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(57) Abstract

The primary energy source of the drive system is formed by a power machine, while the secondary or compensating energy source is formed by a flywheel. Between the flywheel and the driven machine there is a planetary gearing arrangement, in the output branch of which a drive branch with an infinitely variable transmission is interposed. Out of three elements of the planetary gearing arrangement having been arranged around the centre shaft, the arm is connected to the flywheel or to the driven machine, while the infinitely variable connection is always established between the gear connected to the flywheel and the central gear having been left free. Between the commoned output shaft of the primary energy source and the secondary - compensating - energy source, as well as the output shaft of the driven machine, there is a releasable clutch. In another version, at the output of the primary energy source there is a clutch, one engaging point of which is lying between the flywheel and the belonging planetary gearing arrangement, while the other engaging point lies between the planetary gearing arrangement and the driven machine.
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DRIVE SYSTEM FOR MACHINES BEING DRIVEN FROM MORE THAN ONE ENERGY SOURCES, IN PARTICULAR FOR VEHICLES

Technical field

The invention relates to a drive system for machines, being driven from more than one energy sources, in particular for vehicles, having been provided with a power machine, in particular an Otto-or Diesel motor, gas turbine or with an electromotor being supplied from the network, an accumulator or from a chemical energy source as a primary energy supply and containing as a secondary or compensating energy source a flywheel and between the flywheel and the driven machine an epicyclic gear /a planetary gearing arrangement/ is arranged, furthermore in the output branch /distributing branch/ there is a drive branch with an infinitely variable transmission with a loading possibility in both directions.

Background art

As a consequence of the general use of motor vehicles all over the world, in particular vehicles for mass-traffic partaking in urban traffic, the demand and endeavour has arisen to utilize the energy consumed in the brakes in course of frequent brakings to promote frequent acceleration by the provisional storage of kinetic energy. The energy crisis of the recent times and the battle against the ever increasing air pollution imperatively presses the solution of the problem.

Similarly, the results achieved recently by significant developing activities have shown that the compensating energy sources consisting of the epicyclic gear, the flywheel and the infinitely variable drive branch in-between, in the output branch can be successfully used for the utilization of the temporarily stored and regainable kinetic energy.
So e.g. the DE-OS 451 021 makes us acquainted with a solution, with which for the supply of the kinetic energy having been released in course of braking and for the application in certain required cases, between the axle-drive of the vehicle and the flywheel there is an epicyclic gear with an output branch, the drive branch of which with the infinitely variable transmission ratio is formed by a hydrostatic drive. Relating to the synchronization of the primary energy source, the compensating energy source and the axle-drive no teaching can be obtained from said publication.

In the DE-AS 2 515 048 reference is made, in so far as in certain, frequently occurring operational cases it seems to be expedient to establish a direct driving connection between the primary energy source and the axle-drive of the vehicle also with the driving systems with a compensating energy source, while in the DE-OS 2 641 886 it has been proposed to couple the flywheel sidewise to a drive with an essentially traditional automatic transmission via a clutch by inserting an intermediate auxiliary drive. In this case the automatic transmission is formed as an epicyclic gear with an output branch.

In the DE-OS 2 554 157 it has been proposed to connect the parallel-connected primary energy source and the energy accumulator with the flywheel to one of the drive branches of the epicyclic gear with output branch, while the other drive branch with an infinitely variable transmission ratio containing a device for reversing the sense of rotation is applied as a control drive branch having been connected to the primary energy source.

The DE-AS 2 444 564 describes a drive system for vehicles, where a flywheel and two electric or hydrostatic rotary machines are applied, which enable the mutual infinitely variable drive. In such a manner it can be realized that the primary engine and the flywheel can
collectively drive the vehicle, besides the energy having been released in course of braking is led into the flywheel. By means of a change-over clutch, in one position thereof the primary engine is driving directly the vehicle, while in the other position of the clutch the flywheel is driven. The drive system also contains an epicyclic gear, however, since one of the central gears, the internally toothed annular gear has been fixed in the house, the output is not branched-off, accordingly, the connection transmitting rotation could be established between the flywheel and one of the rotary machines only. In such a manner, either in the driven or in the braking state the total output is transmitted to the infinitely variable drive between the flywheel and the shaft of the driven machine.

In the DE-OS 2 436 546 a drive system for vehicles has been specified, where the contained elements are similar to those having been previously described, and the flywheel is connected to one of the rotary machines and to the sun gear of the epicyclic gear. The two rotary machines are producing a drive with an infinitely variable transmission between the sun gear of the epicyclic gear and the ring gear, i.e. between the flywheel and the driven machine. By means of the frictional clutch having been applied between the arm and the ring gear, the epicyclic gear may be closed, that means, the speed of rotation of all elements are rendered identical.

This arrangement, however, does not enable the transmission of a low and high output, respectively, at the different speed of the vehicle. The low speed of the vehicle is accompanied by a low, the high speed by a high speed of rotation of the engine, whereas a significant part of the output arriving from the flywheel and the engine itself has to pass through the infinitely variable drive having been realized between the sun gear and the ring gear.
At last, in the US-Patent 3 870 116 a drive system for motor vehicles has been described, where in addition to the internal combustion engine there is a drive with a branched-off output and with an infinitely variable transmission -- incorporating the flywheel and the epicyclic gear -- arranged, and the flywheel and the sun gear of the epicyclic gear are interconnected, while the axle-drive of the vehicle is partly connected to an arm by means of a drive with a constant transmission, partly it is connected to the ring gear by means of the drive with a variable transmission. In this case, the drive with the branched-off output has been realized, however, due to the disadvantageous arrangement of the elements, the main advantage of the drives with an output branch -- namely that the range of modification of the infinitely variable drive can be widened to such an extent that the speed of rotation of the output shaft could be reduced to zero -- could not be realized with the system according to the US-Patent. As a consequence, the connection between the drive of the flywheel and the axle-drive of the vehicle becomes possible only, when the internal combustion engine has already accelerated the vehicle nearly to the final speed. In such a manner the flywheel is unable to partake either in acceleration or in deceleration to the required extent.

The common characteristics and simultaneously the drawback of the known solutions mentioned above lie in that the requirements regarding to the compensating energy storing drive-systems cannot be met and if, so by making considerable compromises, and as a consequence, the various advantages yielded can be utilized partially only. When compared to the known traditional drive systems, the previously described systems do not show a surprising advantage resulting in a general use and can be taken into consideration as drives only for vehicles of predetermined character, destination and output capacity.
Up to now it has been an unsolved problem to develop complete drive systems, essentially consisting of three components, i.e. the power machine serving as a primary energy source, the compensating energy storing unit with the flywheel and the epicyclic gear with the output branch as a secondary energy source and the machine to be driven, which are showing concrete favourable properties and advantages regarding to economicalness, operational characteristics, controllability by means of the usual operating and handling elements and the reaction to the usual intervention of the driver using said elements.

Disclosure of Invention

The aim of the invention is to develop a system for the possibly most wide spectrum of working machines, in particular motor vehicles, resp. for the different types thereof, which enables the practical realization of drive systems being free of the imperfectness of the known solutions, simultaneously showing up the useful features of the advantageous partial measures having been taken.

The invention is based on the recognition that from the point of view of the formation of the drive system optimally complying with the majority of requirements, the previously mentioned combination of the primary energy source, the secondary energy source, i.e. the compensating energy storing unit and the engine are to be examined and considered as a system, simultaneously taking the points of view of controllability and driving into consideration. In sense of the invention and the aim set, the drive system having been provided with the flywheeled energy accumulator has to enable that by means of the flywheel the motor vehicle could be accelerated from the "zero"-speed - i.e. from the stationary state -, and when braking, energy could be re-fed into the flywheel down to the possible lowest speed and the brake torque could be ensured. In addition to this, in every mode of operation it has to be ensured that just a minimal part of the out-
put to be transmitted should pass through the drive branch-
es with an infinitely variable transmission ratio to be
applied in the drive system.

In accordance with the invention the aim set has
been realized in such a manner that for machines to be
driven from more than one energy sources, in particular
to vehicles, as a primary energy source an engine is used,
while as a secondary or compensating energy source a drive
having been provided with a flywheel is applied; between
the flywheel and the driven machine there is an epicyclic
gear /a planetary gearing arrangement/ arranged and in
the output branch thereof there is a drive branch with an
infinitely variable transmission, with the possibility of
bidirectional loadability; out of the three element of the
epicyclic gear having been arranged around the central
shaft, the arm is coupled to the flywheel or to the driven
machine, while the infinitely variable connection is
arranged in both cases between the gear having coupled
to the flywheel and the central gear having been left
free.

In accordance with the invention the assembly of
the drive system can be performed in two different ways.
In one case between the joined terminals of the
primary energy source and the input of the machine there
is a releasable clutch arranged. In the other case at the
output of the primary energy source a clutch is arranged
and one engaging point of which is lying between the fly-
wheel and the belonging epicyclic gear, while the other
engaging point is to be found between said epicyclic
gear and the driven machine.

In a given case an embodiment may be considered
as advantageous, where in the drive belonging to the
energy storing flywheel a further infinitely variable
drive branch being coupled to the output shaft is contained.

With a further preferred embodiment the primary
energy source is represented by an electric rotary machine,
furtheron the drive having been arranged in the output
branch of the epicyclic gear between the flywheel and the driven machine with a loading possibility in two directions and with an infinitely variable transmission is arranged between the electric rotary machine being coupled to the flywheel and the electric machine being coupled to the sun gear; at last, the function of the change-over and of any other mechanical switching devices of the drive belonging to the flywheeled energy accumulator are realized by means of electric switches having been inserted into the network between said rotary machines.

One of the main groups of the drive systems according to the invention is represented by the solutions, which contain a transmission being directly or indirectly coupled to the axle-drive input of the motor vehicle, and which establishes a kinematically rigid connection between the output shaft of the primary energy source or the intermediate shaft having been connected to the former one in a torque-transferring manner, i.e. any other driving element and the output shaft of the secondary energy source. Within this group, at the drive systems included in the first sub-group, between the output of the transmission and the input of the axle-drive there is a clutch arranged. This kind of driving chain enables the production of cheaper and more simple constructions, mainly for equipments with lower capacity and mainly in cases when the engine of the primary energy source is an Otto-motor, which used to be provided with an infinitely variable drive as a drive system. In the released position of the clutch, in a stationary of freely rolling state of the vehicle the flywheel can be accelerated by means of the primary energy source. In a locked position of the clutch the flywheel and the primary energy source are collectively driving the vehicle. In course of deceleration, accompanied by the back-feed of the energy, the primary energy source may be in an inoperational state or it may charge the flywheel. The clutch may simultaneously perform the
function of a safety element delimiting the torque. At the drive system according to the invention, provided with a transmission and forming the other sub-group, between the output shaft of the primary energy source and the transmission an alternative clutch transferring the torque is inserted, to the common input of which the output shaft of the primary energy source is connected, to one of the alternative output the drive branch leading to the transmission and to the other alternative output the flywheel of the secondary energy source is directly or indirectly connected. Expediently the clutch is having a neutral mid-position, which separates the primary energy source from the system.

Although the drive systems forming the latter sub-group are somewhat more complicated, but they can advantageously used, when the engine of the primary energy source is able to transmit a partial output with a high efficiency, with an optional speed of rotation, as e.g. the electromotor, the Diesel-motor or the gas turbine. In such a manner it might be sufficient to use a multi-stage transmission with a high efficiency with the primary energy source, the more, in a given case it can be even omitted. Furtheron, it can be considered as advantageous, if in one of the end-positions of the clutch the output passing towards the flywheel from the primary energy source is bypassing the infinitely variable drive of the secondary energy source, however, in the other end-position the infinitely variable drive branch is bypassed, when the output passes towards the axle-drive. This arrangement yields the possibility to drive the axle-drive by means of the primary energy source via the infinitely variable drive branch. In case, if the engine of the primary energy source is formed by an electromotor without a transmission, or the drive of the motor of the primary energy source is a transmission with a frictional clutch with a few stages only, it can be substituted or completed by the drive of the
secondary energy source. In one position of the clutch the vehicle may be started with a high moment, while in the other position a soft and comfortable start becomes possible. The driver may choose, but it seems to be better solution to perform automatization by means of the program control. A forced synchronization of the clutch is imperative.

From the prior art it is well known that in the equipments having been described in the introduction, a compensating energy source - consisting of the flywheel, the epicyclic gear and the drive branch with a variable transmission ratio having been inserted inbetween, into the output-branch - is to be used as a secondary energy source. However, according to the tests performed and the recognition gained, from the point of view of economicalness and advantageous effects it is of utmost importance which element of the epicyclic gear is used for a certain function, i.e. whether the arm, the sun gear or the ring gear of the epicyclic gear is used for the introduction and deduction of the output, respectively, furtheron, to which of the elements of the epicyclic gear the infinitely variable drive -- having been inserted into the output branch -- should be connected. In course of the detailed description of the example we shall revert to this question.

With the driving system according to the invention, in particular, when the drive cabin comprises exclusively mechanical elements, it seems to be expedient to use variators with V-belts or any other continuous straplike driving elements as infinitely variable drives. In a given case said variators can be provided with a special adjusting or belt-tightening device, which is able to increase the tightness of the belt in case of the transmission of a higher output.

With drive systems having been dimensioned for a higher output, an infinitely variable drive consisting of
hydrostatic rotary machines may be advantageously used. The losses can be considerably decreased if for both of the rotary machines variable piston displacements are chosen, as in such a manner the ratio of the speed of rotation required for the two elements being engaged with the infinitely variable drive branch of the epicyclic gear can be realized by means of the absolute piston displacement, i.e. by the medium quantity to be delivered, accurately corresponding to the output requirement to be transferred. By increasing the absolute piston displacement, the output to be transferred can be temporarily increased and exclusively for this span of time, when it is required. This is to be considered as measures being analogous with the temporarily increased tightness of belts of the variator with V-belt to be performed in course of the transmittance of higher outputs.

Increase of the starting torque can be performed in a most significant and advantageous manner, in so far as a further, a second drive branch with an infinitely variable transmission ratio is connected to the epicyclic gear. In a given case a mechanical variator, e.g. with a V-belt can be also used, however, a really significant advantage can be achieved if said second drive-branch is applied in addition to the first infinitely variable drive-branch having been formed as a hydrostatic or electric drive branch, expediently by using a third rotary machine of identical character. In such a case practically a rotary machine each is coupled directly or indirectly to all the three elements of the epicyclic gear, i.e. the arm, the ring gear and the sun gear, as a consequence, these can be interconnected by pairs into different infinitely variable drive branches by using proper electric or hydrostatal switching organs in compliance with the prevailing requirements.

Accordingly, the essence of the invention is
represented by the assembly of the system comprising a primary, a secondary energy source, as well as a motor into a proper drive chain, which allows in every single occurring provisional and constant mode of operation the energies prevailing in the system to pass through the drive branches with minimal losses and to avoid resp. to minimize the inner output streams in the epicyclic gears with output branches, being unavoidable idle owing to their character, to the maximal extent. In addition to this, the drive systems according to the invention enable the system control by using the traditional manipulating elements being analogous with the usual ones.

Brief Description of Drawings

The invention will be described in details by means of schematical diagrams and kinematic schemes of embodiments by the way of example, with reference to the accompanying drawings, wherein:

Fig. 1 is showing the schematical diagram of one of the sub-groups incorporating the axle-drive of the drive system according to the invention,

Fig. 2 is the schematical diagram of another group of the drive system,

Fig. 3a and 4a are showing the different possible modes of engagement of the main structural elements of the epicyclic gear, as well as the version of the interposition of the infinitely variable drive branches into the output branch,

Fig. 3b and 4b are diagrams illustrating the energy streams having been realized by means of the engagements according to the Fig. 3a and 4a,

Fig. 5 to 11 are showing the kinematic diagrams of the
different embodiments to be used with the
drive systems of motor vehicles, where the
motor of the primary energy source is an in-
ternal combustion engine,

Fig. 12
   is showing the kinematic diagram of an em-
   bodiment comprising exclusively D.C. electric
   rotary machines.

Best Made of Carrying out the Invention

In Fig. 1 and 2, respectively, expedient sche-
matical diagrams resp. the possible assembly of the
kinematic drive chain according to the invention are
illustrated; the drive chain interconnects into an advan-
tageous complex driving unit the system consisting of the
primary energy source -- containing in: the majority of
cases the power machine provided with the drive 11, in
particular the motor 10, -- of the secondary energy source
2 -- comprising the flywheel 20, the epicyclic gear 210
and an energy accumulator with a drive 21 with the output
branch containing at least one infinitely variable drive
branch 240 -- and of the machine with the input shaft 32,
in particular, the axle-drive 3 of the vehicle.

The kinetic drive chain according to the invention
comprises the engaging point 4 /in general a transmission/
interconnecting kinematically the output shaft 12 of the
primary energy source 1 or an intermediate shaft 61,
which can be engaged in a torque-transferring manner
with the latter one, and the output shaft 22 of the
secondary energy source 2 and said engaging point is to
be continued in the driving shaft 42 having been connect-
ed indirectly /Fig. 1/ or directly /Fig. 2/ to the exist-
ing power machine, in particular to the input shaft 32 of
the axle-drive 3. With the concrete embodiment said trans-
mission 4 is not separated from the other functional
driving elements as a structurally independent unit, in

Fig. 1 and 2 it is illustrated with a separate reference
number for the sake of better understanding.

In case of the schematical arrangement according to Fig. 1 the output shaft 12 of the energy source 1 and the output shaft 22 of the secondary energy source 2 are connected directly and with a steady character to the transmission 4, while between the drive shaft 41 of the transmission and the input shaft 32 of the axle-drive 3 a releasable clutch 5 is interposed.

On the contrary, in Fig. 2 an arrangement, i.e. a kinematic drive chain may be seen, with which between the output shaft 12 of the primary energy source 1 and the transmission 4 a clutch 6, being suitable for the alternating torque transmission is inserted, to the commoned input of which the output shaft 12 of the primary energy source 1 is connected, while to one of the alternative outputs of the intermediate shaft 61 leading to the transmission, and to the other alternative output there of the transmitting shaft 62 is connected. Expediently the clutch 6 may have a neutral position, in which the primary energy source 1 is separated from the drive chain. In certain cases it seems to be advantageous to insert a clutch 5 between the transmission 4 and the axle-drive 3.

With complex driving units of a lower output, in particular, when an Otto-motor having been provided with the drive 11 is used as a primary energy source, due to its simplicity and relative cheapness the schematical arrangement according to Fig. 1 should be used.

Although the arrangement according to Fig. 2 is somewhat more complicated, it represents a better solution with less losses; the application seems to be advantageous in cases when the primary energy source 1 is to be able to transmit a partial output with a high efficiency with an optimal speed of rotation, so e.g. a D.C. electromotor, a Diesel-motor or a gas turbine. In these cases even a multi-stage transmission may suffice as a drive 11, the
more, in certain cases the drive 11 may be even omitted.

With all the embodiments of the drive according
to the invention the application of the epicyclic gear with
an output branch possessing an infinitely variable drive
branch, as a drive — assumed to be known in itself —
it playing a decisive role. The application of an epi-
cyclic gear with an output branch as a drive of the se-
condary energy source is imperative, while the use as a
drive 11 of the energy source 1 may prove as advantageous
and expedient in several cases.

Furthermore, by the aid of the Fig. 3a, 3b and 4a,
4b, respectively, we are dealing in details with the cases
and arrangements, in which the epicyclic gears with an
output branch — expediently containing mainly spur gears —
can be used in drive systems according to the invention.
From the point of view of losses resp. the directions of
the energy stream being realized in the drives it is of
consequence, to which element of the epicyclic gear 15
— containing the sun gear 7, the ring gear 8 and the arm
13 supporting the planet pinions 9 — the varied output
drive is connected, and which of them should be connected
to the infinitely variable drive branch 14, being in de-
pendence of the prevailing requirements generally a variator
with a V-belt, or a hydrostatic drive containing hydraulic
rotary machines or electric drive having been assembled
of electric rotary machines.

In case of the epicyclic gear with the output
branch — having been illustrated in Fig. 3b for the sake
of example — the unvaried output is led from the engine
or the flywheel to the arm 13 of the epicyclic gear, which
is forking on the planet pinions 9; a part of the output
is recirculated via the sun gear 7 and the infinitely
variable drive branch 14 to the shaft of the arm 13,
while the useful output is forwarded from the planet
pinions 9 to the ring gear 8 forming the output shaft
of the drive. The relating output and moment stream, respectively, is to be seen in Fig. 3a.

On the contrary, with the arrangement shown for the sake of example in Fig. 4b in a schematical diagram - in so far as the sun gear 7, the ring gear 8 and the arm 13 are rotating in the same direction - an output stream may be realized, which has been illustrated in Fig. 4a. In this case the unvaried input power arrives at the ring gear 8 of the epicyclic gear 15 and by means of a branch, via the infinitely variable branch 14, it is led also to the sun gear 7. The output arriving via the ring gear 8 and the varied output coming from the sun gear 7 are added on the planet pinions 9 and after having been joined, they leave the drive through the arm 13. From the version according the Fig. 3a and 3b, respectively, an output may be gained, which corresponds to the idle output circulating in the epicyclic gear 15, i.e. the output which can be transmitted through the infinitely variable drive branch 14. However, its advantageous feature lies in, that it can be well applied without any interruption in the range between zero, the more, between the negative speeds of rotation, and the speed of rotation corresponding to the final speed, while with the version shown in Fig. 4a and 4b, respectively, the speeds of rotation ranging from zero to the final speed, i.e. the whole range of the speed of rotation cannot be spanned, there is an interruption therein, that means that certain transmissions cannot be realized. With the drive according to Fig. 4a and 4b two modes of operation are possible. At one of the modes of operation the sun gear 7 is rotating in an opposite direction in relation to the ring gear 8, in this case the behaviour of the drive is rather similar to that of the epicyclic gear according to Fig. 3a and 3b in respect to output transmission. At the other operational mode the sun gear 7 and the ring gear 8 are rotating in the same sense,
and the outputs are added. Between the two operational
modes there is a break, which can be compensated by braking
the sun gear 7 in such a manner that within the range of
break a fixed transmission ratio is to be established; by
applying a further clutch, by the aid of which the epi-
cyclic gear can be locked in such a manner that e.g. the
sun gear 7 becomes engaged with the arm 13, within the
second infinitely variable range a fixed transmission ratio
can be established, through which the output can pass
essentially without any loss.

Below we shall mainly deal with the drive systems
previously described and schematically illustrated in
Fig. 1 and 2, serving in certain cases as the drive 11
of the primary energy source 1, and in particular with
the drive systems according to the invention containing
the epicyclic gears with the output branch and being
applied in the drive 21 of the secondary energy source 2,
as it is to be seen in Fig. 3a, 3b and 4a, 4b respective-
ly.

In Fig. 5 a drive is to be seen, well suitable
for passenger cars, with which the arrangement of the
kinematic drive chain essentially corresponds to that
of Fig. 1. The primary energy source is a motor 10, having
been provided with the drive 11 — formed as an epicyclic
gear with output branch, engaged in sense of the Fig. 4a
and 4b, respectively, with an infinitely variable drive
branch; the motor is advantageously an Otto-motor and
it is arranged on the front part of the vehicle.

Otherwise, the vehicle has a rear wheel drive and
the drive 21, having been provided with the epicyclic
gear with the output branch, infinitely variable driven
— according to Fig. 3a and 3b — and also provided with
a flywheel being symbolized by means of the shaft 201,
serving as a secondary energy source, is arranged in the
vicinity of the axle-drive 3 with the differential 31
driving the differential shafts 34, 35 of the wheels not
illustrated here, in the rear part of the vehicle and it
is connected to the primary energy source 1 via the out-
put shaft 12 formed as a transmission shaft.

The releasable clutch 5, by the aid of which the
axle-drive 3 can be separated from the other driving
units, is arranged between the axle-drive 3 and the trans-
mission 4 having been realized by the bevel gear 43 wedged
onto the output shaft 12 and co-operating with the bevel
gear on the rear side of the ring gear 212 of the drive 21.
The motor 10 is transmitting to the ring gear 112 of the
drive 11, where the input -- after having been branched
off -- arrives directly through the planet pinions partly
to the arm 111 being in a rigid connection with the out-
put shaft 12, partly it arrives at the sun gear 113, by
the intervention of the gears 130 resp. 131, through the
reversing means containing the engaging gears 194 and 196,
which can be alternatively engaged via the variators
comprising the V-belt pulleys 143, 146 having been wedged
onto the shafts 142 resp. 144 and used as a drive branch
with an infinitely variable transmission, as well as con-
taining the parasite wheels co-operating with the wheels
194 and 196; hereafter the input arrives /likewise by the
intervention of the planet pinions/ repeatedly to the arm
111.

If the claw clutch 195 is lifted upwards by
synchronization, the engaging gear 194 is fixed to the
shaft, accordingly, the sun gear 113 and the ring gear 112
will rotate in the same direction. In this case an oper-
ational mode being advantageous for high-speed advance
will be realized. However, when the arm 111 and the sun
gear 113 are rigidly /co-rotating/ coupled by means of the
clutch 160, the previously mentioned, essentially loss-free
fixed stage can be realized.

For the reverse motion, for zero and low speed
the claw clutch 195 is to be moved downwards, whereby the
engaging wheel 196 is fixed to the shaft. In this case
the ring gear 112 and the sun gear 113 will rotate in an
opposite sense. This mode of operation can be considered
as a starting stage. The V-belt pulleys 143, 146 with a
relatively large diameter and requiring a large axle-to-
axle distance, are arranged in the front part of the
vehicle in a freely accessible manner; in order to be able
to increase said axle-to-axle distance, at least into one
of axles hinges are to be built in. The flywheel with the
vertical shaft 201 and the pair of bevel gears 202 trans-
mit to the transversal arm shaft 203 of the drive 21
having been arranged in the rear part of the vehicle;
from here the drive arrives at the gear 212 and at the
driven annular disc of the clutch 5 having arranged there-
on. Similarly, the bevel gear 43, as a transmission, is
transmitting onto the ring gear 212. The output having
been branched off by means of the pair of bevel gears 241
wedged onto the arm shaft 203 to the drive branch with an
infinitely variable transmission arrives through the
variator with the V-belt containing the V-belt pulleys
243, 246 arranged on the shafts 242 resp. 244 and via the
bevel gear 245 to the sun gear 213 and therefrom it streams
back via the planet pinions to the arm 211.

In accordance with the arrangement as illustrated
in Fig. 3a and 3b, the output torque is produced in such
a manner that the sun gear 213 is braked and thus it re-
transmits to the arm-shaft 203; as a consequence, a
tangential force will arise, which is corresponding to
the force arising on the teeth of the sun gear 213 and
the pitch circle thereof, respectively. The commoned out-
put of the drives 21 and 11 is forwarded to the differen-
tial 31 of the axle-drive 3 by means of a pair of spur
gears 311 having been wedged onto the half-clutch of the
clutch 5 being supported in bearings on the part of the
ring gear 212, which is lengthened in a tubular shaftlike manner, i.e. onto the input shaft 32 and the differential 31. In a released state of the clutch 5 the flywheel can be accelerated to the required energy level even in a stationary state of the vehicle. Release of the connection may be desirable on other occasions, too.

The varior with the V-belt comprising the V-belt pulleys 243 and 246 is provided with a special device for tightening the belt, the aim and destination of which is to keep the tightening and the accompanying losses at a relatively low value when an inconsiderable output is transmitted, while during the transmission of the output, i.e. when transmission is changed, tightening of the belt could be considerably increased. In such a manner a varior-type being well suitable for the transmission of output can be obtained.

The lower part 2431 of the V-belt pulley 243 is fixed rigidly to the shaft 242, the half-disc 2432 is co-rotating with the shaft 242, simultaneously it is able to shift axially thereon. The adjusting arm 2433 is pressing the movable half-disc 2432 -- by the intervention of the thrust bearing not illustrated here -- to the fixed half-disc 2431. The adjusting arm may freely move towards the shaft mentioned before, while the guide stem 2434 can also move freely in the same direction in the conduit having been fixed to the house of the axle-drive 3. The buffer disc 2435 is rigidly fixed on the guide stem 2434. The buffer disc 2436 can be adjusted by means of the bolt 2437, while during the operation it is in its fixed position. The stretcher arm 2439 is connected to the adjusting arm by means of the transfer bar 2438, whereas by means of the transfer bar 2468 it is connected to the adjusting arm 2463. Prior to use, the desired tightness of the V-belt 247 is to be adjusted by means of the bolt 2437. The transmission of the varior with the V-belt can
be changed by means of the described device in the following manner:

Acceleration: the stretcher arm 2439 is pressed by the aid of the throttle pedal in the direction and on the spot indicated by the arrow. This force brings nearer the movable half-disc 2462 to the stationary half-disc 2461 by means of the transfer bar 2468 and the adjusting arm 2463. As a consequence of this displacement the V-belt 247 gets onto the circle of larger diameter and it is forced onto the circle of smaller diameter of the other disc. This change becomes possible by the withdrawal of the half-disc 2432 from the half-disc 2431.

As a consequence of the changed diameters the sun gear 213 is slowing down and in accordance with the partial figure on the right side of Fig. 3 the ring gear 212 and accordingly the vehicle accelerates. According to the operational mode having been described up to now, the guide stem 2434 was displaced in the conduit fixed to the house, and the mutual position of the adjusting arms and in relation to the stem did not change, that is to say, all the components having been thereon were moving together with the guide stem. When the throttle pedal is pressed down vigorously and the pressing force is even increased by means of a mechanical servo and changing of the transmission cannot take place rapidly enough, the stretcher arm 2439 - supported by the transfer bar 2468 - is tilting counter-clockwise and is pulling the half-disc 2432 nearer to the half-disc 2431 by means of the adjusting arm 2433. As a consequence of this displacement the V-belt is tightened on the disc to a greater extent and accordingly, it will be able to transfer a higher output without sliding. By tightening the V-belt only to the necessary extent, the losses are reduced and simultaneously the useful life of the V-belt 247 will be increased.

When decelerating, the stretcher arm 2439 is
pulled in the direction and on the spot as indicated by the left arrow. Expediently this displacement is performed by means of the brake pedal in such a manner that first the mechanism should be put into operation and the traditional frictional brake should function only after the reduction of the vehicle speed.

The drive system shown in Fig. 6 for the sake of example is identical or similar to the equipment shown in Fig. 5 in several respects, accordingly, we shall deal with the differences only. One of the differences lies in that the drive 11 connected to the motor 10 of the primary energy source is assembled in accordance with the principle shown in Fig. 3a and 3b, respectively. With this solution the driving shaft of the motor 10 is connected to the arm 111, while the output shaft 12 is coupled with the ring gear 112. Said drive is well suitable for establishing two stages with fixed transmissions within the range of the infinitely variable transmission in such a manner that a brake resp. clutches having been interposed in the proper place are used. One fixed transmission stage is realized by braking the sun gear 113 in such a manner that by means of the brake 170 fixed onto the end of the shaft 140 of the gear 141 being engaged with the sun gear 113 via the 145 -- the end of said shaft being led through the gear-box -- the sun gear 113 is braked and fixed. Simultaneously, the connection between the shaft 144 of the V-belt pulley 146 of the infinitely variable drive branch and the arm 11, i.e. the shaft 139 of the motor 10, having been established by means of the gears 138 and 147 has to be ceased by releasing the clutch 180, since by means of the variator with the V-belt a transmission ratio, namely that of the V-belt pulley 143, cannot be realized. The other fixed transmission ratio, i.e. stage can be obtained in such a manner that the sun gear 113 is rigidly connected to
the arm 111, i.e. to the shaft 139 of the motor 10 by means of the clutch 160.

In the drive 21 of the secondary energy source the flywheel with the vertical shaft 201 is driving through the pair of bevel gears 202 the arm 211 of the epicyclic gear i.e. its shaft 200, however, in this case the output arrives by the aid of the pair of spur gears 44 forming the transmission, through the sun gear 213 and after having been joined with the drive arriving from the cardan shaft forming the output shaft 12 of the primary energy source, it comes to the clutch 5, from where it is led via the pair of bevel gears 236 to the differential, whereas the varied output is recycled through the ring gear 212, the infinitely variable drive branch including the variator with the V-belt and the V-belt pulleys 243, 246 and through several spur gears having been partly supported in bearings in a free running manner to the shaft 200 of the arm 211.

Otherwise, the arrangement of the main elements within the vehicle is quite identical with that shown in Fig. 5 and the kinematic drive chain is also realizing the schematical arrangement shown in Fig. 1, in so far as the energy stream composed of the joined output coming from the flywheel and the motor and streaming towards the axle-drive 3 may be interrupted by means of the clutch 5. In this case, in the drive 21 of the secondary energy source the infinitely variable drive branch is driven from the ring gear, since in case if the drive took place from the sun gear, it could not have been directly matched to the variator with the V-belt due to the rather high speed of rotation.

In the Fig. 5 and 6 it can be equally seen that the discs of the variators with the V-belts must be always arranged on the shaft-ends, expediently on the front and rear part of the vehicle, under the mantle, behind the
buffer elements. Taking the required longer axial distances into consideration, universal joints are to be inserted into the shafts of the V-belt pulleys.

With the embodiment according to Fig. 7 infinitely variable drive branches with variators with V-belts have been applied in the drives with an epicyclic gear with output branch, the axial distance of which is lying in the order of magnitude of the usual and necessary axial distances of gear drives. With this embodiment the drive system has a rather compact construction, it can be arranged together with all the main components either in the front or in the rear part of the vehicle, with an axle-drive with a half swing-axle. Also in this case the motor 10 of the primary energy source is expeditiously an Otto-motor, the drive 11 is essentially arranged as it is to be seen in Fig. 4a and 4b, respectively; in the drive of the secondary energy source the flywheel is engaged with the arm 211 of the epicyclic gear, the output shaft to the ring gear 12, while the infinitely variable driven branch /at both drives a variator with a metal V-belt, having been arranged in the oil sump resp. gear-box/ is interposed between the arm and the ring gear. In this case, in such a manner we are confronted with an arrangement according to Fig. 3a and 3b, but with a slight difference.

The drive system according to Fig. 7 is realizing also the schematical arrangement according to Fig. 1; by means of the clutch 5 having been inserted before the differential 31, the already commoned drive chain can be released resp. interrupted. With this embodiment the differential can be realized essentially in such a manner that the drive 11 of the primary energy source and the drive 21 of the secondary energy source have a common output shaft 12, 22, onto which one of the engaging elements of the clutch 5 is wedged. The ring gears 112, 212 of the drives 11, 21 are serving simultaneously as
axially consistent half-discs to the V-belt pulleys 143, 243, owing to the conical shape of their rear face. The other half-discs, which can be displaced axially and their carrier organs are only outlined. In the drive 11 of the primary energy source the epicyclic gear is arranged in accordance with Fig. 4a and 4b. In this case establishment of the fixed transmission stage, i.e. the braking and fixing of the sun gear 113 is performed by the brake 170 being subordinated to the shaft of the parasite wheel 193. Sense of rotation of the sun gear can be selected by the alternatively functioning frictional clutches 191 and 192. In the fixed state of the clutch 191 the sun gear is co-rotating with the ring gear, while in a fixed state of the clutch 191 it is rotating in an opposite direction.

In Fig. 8 a further expedient embodiment of the drive system according to the invention is shown, which can be used advantageously in passenger cars with frontal drive. The primary energy source is the drive 11 connected to the Diesel-motor 10 - known in itself and therefore not detailed here - provided with a multi-stage transmission.

The kinematic chain of the drive corresponds to the schematical arrangement according to Fig. 2, where the output shaft 12 of the primary energy source is simultaneously forming the input of an alternative clutch 6, and the claw clutch element 60 thereof connects the primary energy source either directly to the differential of the axle-drive 3 via the gears 36 and 361, or to the arm 211 of the epicyclic gear with output branch with the infinitely variable drive branch belonging to the secondary energy source, i.e. to the shaft 203, which again is engaged with the flywheel with the 201 via the pair of bevel gears 202. It seems to be advantageous if the clutch 60 has also an idle, a neutral position.

In the drive 21 of the secondary energy source the output epicyclic gear is formed by the gear ring 212,
which is connected via the spur gears 218, 219 and the
torque-limiting safety clutch 33 to the input of the
differential 31 of the axle-drive 3. The drive branch
realizing the infinitely variable transmission ratio is
driven by means of the special variator with V-belts
having been interposed between the sun gear 213 and the
arm 211 of the epicyclic gear; the variator is provided
with the narrow V-belts 247. In order to find room for
the V-belt pulleys before i.e. beside the differential
shaft 34 of the axle-drive 3, the driving torque having
been branched off from the arm shaft 203 is first trans-
ferred to a parallel tubular shaft 229, whereby the
axial distance suffices for connecting the other end of
the infinitely variable drive branch to the sun gear 213,
accordingly, -- in a most advantageous manner -- the ring
gear 212 may form the output element of the epicyclic
gear. The V-belt pulley 243 is wedged onto the tubular
shaft 229 in a co-rotating manner, while the V-belt
pulley 246 is connected to the shaft 244 -- having been
led through the tubular shaft 229 -- in a torque-trans-
ferring manner, simultaneously it is engaged with the
sun gear 213 via the spur gears 214, 215. The upper half-
disc of the V-belt pulley 243 is fixed on the tubular
shaft 229, while the lower half-disc is fixed on the
shaft 244 also in axial direction. The inner disc-halves
238, 239 of the V-belt pulleys may be displaced in the
axial direction and are bearing up against one another
by means of the thrust bearing 248, as in general their
speed of rotation is different. On a further parallel
tubular shaft 2441 having been arranged in a proper dis-
tance and being driven by the V-belt 247, the V-belt
pulleys are essentially fixed and carried in an opposite
direction. The central twin-pulleys 2442 are also axially
fixed on the shafts, whereas the other half-discs 2443 and
2444 can be axially displaced. This axial displacement
represents the place of intervention, where change of transmission can be performed i.e. where influencing of the transmission ratios becomes possible. The lower half-disc 2443 has a solid passing axle, while the movable part of the upper half-disc 2444 is provided with an actuating element having been led through the tubular shaft, which -- when connected to a pulley each -- forms the intervention element of the infinitely variable drive. This special variator with the V-belt may be provided with a hinged device, which increases the tightening force, when the output to be transmitted is increased /as having been described in details in connection with the Fig. 5/. By means of the belt tightening device at the increase of the adjusting force the stretcher arms 2439 are tilted, as a consequence, the pressure plate 2445 being fixed in the half-disc 2443 is moving upwards, while the pressure plate 2446 being fixed in the half-disc 2444 is moving downwards. In such a manner the movable half-discs are approximating each other, at the same time the belts - compared to their starting position - will be tightened to a greater extent.

The layout and function of the drive system according to the invention, shown for the sake of example in Fig. 9 can be easily perceived on basis of the previous examples. In this case the motor of the primary energy source is a Diesel-motor and as a drive 11 expediently a multi-stage or any automatized speed-gear may be used. The alternative clutch 6 having in a given case three positions consists of the two frictional clutches 63 and 64. By closing the clutch 64 the output shaft 12 is directly connected to the differential 31 of the axle-drive 3, while in the closed position of the clutch 63 the output shaft 12 connects to the input shaft 203 driving the arm 211 of the epicyclic gear of the secondary energy source with an output branch and with a drive branch with infinitely variable transmission ratio, at the same time
the input shaft 203 is connected to the flywheel with the shaft 201 via the pair of bevel gears, 202. The element of the epicyclic gear transmitting the output to the differential 31 is formed by the ring gear 212, while the drive branch containing the variator with the V-belt /not detailed here/ has been interposed between the arm 211 and the sun gear 213 of the epicyclic gear via the bevel gear pairs 224 and 245, respectively, changing the axial direction.

The special feature of the embodiment serving as an example lies in that it is also provided with a torque converter or a hydrodynamatic clutch 220 connecting the sun gear 213 of the epicyclic gear and the ring gear 212, which is well suitable for establishing a second infinitely variable but unidirectional drive branch between the sun gear 213 and the output ring gear 212 in such a manner that the sun gear 213 is connected to the pair of spur gears 223, 225, the housing 221 of the clutch 220, resp. to the pump wheel thereof, while the ring gear 212 engages with the turbine wheel 222 of the clutch. In such a manner in the starting period of the vehicle, by the aid of said infinitely variable drive branch the starting torque will be increased; this phenomenon is to be considered as advantageous, since one of the unfavourable features of the epicyclic gear with the output branch lies in that by changing the speed of rotation of the ring gear having been applied as an output element towards the axle-drive, the torque does not change to the desired extent. In this case namely the output torque is essentially changing in the opposite way, than with the traditional drive systems of the vehicles. In a stationary state of the vehicle and in course of a slow advance the sun gear has to rotate quickly. On the driving ring gear the driving moment arises in an already described manner that way that the rapidly rotating sun gear is braked by
transferring the energy from the sun gear to the arm by means of the infinitely variable drive, i.e. to the connected flywheel. This effect -- decelerating the sun gear and increasing the starting torque -- can be increased by the more intensive braking of the sun gear, being well completed by the hydrodynamic clutch 220 of the embodiment shown in Fig. 9, when in course of starting, by intensifying the braking moment is utilized as an accessory moment increasing the input starting torque of the ring gear, thereby considerably improving the behaviour of the epicyclic gear in a positive sense while starting.

In Fig. 10 a drive system has been illustrated, which has a motor 10 -- expediently an Otte-motor -- as a primary energy source, having been provided with a drive 11 having an epicyclic gear with an output branch, as it is to be seen in Fig. 4a and 4b. In the drive 21 of the secondary energy source, having been provided with the output branch, the axle-drive 3, i.e. the gear transmitting to the pair of spur gears 44, 136 serving as a transmission is the sun gear of the epicyclic gear; the flywheel having been symbolized by the shaft 201 is connected to the input shaft 203 via the pair of bevel gears 202, onto which the arm 211 of the epicyclic gear has been wedged and in the present case the infinitely variable hydrostatic drive branch -- containing the commercially available rotary machines 249, 250 having been built-in in a common rotary -- is inserted between the ring gear 212 of the epicyclic gear and the arm 211 thereof. The drive branch of the drive 21 of the primary energy source, having an infinitely variable transmission ratio, is also formed as a hydrostatic infinitely variable drive between the ring gear 112 and the sun gear 113 of the epicyclic gear. The infinitely variable hydrostatic drive comprises two hydrostatic rotary machines 149, 150 having been interconnected by
means of a hydraulic duct system and a proper valved /190/ connection, while at least one of them, but expediently both are formed with a variable piston displacement. The drive 11 of the primary energy source with the epicyclic gear is containing two stages with a fixed transmission ratio and with a minimal loss, due to the fact that the output shaft 12 with the arm wedged thereon may be rigidly connected to the sun gear 113 by means of the clutch 160, i.e. the rotary machine 150 is brought in a locked state having been blocked by means of the valves, while the rotary machine 149 is allowed to rotate freely. The directional change needed for changing the operational mode of the drive 11, as previously described, is also performed by the proper change-over of the valves connecting the hydraulic machines 149 and 150. The kinematic drive chain of the drive system is following the schematical diagram resp. layout according to Fig. 1, the added driving moment of the primary and secondary energy source can be transmitted to the axle-drive via the clutch 5, that is to say, by releasing the clutch 5, the axle-drive 3 may be separated from the system. Advantageously, the structural units of both of the energy sources can be arranged below the floor of the vehicle. The primary energy source can be arranged in the front part of the vehicle, the axle-drive 3 is solved with a rigid axle housing with the differential 31.

A further especially advantageous embodiment of the drive system according to the invention is to be seen in Fig. 11. Also in this case the primary energy source is a Diesel-motor 10 having been provided with a drive 11 formed as a multi-stage transmission, with a mechanic or automatized hydrodynamic clutch. As a secondary energy source a drive 21 having an epicyclic gear with an output branch being connected to the flywheel having been symbolized by the vertical shaft 201, was used. The kinematic drive chain of the drive is showing the schematical
arrangement i.e. the layout according to Fig. 2, where by using a three-position clutch 6 with the claw clutch 60, the output shaft 12 of the primary energy source may be engaged either directly with the input shaft 32 of the axle-drive 3 or via the pair of bevel gears 202 of the secondary energy source to the flywheel, being simultaneously connected to the input shaft 203 forming the shaft of the arm 211. In the neutral central position of the claw clutch 60 the primary energy source is separated from the other units of the system. The input element of the epicyclic gear of the secondary energy source with the output branch, having been provided with a drive branch of an infinitely variable transmission ratio, being connected to the flywheel, is formed by the arm 211, the varied output transmitting element of the epicyclic gear is the ring gear 212, while the first infinitely variable drive branch formed with the two hydrostatic rotary machine 249, 250 with the variable piston displacement is interposed between the sun gear 213 and the arm 211 of the epicyclic gear. On the input shaft 203 of the epicyclic gear – as near to the flywheel as possible – a torque-limiting safety clutch 180 is also arranged. In the figure the clutch is illustrated as an epicyclic gear, which is in a closed position, when the ring gear is fixed, however, when the ring gear is disengaged, it takes up its open position.

At the embodiment of the drive system according to the invention shown in Fig. 11, there is a further hydrostatic rotary machine 251, which is connected to the ring gear 212 by means of the clutch 260 transmitting the torque in one direction of rotation and running in the other direction free, by inserting the spur gears 263 and 264. By means of this third rotary machine 251, being connected to the medium supply and control system of the rotary machines 249, 250 a wide range of possibilities is given for improving the characteristics of the drive.
In connection with the Fig. 9 we mentioned that the unfavourable torque-transmitting properties of the drive with the epicyclic gear in the starting period can be improved by different measures. The third rotary machine 251 - when it rotates with a higher speed of rotation than the output ring gear 212 - promotes the function of the ring gear 12 in a torque increasing sense by means of the free running clutch 260. It becomes obvious that by the application of the three rotary machines 249, 250, 251 having been connected to the proper hydraulic system, essentially a further infinitely variable drive branch may be established between the ring gear 212 and the sun gear 213. In the following we shall deal with the advantageous effects thereof.

In compliance with the schematical arrangement according to Fig. 2, in the upper end position of the claw clutch 60 the engine 10 is directly driving the flywheel and drives the vehicle via the epicyclic gear. In the central neutral position of the claw clutch 60 the flywheel is connected to the axle-drive 3 of the vehicle via the epicyclic gear, while the motor 10 is separated from the system. Accordingly, in the lower position of the claw clutch 60 the motor 10 is directly driving the axle-drive 3, i.e. the vehicle, while the connection with the flywheel is established by the epicyclic gear. In such a manner, by applying the alternative clutch 6, in the upper position thereof; in the stationary state of the vehicle the flywheel can be accelerated. When braking with the flywheel, i.e. when regaining the kinetic energy, the flywheel can be charged with energy by means of the motor without the necessity to reduce the braking capacity of limited extent. In the lower position, in course of acceleration, the output of the flywheel and the motor are added. When progressing with a steady speed, the output of the motor may arrive directly at the wheels, it is
bypassing the infinitely variable drive branch, accordingly no losses arise. It goes without saying that we have to provide for the synchronization of the clutch 6.

Although theoretically the third rotary machine 251 can be connected to the system in diverse manners, either on the mechanical or on the hydraulical side, in case of the embodiment having been illustrated here, the connection to the ring gear 212 through the transmission with the spur gears 263 and 264, by means of the free-running clutch 260 is presented. It seems to be expedient to choose the transmission so, as at the half at most of the maximal speed of rotation of the output ring gear 212 the rotary machine 251 should already reach the maximal speed of rotation — since this is a requirement at low output speed of rotation only, — however, in this case a high torque is imperative. The rotary machine 251 is supplied with oil through the oil ducts 252, 253. When the rotary machine 250 connected to the sun gear 213 is working in a pumping operation, an overpressure prevails in the nodal point 18.

In this case the sun gear 213 is braked by loading and the vehicle is accelerated. In course of deceleration the role of the rotary machines 249, 250 is interchanged, and the overpressure now prevails in the nodal point 19. Then the check valve 23 in the duct 253 is closing the cross-section of the oil stream. The piston displacement of the rotary machine is to be adjusted in dependence of the vehicle speed in such a manner that within the range between the stationary state of the vehicle and about 10% of the final speed the piston displacement of the rotary machine 251 functioning as a motor should reach its maximal value /supposed that the accelerating pedal is actuated/, in the range between about 10% and 30% of the final speed the piston dis-
range between 30% and 40% of the final speed -- by closing the throttle valve -- the rotary machine 251 should gradually stop. When the vehicle is progressing and the decelerating pedal is actuated, the throttle valve 17 is opening, however, the rotary machine will not rotate in the opposite direction, as the check valve 23 -- due to the overpressure prevailing in the nodal point 19 -- is hindering the backward motion. When under the pressure of the decelerating pedal the vehicle stops and the driver continues to press the decelerating pedal, the vehicle ought to start backwards, however, the reverse motion is not allowed by the free-runner. For the reverse motion of the vehicle the driver has to open the check valve 23 and the throttle valve 17. The accessory advantage of the structural solution with the check valve and the free-runner lies in that rolling back of the vehicle having been stopped when ascending the hill, is hindered by all means, even when the driver is pressing the start pedal but the pressure prevailing in the nodal point 18 does not suffice for the start of the vehicles. The low-pressure supply system supplying the system with oil may be connected to the nodal points 18 and 19 by applying check valves for preventing the discharge from the system and safety valves protecting against overpressure. The distant transmitters 24 (also to be seen in the figure) are playing a role in actuating the control unit controlling the piston displacement of the rotary machines.

The driver may control the vehicle speed in diverse manners. One expedient method is the following:

The vehicle has two pedals, one is the "gas", "running", or "forwards" pedal, the other the "brake", "deceleration" or "reverse" pedal. Although the inner structure and functional mechanism is differing from the traditional, where the gas pedal is serving for the control of the throttle valve and of the quantity of the injected fuel,
we strived for the usual reaction of the vehicle on pressing the pedal, i.e. the final speed of the vehicle should be proportional with the extent of the pressure having been applied onto the pedal, while the extent of acceleration should be proportional with the difference of the adjusted and real speed; this is realized by changing the piston displacement of the rotary machines 249 and 250. The piston displacement of the presently used hydrostatic rotary machines may be changed in a ratio of 1:3,4 if they are operated as motors, however, when operated as pumps, the piston displacement can be reduced even to zero. Taking into consideration that the role of the rotary machines is changing, i.e. when accelerating, the rotary machine 249 is acting as a "motor" and the rotary machine 250 as a "pump", and when decelerating, the rotary machine 249 is the pump and the rotary machine 250 the motor, the piston displacement can change with both machines in a proportion of 1:3,4 only.

For the proper use of the equipment it would be sufficient if only the piston displacement of one of the rotary machines would be changed in the said proportion. However, the losses can be considerably reduced by the fact that both rotary machines 249, 250 have variable piston displacements, as in such a manner the desired ratio of the speed of rotation of the arm 211 and the sun gear 213, i.e. the necessary ratio of the piston displacements of the two machines can be equally realized with smaller of larger piston displacements. The difference lies in that by the smaller piston displacements a lower output may be achieved, but at the same time streaming losses are also less. By increasing the piston displacement both the output and the losses will increase, similarly to the case of the variators with the V-belts, when the tightness of the V-belt is increased.

The control centre is changing the piston dis-
placement in such a manner that the acceleration according
to the command coming from the pedals could be realized
with the possibly minimal loss.

In Fig. 12 a structural solution serving as a
drive for vehicles has been illustrated, where the secon-
dary energy source is an epicyclic gear with an output
branch, with a drive branch with an infinitely variable
transmission ratio --essentially, as illustrated in Fig.
3a and 3b, respectively -- with the difference that the
primary energy source and the infinitely variable drive
branch are realized by means of electrical rotary machines.
In a certain sense the structure is similar to the embodi-
ment with the hydrostatic rotary machine shown in Fig. 11
and it can be advantageously used for vehicle-drives to be
arranged under the floor, with an axle-drive 3 with a ri-
gid axle housing. The flywheel in the epicyclic gear of
the secondary energy source -- symbolized by the shaft
201 -- is connected to resp. driving the arm 211 through
the pair of bevel gears 202 and the torque-limiting clutch
260. The output transmitting element of the drive is the
ring gear 212, which can be directly fastened to the
shaft of the D.C. electric rotary machine 313 with a
passing axle. Advantageously the other end of the passing
axle of the rotary machine is connected to the input of
the differential of the axle-drive 3 by inserting universal
joints. The infinitely variable drive branch of the epi-
cyclic gear consisting of the electric rotary machines
254, 255 is interposed between the sun gear 213 and the
arm 211 via the spur gears 261, 262 and the auxiliary
shafts. The structural analogy with the embodiment accord-
ing to Fig. 11 becomes even more obvious when said systems
are considered resp. compared in such a manner as if at
the embodiment according to Fig. 11 the accessory third
rotary machine 251 were the primary energy source of the
drive system, the analogue of which in the embodiment
shown in Fig. 12 is represented for certain operational modes by the D.C. electric rotary machine 313 serving as a primary energy source. With this embodiment the epicyclic gear comprises a further clutch 280, by the aid of which a rigid connection may be established between the sun gear 213 and the arm 211 of the epicyclic gear, resulting in a "short circuited" state of the epicyclic gear. The advantage of said arrangement lies in that the D.C. electric rotary machines 254 and 255 - having been switched to motor-operation - may help the rotary machine 313 working as a motor and as a primary energy source to drive the vehicle. Of course, in these cases the inert mass of the vehicle is increasing with the increasing mass of the flywheel. The clutch 280 must and may be locked, when the vehicle has been already accelerated and the speed of rotation of the sun gear 213 and the arm 211 are identical. The speed of rotation of the flywheel is to be chosen so that when the vehicle has been already accelerated to the planned final speed of e.g. 50 km/h, the shafts to be interconnected, i.e. the rotating elements should rotate with identical speed of rotation.

The main advantage of the drive system with the electric rotary machine as shown in Fig. 12 lies in that drives with nearly negligible losses may be realized, since, owing to the different connections and operational modes of the electric rotary machines the disadvantageous operational states, in so far as in the epicyclic gear with the output branch considerable idle outputs are circulating, may be avoided i.e. eliminated in a most favourable manner by changing the mode of operation and using electrical switch-over.

Accordingly, the alternative connection having been realized by means of mechanical elements /Fig. 2/ is now established by using electrical switches. The prerequisite for this solution lies in that in the output
branch of the epicyclic gear the infinitely variable connection should be realized by the aid of electric rotary machines and the drive should be supplied with electric energy also from the outside.
Claims:

1. Drive system for machines driven from more than one energy sources, in particular for vehicles, with a power machine as a primary energy source and a flywheel as a secondary or compensating energy source, where between the flywheel and the driven machine an epicyclic gear is arranged and in the output branch thereof there is a drive branch with an infinitely variable transmission and with a loading possibility in two directions, characterized in that out of the three elements of the epicyclic gear /15/ having been arranged around the centric shaft, the arm /13/ is connected either to the flywheel /20/ or to the driven machine /3/ and the infinitely variable connection is always established between the gear having been engaged with the flywheel /20/ and the central gear having been left free, further between the commoned output shafts /12, 22/ of the primary energy source /1/ and the compensating secondary energy source /2/, as well as the input shaft /32/ of the driven machine /3/ there is a releaseable clutch /5/ arranged. /Fig. 1/.

2. Drive system for machines driven from more than one energy sources, in particular for vehicles, with a power machine as a primary energy source and a flywheel as a secondary or compensating energy source, where between the flywheel and the driven machine an epicyclic gear is arranged and in the output branch thereof there is a drive branch with an infinitely variable transmission and with a loading possibility in two directions, characterized in that out of the three elements of the epicyclic gear /15/ having been arranged around the centric shaft, the arm /13/ is connected either to the flywheel /20/ or to the driven machine /37/ and the infinitely variable connection is established in both cases between the gear having been engaged with
1 the flywheel /20/ and the central gear having been left 
free, furtheron at the output /12/ of the primary energy 
source /1/ there is a clutch arranged and one of the 
engaging points /16/ is lying between the flywheel /20/ 
and the belonging epicyclic gear /210/, while the other 
engaging point /3/ is lying between said epicyclic gear 
/210/ and the driven machine /3/. /Fig. 2/.

3. Drive system as claimed in claim 1, 
characterized in that in the drive belonging 
to the energy source with the flywheel there is a further 
ininitely variable drive branch /220, 221, 222 resp. 
249, 250, 251/. /Fig. 9/.

4. Drive system as claimed in any of the claims 
1 to 3, characterized in that the primary 
energy source is an electric rotary machine /13/ and the 
drive with the infinitely variable transmission and with 
the loading possibility in both directions having been 
arranged in the output branch of the epicyclic gear bet-
ween the flywheel /201/ and the driven machine /3/ is 
lying between the electric rotary machine /255/ being 
coupled to the flywheel /201/ and the electric rotary 
machine /254/ being coupled to the sun gear /213/ and 
at last, the function of the clutch /6/ and other mecha-
nical clutches /220, 221, 222/ having been applied in the 
drive belonging to the energy source with the flywheel 
is performed by electric switches interposed into the 
network between said electric rotary machines /13, 254, 
255/. /Fig. 12/.

5. Drive system as claimed in claim 1, 
characterized in that as a primary energy 
source an internal combustion engine /10/ is applied, 
which is provided with a drive /11/ comprising an ep-
cyclic gear with an output branch including a drive 
branch with an infinitely variable transmission ratio, 
and out of the three elements of the drive /11/ compris-
ing the epicyclic gear, having been arranged around the
centric shaft, the ring gear /112/ is connected to the in-
ternal combustion engine /10/, the arm /111/ to the shaft
/12/ leading to the driven machine and the sun gear /113/
is engaged with two gears in a rotation transmitting
manner, one of the two gears /130/ is engaged with a gear
/194/ having been arranged in a freely rotating manner on
the coupling shaft /144/; while the other gear /131/ is
engaged with the gear /196/ having been also arranged on
the same coupling shaft /144/ in a freely rotating manner
via the inserted parasite wheel /193/, furtheron between
the two freely rotating gears /194, 196/ an alternative
clutch, expeditiously a synchronized clutch /195/ is wedged
onto the shaft /144/; between the sun gear /113/ and the
arm /111/ a clutch /60/ and between the sun gear /113/
and the house of the drive /11/ a brake, preferably a
disc brake /170/ are inserted and at last in the drive
/21/ of the flywheel /201/, onto the shaft /203/ connect-
ed to the flywheel the arm /211/ is wedged; the ring gear
/212/ of the epicyclic gear is partly connected with the
shaft /12/ coming from the primary energy source /10/ via
the bevel gear /43/; partly it is connected to the differen-
tial /31/ of the driven wheels of the vehicle via the
releaseable clutch /5/ and the spur gear /311/ and the
variator with the V-belt, having been arranged between
the sun gear /213/ and the shaft /203/ coming from the
flywheel, is provided with a device for the control and
changing the tightness of the V-belt /247/. /Fig. 5/.

6. Drive system as claimed in claim 1,
characterized in that as a primary energy
source an internal combustion engine /10/ is applied,
which is provided with a drive /11/ comprising an epi-
cylic gear with an output branch including a drive branch
with an infinitely variable transmission, and out of the
three elements of the drive /11/ comprising the epicyclic
gear, having been arranged around the central shaft, the arm /111/ is connected to the internal combustion engine /10/, the ring gear /112/ to the shaft /12/ leading to the driven machine and the sun gear /113/ is engaged with a gear /145/ in a rotation transmitting manner and said gear /145/ is engaged with the gear /141/ having been wedged onto the shaft being coupled to the countershaft /142/ and to be fixed with the brake /170/, while the countershaft /142/ is connected to the coupling shaft /144/ via the two V-belt pulleys /143, 146/ of the variator with the V-belt, onto which a gear /147/ is fixed by means of the releaseable clutch /180/ being engaged with the gear /138/ wedged onto the shaft /139/ of the arm; between the sun gear /113/ and the arm /111/ a releaseable clutch /160/ is inserted, furtheron in the drive /21/ of the flywheel /201/ onto the shaft /200/ connected to the flywheel the arm /211/ of the epicyclic gear is wedged, whereas the ring gear /212/ of the epicyclic gear is connected to the flywheel through the shaft /244/ of the variator, the pulleys /243, 246/ and the other shaft /242/ thereof, through the gear /231/ having been wedged onto the shaft /230/ connected to said shaft /242/ via the parasite wheel /232/ supported in bearings on the output shaft /12/ of the primary energy source and via the gear /233/ having been wedged onto the shaft /200/ of the arm /211/ and at last; the gear /234/ co-rotating with the sun gear /213/ is connected to the differential /31/ of the driven wheels of the vehicle via the gear /44/ having been wedged onto the output shaft /12/ of the primary energy source, the releaseable clutch /5/ and the pair of bevel gears /236/. /Fig. 6/.

7. Drive system as claimed in claim 1, characterized in that as a primary energy source an internal combustion engine /10/ is applied, which is provided with a drive /11/ comprising an epi-
cyclic gear with an output branch including a drive branch with an infinitely variable transmission ratio and out of the three elements of the drive /11/ comprising the epicyclic gear, having been arranged around the central shaft, the ring gear /112/ is connected to the internal combustion engine /10/, the arm /111/ to the shaft /12/ leading to the driven machine and the sun gear /113/ is engaged with two gears /114, 115/ in a rotation transmitting manner, which are arranged on a coupling shaft /144/ in a freely rotating manner and can be fastened thereon by means of a frictional clutch /191, 192/ each; one of the gears /115/ is engaged with the gear /117/ co-rotating with the sun gear /113/ via the parasite wheel /195/, which can be fixed by means of a disc brake /170/, while the other gear /114/ is engaged with the other gear /116/ co-rotating with the sun gear /113/, furtheron in the drive /21/ of the flywheel the arm /211/ of the epicyclic gear is wedged onto the shaft /203/ having been coupled to the flywheel; the ring gear /212/ of the epicyclic gear is engaged with the flywheel through the variator /243, 246/, the gear /234/ having been wedged onto the other shaft /233/ of the variator, the parasite gear /235/ and via the gear /236/ being wedged onto the shaft /203/ of the arm /211/; the sun gear /213/ is wedged onto the output shaft /12/ of the primary energy source and the gear /237/, that can be fixed by means of the clutch /5/, is supported in bearings in the same shaft /12/ and said gear /237/ is engaged with the gear /311/ having been fastened to the differential /31/ of the driven wheels of the vehicle, and at last, the variator of both drives /11, 21/ comprises and endless driving element /247/ also containing metal - preferably steel - elements, while the variators are arranged in the gear case of the drives /11, 21/. /Fig. 7/.

8. Drive system as claimed in claim 2,
characterized in that the primary energy source comprises an internal combustion engine /10/ being provided with a drive /11/ formed as a multi-stage, manually actuated or automatized transmission, in the drive /21/ of the flywheel /201/ the arm /211/ of the epicyclic gear is wedged onto the shaft /203/ coupled to the flywheel, while the gear fastened to the sun gear /213/ and co-rotating therewith is engaged with the gear /215/ having been wedged onto one /244/ of the shafts of the variator and the outer half-disc /246/ of the variator containing two V-belts connected in series is also wedged on this shaft /244/ and co-rotating with said half-disc /246/ but axially displaceable in relation to the same, the belonging inner half-disc /238/ is arranged; the tubular shaft /229/ carrying the other half-disc /243/ is supported in bearings on the shaft /244/ and thereon, co-rotating with the outer half-disc /243/ but axially displaceable, the belonging half-disc /239/ is arranged, the gear /216/ thereon is engaged with the gear /217/ wedged on the shaft of the arm /211/; the two inner half-discs /238, 239/ are bearing up against one another via a thrust bearing /248/ and on the other shaft /2441/ of the variator the co-rotating inner twin-discs /2442/ are arranged; the outer half-discs /2443, 2444/ can be axially displaced and the mutual distance may be adjusted by means of a stretcher device; the gear /218/ co-rotating with the ring gear /212/ is engaged with the differential /31/ via a gear /219/ and a safety clutch /33/, and at last, the output shaft /12/ is forming the input shaft of an alternative clutch, the claw clutch /60/ of which is coupled to the gear /36/ of the differential /31/ in one of its positions, while in its other position it is coupled to the arm /211/ of the epicyclic gear of the flywheel /Fig. 8/.

9. Drive system as claimed in claim 2,
characterized in that the primary energy source comprises an internal combustion engine /10/, which is provided with a drive /11/ being formed as a multi-stage, manually actuated or automatized transmission, in the drive /21/ of the flywheel /201/, onto the shaft /203/ coupled to the flywheel, the arm /211/ of the epicyclic gear is wedged, the gear /223/ being fixed to the sun gear /213/ and co-rotating therewith is engaged with one of the shafts /244/ of the variator via a pair of bevel gears /245/, while the other shaft /242/ of the variator is connected via the pair of bevel gears /224/ to the shaft /203/ of the arm /211/ being connected to the flywheel, furtheron, the spur gear /223/ co-rotating with the sun gear /213/ is engaged with the gear /225/ forming the input drive of a hydrodynamic clutch /220/ resp. torque converter and the output of said clutch /220/ is connected via the transmitter shaft /62/ and the gear /226/ having been wedged thereon to the ring gear /212/ of the epicyclic gear and therethrough to the differential /31/;

and at last, the output shaft /12/ of the primary energy source is coupled via the countergear /61/ to the alternative coupling organ consisting of two - preferably frictional - clutches /63, 64/, and in the locked state of one of the clutches /63/ the primary energy source /10/ is coupled to the flywheel, while in the locked state of the other clutch /64/ the primary energy source /10/ will be coupled to the ring gear /212/ forming the output of the epicyclic gear and therethrough to the differential /31/. /Fig. 9/.

10. Drive system as claimed in claim 1, characterized in that as a primary energy source an internal combustion engine /10/ is applied, which is provided with a drive /11/ comprising an epicyclic gear with an output branch including a drive branch with an infinitely variable transmission ratio,
and out of the three elements of the drive /11/ comprising the epicyclic gear, having been arranged around the centre shaft, the ring gear /112/ is connected to the internal combustion engine /10/, the arm /111/ to the shaft /12/ leading to the driven machine and the sun gear /113/ is engaged via the co-rotating spur gear /132/ with the gear /134/ having been wedged onto the extended shaft /135/ of the hydrostatic rotary machine /150/ with the variable piston displacement, furtheron the hydrostatic rotary machine /150/ is connected via a duct and a control organ /190/ to an other hydrostatic rotary machine /149/ also with a variable piston displacement, which is connected via the pair of gears /135/ to the main shaft of the internal combustion engine /10/, between the shaft /12/ of the arm /111/ and the sun gear /113/ a frictional clutch /160/ is arranged and at last, in the drive /21/ of the flywheel /201/ the arm /211/ of the epicyclic gear is wedged onto the shaft /203/ coupled to the flywheel /203/, the rotor of the hydrostatic machine /250/, preferably with the variable piston displacement, having been built-in in a common house, is also wedged onto said shaft, while the rotor of the other hydrostatic rotary machine /249/, preferably with an adjustable piston displacement, is connected to the ring gear /212/ of the epicyclic gear, while the sun gear /213/ of the epicyclic gear is engaged with the axle-drive /3/ of the vehicle via the co-rotating gear /123/ and the connected gear /44/ having been wedged onto the output shaft /12/ of the primary energy source, through the releasable clutch /5/. /Fig. 10/.

11. Drive system as claimed in claim 2, characterized in that the primary energy source comprises an internal combustion engine /10/, which is provided with a drive /11/ formed as a multi-stage, manually actuated or automatized transmission, in
the drive /21/ of the flywheel the arm /211/ of the epicyclic gear is wedged onto the shaft /203/ coupled to the flywheel, between the flywheel /201/ and the arm /211/ there is a further epicyclic gear /180/ inserted as a safety clutch, furtheron the gear having been fixed to the sun gear /213/ and co-rotating therewith is connected via the pair of spur gears /256/ to a hydrostatic machine /250/ preferably with a variable piston displacement, and said machine is connected via a duct with a hydrostatic machine /249/ of a variable piston displacement and having been wedged onto the shaft of the arm /211/, while the pipes /252, 253/ branched-off from the clutch system of the hydrostatic machines, are coupled to a further hydrostatic machine /251/ also with a variable piston displacement and the shaft /257/ thereof is engaged with the ring gear /212/ via the interposed clutch /260/ being suitable for the transmission of the torque, simultaneously the ring gear /212/ engages with the axle-drive /3/ of the vehicle through the gears /258, 259/ and at last, the output shaft /12/ of the primary energy source /10/ is forming the input of an alternative clutch, the claw clutch /60/ of which is engaged with the axle-drive /3/ in one of its positions, while in its other position it is engaged with the flywheel /201/. /Fig. 11/.

Drive system, as claimed in claim 2, characterized in that the primary energy source is an electromotor /313/, which is directly connected to the axle-drive /3/ of the vehicle, between the flywheel /201/ and the arm /211/ of the epicyclic gear there is a safety clutch /260/ arranged, the sun gear /213/ is coupled via a pair of gears /261/ to an electric rotary machine /251/, while the arm /211/ and the flywheel /201/ are coupled via a pair of gears /262/ to a second electric rotary machine /255/, furtheron, between the arm /211/ and the sun gear /213/ a clutch /280/ is interposed, at
last, the leads of the three electric rotary machines /313, 254, 255/ are connected to an organ ensuring their connection by pairs. /Fig. 12/.
Fig. 7.
**INTERNATIONAL SEARCH REPORT**

**International Application No.** PCT/IB81/00037

**I. CLASSIFICATION OF SUBJECT MATTER** (if several classification symbols apply, indicate all)

According to International Patent Classification (IPC) or to both National Classification and IPC:

B60K 17/00; B60K 9/04

**II. FIELDS SEARCHED**

Minimum Documentation Searched

<table>
<thead>
<tr>
<th>Classification System</th>
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<td>IPC</td>
<td>B60K 17/00; B60K 17/04; B60K 9/04</td>
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<td>IPC</td>
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<tr>
<td>DPC</td>
<td>63c 8/01; 63c 10/02</td>
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

**III. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of Document, with indication where appropriate, of the relevant passages</th>
<th>Relevant to Claim No.</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>US, A, 3870116, published 11 March 1975, Joseph Seliber</td>
<td>1-12</td>
</tr>
</tbody>
</table>

* Special categories of cited documents:

- **A** - document defining the general state of the art
- **E** - earlier document but published on or after the international filing date
- **L** - document cited for special reason other than those referred to in the other categories
- **O** - document referring to an oral disclosure, use, exhibition or other means
- **P** - document published prior to the international filing date but on or after the priority date claimed
- **T** - later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention
- **X** - document of particular relevance

**IV. CERTIFICATION**

- **Date of the actual completion of the international search**: 03 December 1981
- **Date of mailing of this international search report**: 15 December 1981

International Searching Authority: ISA/SU

Signature of Authorized Officer: [Signature]

Form PCT/ISA/210 (second sheet) (October 1977)
FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

II.
US 180-54
GB B7H; F2D

V. OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:
1. Claim numbers ______, because they relate to subject matter not required to be searched by this Authority, namely:

2. Claim numbers ______, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

VI. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This international searching authority found multiple inventions in this international application as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest
☐ The additional search fees were accompanied by applicant's protest.
☐ No protest accompanied the payment of additional search fees.