rotatable in any position under the contact wire system through an angular range from 0 to 360 degrees. Because the supply cable itself cannot be rotated as desired, mechanical tensile stresses, ruptures and disruptive electric discharges can easily occur. In most cases the supply cable sags and it may be damaged as it is dragged on the floor or chafes on the vehicle.

Other known vehicles of the kind described hereinbefore have disadvantages residing in a small range of travel, an excessive unladen weight of vehicles powered by a battery or from a contact wire, a susceptibility of rectifier installations to shock and a susceptibility of d.c. drives provided with a collector to moisture and aggressive gases and liquids.

It is an object of the present invention to provide a vehicle which is of the kind described first hereinbefore and which can operate along any desired path within the range of travel of the system without an undesired twisting of the flexible supply cable and without a need for a steering of the vehicle along a cyclic course by the drive.
In a trackless, center-pivot-steered underground vehicle having a tractor section which is driven by an electric motor, which is powered via a sliding contact line, a current collector device, which is movable along said line, and a supply cable, which is electrically and mechanically connected to said current collector device and adapted to be withdrawn from a reel against a restoring force, that object is accomplished in that said vehicle embodies the following feature in combination:

a) The supply cable is connected to the current collector device by a slip ring member, which is rotatable about a vertical axle;

b) A helically winding cable reel is mounted on the tractor section and rotatable about a vertical axle, which is provided with a slip ring member;

c) A guide arm is coaxially arranged with respect to the cable reel and adapted to be pivotally movable by hydraulic means;

d) A hydrostatic axial piston transmission is coupled to a three-phase a.c. motor.

By means of the invention it is ensured that the hauling vehicle will continuously be powered from the power supply system (conductor rail system) during a travel in the longitudinal direction, e.g., along the haulage road, and during a transverse travel in the space, e.g.,
the free space, at the forward end, e.g., of the haulage road whereas the trackless hauling vehicle is free to move to the desired extent and any twisting of the supply cable will reliably be avoided.

In another embodiment the underground vehicle in accordance with the invention is provided at the current collector device with a disconnector for the detachable electric supply cable. As a result, the vehicle can be electrically disconnected from the stationary electric power supply system, e.g., when the vehicle is to be replaced or in case of danger or of accidents. On the other hand, an additional disconnector provided on the tractor section can be used for an electric connection between a mobile electric power source and the underground electric vehicle. A mechanical coupling is additionally effected. In that case a generator may be mounted on a separate vehicle, such as a trailer, and may be used to power the underground electric vehicle traveling underground on the surface. The supply cable of the electric vehicle is suitably connected to the generator by means of a socket outlet. Then the mobile generator is not required, it can be parked on the surface and in case of need it can quickly be moved to the desired underground vehicles (electric loader, electric dumper).

The underground vehicle in accordance with the invention is an all-wheel-driven, center-pivot-steered
vehicle having a cradle frame. The vehicle is generally driven by an electric motor having a power of, e.g., 200 kW at 1500 r.p.m and a voltage of 950 volts. For the travel drive, the motor is succeeded by a power divider and a plurality of hydraulic axial-piston transmissions for powering the hydrostatic drive motors for all four wheels. The working and steering hydraulic systems and the hydraulic means for driving the cable reel and the guide arm are also powered from the electric motor via hydraulic axial-piston transmissions.

As the underground vehicle in accordance with the invention moves away from the sliding contact line, the supply cable will be unwound from the cable reel, which rotates about a vertical axle and on which the cable is helically wound and in that case a contact of the supply cable with the floor will be avoided. As the vehicle moves back toward the sliding contact line, the connecting cable is automatically wound up.

The tension of the supply line can be varied in dependence on the length of the unwound cable in such a manner that the supply cable will be clear of the floor between the current collector car and the vehicle. This can be accomplished, e.g., by a continuous change of the torque of the cable reel, e.g., by a control of the pressure applied to the hydraulic motor for driving the cable reel in dependence on the
length of the unwound cable.

For a longitudinal travel of the vehicle along the sliding contact line the tension of the supply cable wound on the cable reel is so adjusted that the supply cable will move the current collector car along the sliding contact line during the travel of the vehicle.

The cable reel which is rotatable about a vertical axle is suitably disposed directly above the tractor section of the vehicle. Such an arrangement permits the vehicle to have a small overall height and can be accommodated within the height of the haulage road.

The electric connection of the connecting cable to the sliding contact line, i.e., the current collectors associated with the conductor rails of the sliding contact line, is suitably established by means of a slip ring member, which is suspended from the current collector car and rotatable about a vertical axle. That slip ring member ensures that the transport vehicle will be freer movable and that the supply cable will not be twisted.

The guide arm required for a controlled unwinding and winding of the supply cable from and on the cable reel and is coaxial to the cable reel and is suitably moved by hydraulic drive means in the winding sense. The means for driving the cable reel and the guide arm act in mutually opposite senses of rotation so that the supply cable will be held under the required tension in dependence on the speed of travel of the vehicle and that tension will be
adapted to the weight of the cable which has been unwound.

In order to prevent a complete unwinding of the supply cable from the reel so that the risk of a rupture of the cable would be increased, another embodiment of the invention comprises an electric limit switch, which is mounted on the cable reel adjacent to the inner region of the coiled cable. Such a location is selected for that switch that as the cable is unwound a preselected length of the cable will remain on the reel and will be available for a compensation of movement whereas the vehicle is automatically de-energized and arrested by the limit switch. In dependence on the diameter and material of the supply cable, the latter has a certain stiffness, which may give rise to trouble when the vehicle moves very close to the sliding contact line or to the slip ring member. To permit a substantial compensation of the stiffness of the cable, the free length of the cable between the guide arm and the slip ring member must not be too small. In a further embodiment of the invention, at least two electric limit switches are mounted in combination on the cable reel adjacent to the outer region of the coiled cable and the locations of said switches are so selected that the vehicle will be automatically de-energized and arrested before the cable length between the guide arm and the slip ring member is reduced below the shortest permissible length as the cable is wound on the reel and particularly toward the end of that winding operation.
The cable reel provided in accordance with the invention is also provided with a coupling element, by which the guide arm can be locked to the cable reel so that both elements can jointly be moved and adjusted.

Electric power is supplied to the underground vehicle in accordance with the invention from the sliding contact line via the current collector arm and the cable reel mounted on the vehicle to the power inlet of the vehicle. Circuitry for the following functions, for instance, is installed for reasons of safety. The travel motor cannot be switched on unless the direction-of-travel lever is in a neutral position and the auxiliary drives are energized. In response to a stop of the vehicle, the parking brake of the vehicle and the brake for the cable reel are automatically applied. That feature is necessary to ensure that the vehicle will be stopped immediately in case of a power failure or of an emergency cutoff because the electric motor has no braking function. Then, the cable has been unwound from the cable reel as far as to an adjustable limit, a visual signal which cannot be overlooked will be given to the driver by a flashing light. Then the driver then continues to travel away from the sliding contact line, the travel motor will be deenergized and the brake will be applied in time.

The vehicle is also provided with means for automatically monitoring the insulation resistance of the feed line
and security of the conductors of the feed line against fracture so that risks can be avoided in time.

Means for monitoring the insulation are known per se and are conventionally employed also in mining in low-voltage power supply systems having an open star point. Such means measure the insulation resistance between the ground potential and each conductor of the power supply system. Means for monitoring the security against fracture of a monitoring conductor incorporated in supply cables are also known.

The invention will be explained more in detail and by way of example with reference to an illustrative embodiment which is diagrammatically shown on the drawing.

The drawing shows an underground vehicle on the haulage road 11, which extends into the depth of the drawing from the working space 12, which is disposed at the end of the haulage road 11 and protrudes laterally from the cross-section of the haulage road 11. The material which has been recovered in the working space 12 is hauled along the haulage road 11 by means of the trackless under- ground vehicle 13, which is a self-propelled dumper. For this reason the vehicle 13 must be able to travel trans- versely in the working space 12 in the direction indicated by the double-headed arrow B and longitudinally along the haulage road 11 in the directions indicated by the double-
headed arrow A.

For a supply of electric power to the underground vehicle 15 driven by an electric motor a suspended sliding contact line 31 is provided, which extends throughout the length of the tunnel road 11 and has associated with it a track 311, on which a current collector device or current collector car 312 is movable. The current collectors of that device or car are in electric contact with the conductor rails of the sliding contact line.

The current collector car 312 is connected to a slip ring member 213, which is connected to a tension-resisting line 311, which leads to the vehicle 15 and consists of a supply cable that can be unwound from the cable reel 31 mounted on the vehicle 15.

The cable reel 31 is subjected to an adjustable restoring force, which during a longitudinal travel of the vehicle 15 in the directions indicated by the double-headed arrow A is so controlled that the traveling vehicle 15 will pull the current collector car 312 along. During a transverse travel in the directions indicated by the double-headed arrow B, that force is variable so that the cable 311 can be unwound from the cable reel 31 as the vehicle 15 moves away from the sliding contact line system and that the unwound cable 311 will not sag.

The slip ring member 213 associated
with the current collector car 212 ensures that the end of the line 31 will be oriented in the direction of tension (double-headed arrow C) during a travel of the vehicle 13 along the haulage road 11 in both directions indicated by the double-headed arrow A, i.e., during a travel toward and away from the working space. The slip ring member 213 also permits an orientation in dependence on the direction of travel of the vehicle 13 as it turns from the haulage road 11 into the working space 12 and during a transverse travel of the vehicle in the working space 12 in the directions indicated by the double-headed arrow B.

The cable is guided by a funnel 214, which precedes the slip ring member 213, and by a guide arm 312, which is coaxial to the cable reel 31 and is suitably pivotally movable relative to the cable reel 31 in a horizontal plane (double-headed arrow D).

It is understood that another slip ring member is provided in known manner between the cable reel 31 and the supply line leading to the electric motor mounted on the vehicle 13. That slip ring member is mounted on the vertical axle of the reel.

The advantages afforded by the underground vehicle in accordance with the invention are seen in that such vehicle can travel virtually unlimited distances
that the direction of travel of both arrow A, i.e., working space.

orientation in the vehicle 13 shows the working space within the vehicle indicated by reel 214, which guide arm and is suit-

slip ring on the cable reel electric motor

underground seen in that instances

and has a large width range even in roads in which the clearance space above the vehicle is very small.
The vehicle can also travel freely throughout its range of action without a twisting of the electric supply cable or other trouble with that cable.
The following statement is a full description of this invention, including the best method of performing it known to us.
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A trackless, center-pivot-steered underground vehicle having a tractor section, which is driven by an electric motor, which is powered via a sliding contact line, a current collector device, which is movable along said line, and a supply cable, which is electrically and mechanically connected to said current collector device, and adapted to be unwound from a reel against a restoring force, characterized by the following features in combination:
   a) the supply cable is connected to the current collector device by a slip ring member, which is rotatable about a vertical axle;
   b) a helically winding cable reel is mounted on the tractor section and rotatable about a vertical axle, which is provided with a slip ring member;
   c) a guide arm is coaxially arranged with respect to the cable reel and adapted to be pivotally movable by hydraulic means;
   d) a hydraulic axial piston transmission is coupled to a three-phase a.c. motor.

2. An underground vehicle according to claim 1, characterized by a disconnector provided on the current collector device for the supply cable.

3. An underground vehicle according to claim 1 or 2, characterized by a cable reel for exerting an adjustable tension on the cable.

4. An underground vehicle according to claims 1 to 3, characterized by a cable reel for exerting on the cable a tension which varies in dependence on the weight
of the cable which has been unwound.

5. An underground vehicle according to claims 1 to 4, characterized by drive means for rotating the cable reel and the guide arm in mutually opposite senses.

6. An underground vehicle according to claims 1 to 5, characterized in that an electric limit switch is mounted on the cable reel adjacent to the inner region of the coiled cable and is so located that the vehicle will be de-energized (stopped) when a predetermined length of the cable is still on the drum.

7. An underground vehicle according to claims 1 to 6, characterized in that at least two electric limit switches are mounted in combination on the cable reel adjacent to the outer region of the coil cable and are so located that the vehicle will be de-energized (stopped) when the cable between the guide arm and the slip ring member has the shortest permissible length.

8. An underground vehicle according to claims 1 to 7, characterized in that the cable reel comprises a coupling element for locking the guide arm to the cable reel.

DATED this 29th day of January 1986

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DRAWINGS
motor for driving the cable reel in dependence on the