ABSTRACT

STARTER CIRCUIT OF A MOTOR VEHICLE COMPRISING A DEVICE FOR STEPPING UP THE BATTERY VOLTAGE, AND STARTER PROVIDED THEREWITH

The invention relates to a starter circuit that comprises a combination of a starter and a device for stepping up the battery voltage. The device for stepping up the battery voltage makes it possible to prevent a drop in the battery voltage caused by a surge of current occurring in a power circuit of the starter when the latter is powered on. The starter conventionally includes an electric motor and an electromagnetic contactor. According to the invention, the device for stepping up the battery voltage comprises an inductive filtering device that includes a magnetic circuit consisting of a housing made of a magnetic material and comprising a cylindrical head, two closing parts, and an axial core around which a primary winding circuit, which is to be inserted, in series, onto the power circuit, and a short-circuited secondary winding circuit are arranged, said axial core having at least one air gap.

CLAIMS

1. Combination (1) in an electric starter circuit of a motor vehicle, of a starter (DCM, EC) and a device (LPF) for stepping up the battery voltage, the said starter (DCM, EC) comprising an electric motor (DCM) and an electromagnetic contactor (EC), the said device (LPF) for stepping up the battery voltage being designed to prevent a drop in the battery voltage (Vbat) further to a current surge caused by putting the said starter (DCM, EC) into service in a power circuit, characterised in that the said device (LPF) for stepping up the battery voltage consists of a filtering device of an inductive type (LPF), which is fitted in series with the said electric motor (DCM) in the said power circuit, the said filtering device comprising a magnetic circuit (YO, C, CM, CM') which consists of a housing (YO, C) made of magnetic material comprising a cylindrical head (YO), two closure parts (CM, CM') and an axial core (C), around which there are provided a primary winding circuit (W1) which is designed to be inserted in series in the said power circuit, and a secondary, short-circuited winding circuit (W2), and in that the said axial core (C) has at least one air gap (AG; AG1, AG1').

2. Combination according to claim 1, characterised in that the said at least one air gap is a median air gap (AG).

3. Combination according to claim 1, characterised in that the said at least one air gap comprises two end air gaps (AG1, AG1') between the said closure parts (CM, CM').

4. Combination according to claim 1, characterised in that the said closure parts (CM, CM') each have an annular air gap (AG2, AG2'; AG3, AG3').

5. Combination according to claim 4, characterised in that the said annular air gap (AG2, AG2'; AG3, AG3') is aligned axially with the said primary winding circuit (W1) or with the said secondary winding circuit (W2).

6. Combination according to any one of the preceding claims 1 to 5, characterised in that the secondary winding circuit (W2) consists of an electrically conductive tube.

7. Combination according to claim 6, characterised in that the said tube consists of copper or aluminium, and has a predetermined ratio of length to radius, as well as a predetermined thickness.

8. Combination according to any one of claims 1 to 7, characterised in that the said filtering device (LPF) is inserted in the said starter power circuit (DCM, EC), between a positive terminal (B+) of a battery of the said vehicle, and a power contact (CP) of the said electromagnetic contactor (EC).

9. Combination according to any one of claims 1 to 7, characterised in that the said filtering device (LPF) is inserted in the said starter power circuit (DCM, EC), between a power contact (CP) of the said electromagnetic contactor (EC) and the said electric motor (DCM).

10. Starter (DCM, EC) which can be incorporated in a combination (1) according to any one of claims 1 to 9, characterised in that the filtering device (LPF) included in the said combination (1) is secured on an outer case of the starter (DCM, EC).

Dated this 10th day of January, 2014

[SWATI PAHUJA]
OF REMFRY & SAGAR
ATTORNEY FOR THE APPLICANT[S]

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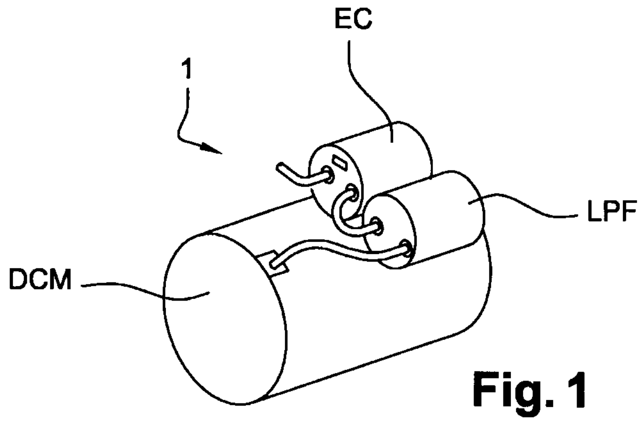

Fig. 1

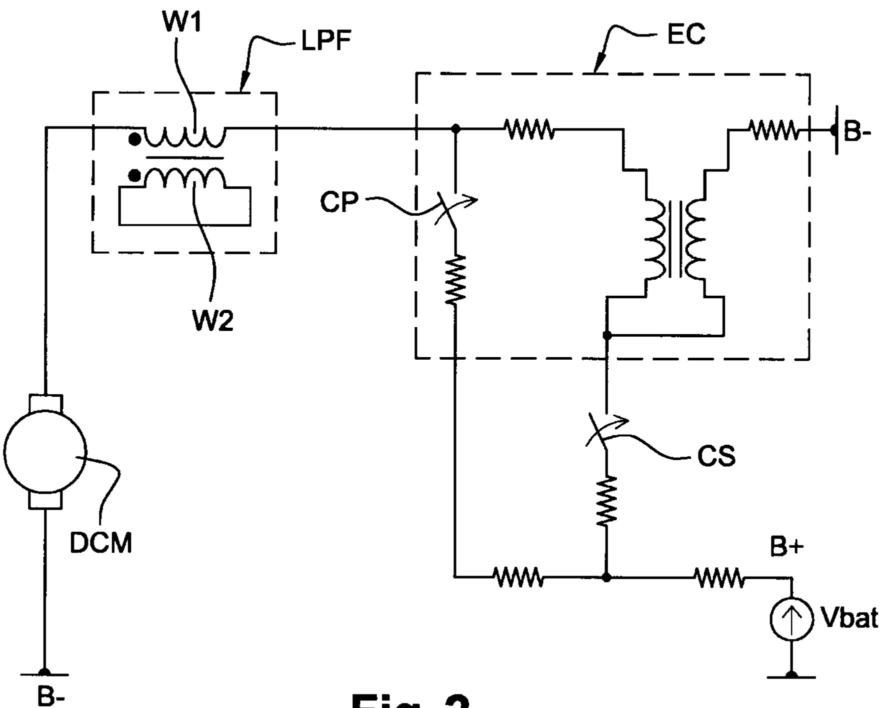

Fig. 2

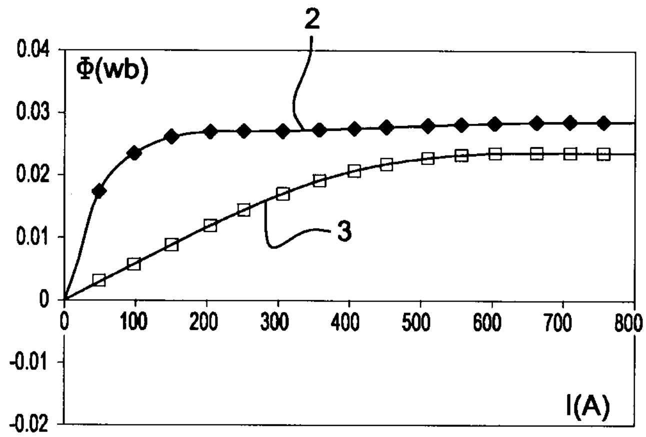

Fig. 3a

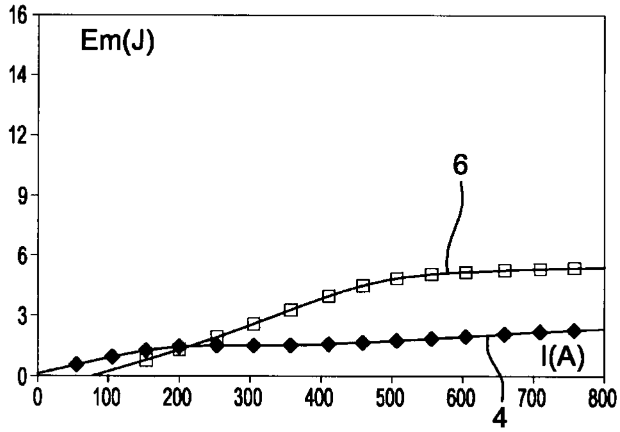

Fig. 3b

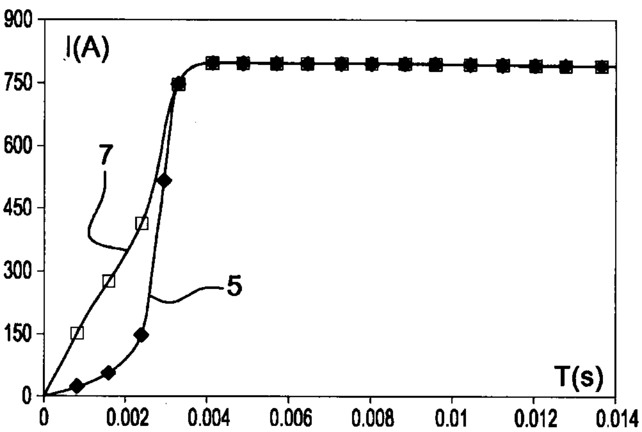

Fig. 3c

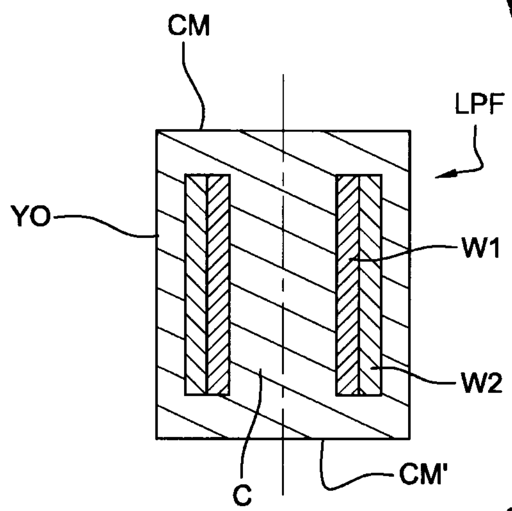

Fig. 4

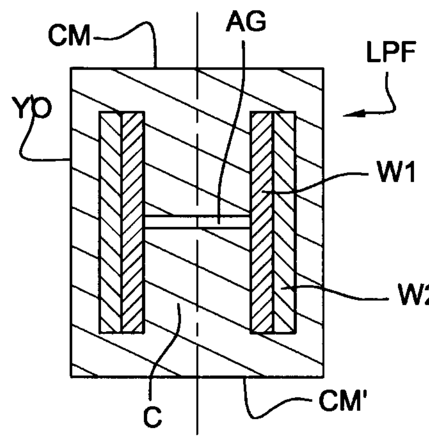

Fig. 5

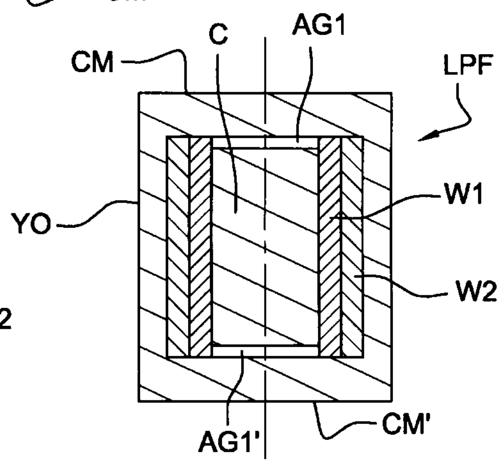

Fig. 6

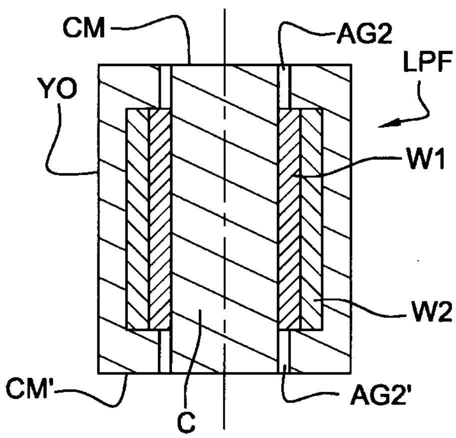

Fig. 7a

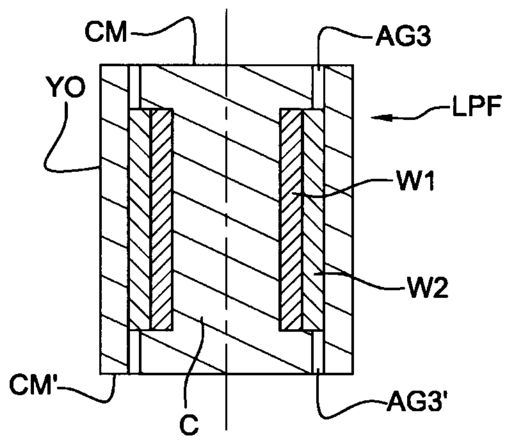

Fig. 7b

MOTOR VEHICLE STARTER CIRCUIT COMPRISING A DEVICE FOR STEPPING UP THE BATTERY VOLTAGE, AND A STARTER EQUIPPED WITH A CIRCUIT OF THIS TYPE

TECHNICAL FIELD OF THE INVENTION

In general, the invention relates to the field of starters for thermal engines in motor vehicles. More particularly, the invention relates to the combination of a starter and a device which allows the voltage at the battery terminals of the vehicle to be stepped up when the starter is switched on.

TECHNOLOGICAL BACKGROUND OF THE INVENTION

When a starter is switched on, in order to ensure the starting of the thermal engine of the vehicle, a substantial requirement for current arises which is close to the short-circuit current level of the starter, i.e. a current of approximately 1000 A. The intensity of this current requirement when the starter is switched on then decreases as the speed of the armature of the starter, corresponding to the rotor of the machine, increases.

A consequent drop in the voltage at the terminals of the battery corresponds to this initial current surge. Other less substantial voltage drops then arise during the starting phase, corresponding to passages through successive top dead centres of the thermal engine.

The development of so-called "reinforced" starters, designed for automatic stop/start systems of the thermal engine (so-called “Stop/Start" or "Stop & Go" systems) now impose new constraints on motor vehicle parts manufacturers relating to compliance with minimum voltage thresholds of the battery during the current requirement when the starter is switched on. Thus, in their specifications, the motor-vehicle manufacturers define a first voltage threshold which is habitually contained between 7 and 9 V, below which the battery voltage must not drop. For the following voltage drops, corresponding to the top dead centres of the thermal engine, the battery voltage must remain higher than a second voltage threshold which is habitually contained between 8 and 9 V. During the starting of the thermal engine, the voltage of the vehicle on-board network thus remains at a value which is sufficient to guarantee the required functioning of the vehicle equipment.

Reinforced starters generally have power which is greater than conventional starters, such as to obtain rapid starting for increased comfort of the users. This results in a higher current requirement when the power is switched on, and therefore a first battery voltage drop which goes beyond the habitual values, and in relation to high demands. This gives rise to a real difficulty for the designer, since, in order to go above the battery voltage, it would be necessary for the starter to have internal voltage drops so high that there would then no longer be the power necessary to drive the thermal engine at a sufficient speed at low temperature.

In the prior art, solutions have been proposed for the above-described problem. A first solution known to the inventive body is based on the use of electronic converters to increase the voltage, in order to prevent an excessively low voltage level in the on-board network. A major disadvantage of these converters consists in the substantial costs which they introduce.

Another known solution proposes controlling the starter by means of two relays, a timer, and a current limitation resistor. In a first functioning phase, the duration of which is determined by the timer, an additional resistor is inserted in series in the starter circuit, and limits the initial current surge. In a second functioning phase, the additional resistor is removed from the starter circuit, in order to allow the passage of sufficient current into the starter armature, and to permit an increase in the speed of the starter.

Documents EP2080897A2 and EP2128426A2 describe a starter of the above type. As well as the disadvantage of the additional cost which the extra control relay, the timer and the current limitation resistor involve, the introduction of this extra relay, comprising mobile mechanical parts which are subject to wear, has a negative impact on the service life of the starter in terms of the number of starting cycles which the starter must be able to withstand without difficulty. The service life of the starter in terms of the number of starting cycles is a particularly stringent constraint for starters which are designed for stop/start systems. In fact, starters of this type are required to withstand approximately 300,000 starting cycles, i.e. ten times more than the approximately 30,000 cycles required from conventional starters.
In addition to the above-described disadvantages, the use of this second solution according to the prior art can prove unsuitable when compliance with a voltage range which is restrictive in terms of time is required by the motor vehicle manufacturer. A range of this type generally

comprises a low voltage step, corresponding to the first voltage threshold indicated above, and a high voltage step, corresponding to the second voltage threshold. A rising voltage gradient is also included in the range, between the low step and the high step.

The tests carried out by the inventive body, with the conventional values of the manufacturers for the duration of the low step and the slope of the gradient of the range, show the difficulty which exists in this second solution according to the prior art of remaining within the range. In fact, a risk has been found of going beyond the range at the level of its voltage gradient, when the battery voltage, after having been rectified once the initial current surge has been absorbed, drops once more at the end of the timing, with the current which passes through the armature of the starter then increasing substantially as a result of the output of the current limitation resistor of the starter circuit. After thus going beyond the range, the battery voltage can remain below the range for a certain duration, and return within the range only after the end of the rising voltage gradient, whereas the instant of the start of the high voltage step has already been reached.

For the purpose of eliminating the above-described disadvantages, the inventive body has already proposed improvements to the existing starters according to the prior art, in particular for applications in motor vehicles relating to the automatic stop/start function of the thermal engine.

In general, these improvements have consisted of fitting a filtering device of an inductive type in series with the electric motor in the power circuit of the starter, such as to prevent a voltage drop of the battery, further to a current surge caused by putting the electric motor into service.

New studies carried out by the inventive body have made it possible to optimise the embodiments of these improvements.

GENERAL DESCRIPTION OF THE INVENTION

According to a first aspect, the present invention thus relates to a combination in an electric starter circuit of a motor vehicle, of a starter and a device for stepping up the battery voltage, the starter comprising an electric motor and an electromagnetic contactor, the device for stepping up the battery voltage being designed to prevent a drop in the battery voltage further to a current surge caused by putting the starter into service in a power circuit.

According to the invention, the device for stepping up the battery voltage consists of a filtering device of an inductive type, which is fitted in series with the electric motor in the power circuit, the filtering device comprising a magnetic circuit which consists of a housing made of magnetic material comprising a cylindrical head, two closure parts and an axial core, around which there are provided a primary winding circuit which is designed to be inserted in series in the power circuit, and a secondary, short-circuited winding circuit, and comprising an axial core which has at least one air gap.

According to a first particular embodiment, the at least one air gap is a median air gap.

According to a second particular embodiment, the said at least one air gap comprises two end air gaps between the closure parts.

According to a third particular embodiment, the closure parts each have an annular air gap. Preferably, the annular air gap is aligned axially with the primary winding circuit or with the secondary winding circuit.

According to a particular characteristic, the secondary winding circuit consists of an electrically conductive tube. The tube consists of copper or aluminium, and has a predetermined ratio of length to radius, as well as a predetermined thickness.

According to another particular embodiment, the filtering device is inserted in the starter power circuit, between a positive terminal of a battery of the vehicle, and a power contact of the electromagnetic contactor.

According to yet another particular embodiment, the filtering device is inserted in the starter power circuit, between a power contact of the electromagnetic contactor and the electric motor.

According to another aspect, the invention also relates to a starter which can be incorporated in a combination such as briefly described above. According to the invention, the filtering device included in the combination is secured on an outer case of the starter.

The above few specifications will have made apparent to persons skilled in the art the additional advantages obtained by means of the optimisation by the applicant company of its filtering device of an inductive type.

The detailed specifications of the invention are given in the following description which is provided in association with the appended drawings. It should be noted that these drawings serve the purpose simply of illustrating the text of the description, and do not constitute in any way a limitation of the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a view in perspective showing a combination of a starter and a filtering device of an inductive type, of the type previously developed by the applicant company.

Figure 2 is a process diagram of an electric starter circuit comprising a combination as shown in figure 1.

Figures 3a, 3b and 3c show respectively the variation of the magnetic flow and the magnetic energy in the filtering device, according to the current which circulates in the power circuit of the starter, as well as the development of the current on a time basis, in the case of the filtering device according to the invention (square) and in the case of the prior filtering devices (rhombuses).

Figure 4 is a view in cross-section of a filtering device of an inductive type, of the type previously developed by the applicant company.

Figure 5 is a view in axial cross-section of the filtering device according to the invention, in a first preferred embodiment.

Figure 6 is a view in axial cross-section of the filtering device according to the invention, in a second preferred embodiment.

Figures 7a and 7b are views in axial cross-section of examples of the filtering device according to the invention, in a third preferred embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Figure 1 shows a combination 1 of a starter, comprising a direct current electric motor DCM and an electromagnetic contactor EC, and a filtering device LPF of an inductive type, to which the optimisation efforts by the applicant company have been applied.

In this embodiment, the filtering device LPF is secured mechanically to an outer case of the starter, in the vicinity of the contactor EC.

The electrical connections between the filtering device LPF, the contactor EC and the electric motor DCM are shown in figure 2.

The filtering device LPF is fitted electrically in series between the power contact CP of the contactor EC and the motor DCM.

According to an alternative embodiment (not represented), the filtering device LPF is not integrated in the starter EC, DCM, but is inserted in the power circuit, between the positive terminal B+ of the battery and the power contact CP.

The contactor EC is in this case a conventional starter contactor, with a simple power contact CP, and comprises a solenoid formed by a pull-in coil and a hold-in coil.

The closure of a starter contact CS of the vehicle commands the excitation of the pull-in and hold-in coils, and the activation of the starter, according to a sequence which is well known to persons skilled in the art, and will not be described in detail here.

The aforementioned initial current surge takes place at the closure of the power contact CP, when the motor DCM is supplied with full power.

closure of the power contact CP also gives rise to the circulation in the filtering device LPF of a power current which supplies the motor DCM.

As shown by its electric diagram represented in figure 2, the filtering device LPF is in this case a device of an inductive type, which is in this case takes the form of a transformer of the armoured type, with windings which are coupled magnetically. It will be noted that, depending on the applications, a simple inductive resistor can have been used to form the low-pass filtering device to which the optimisation work relates. However, the embodiment with a transformer makes it possible to have more parameters to adjust the frequency response of the device LPF according to the application. Thus, it is possible to optimise this response by regulating the inductive resistors of the primary and secondary circuits W1, W2, and the mutual inductance introduced by the coupling between these circuits.

The primary winding circuit W1 is the one which is inserted in the power circuit of the starter. The secondary winding circuit W2 is short-circuited.

Typically, the equivalent inductance of the inductive filtering device LPF is contained between approximately 0.1 and 10 mH for currents with an approximate size of 300 to 1000 A.

The effect of stepping up the battery voltage obtained is derived from the fact that when the motor DCM is switched on, the initial current surge is cut (attenuated by approximately half), as a result of the production of strong currents induced in the short-circuited secondary circuit W2, which oppose the sudden variation of magnetic flow which generates them.

Figure 3a shows the variation of the magnetic flow Φ in a magnetic circuit of a non-optimised filtering device LPF (curve with rhombuses 2) and in the magnetic circuit of an optimised filtering device LPF (curve with squares 3) according to the invention.

In the case of the non-optimised filtering device LPF, the magnetic flow Φ increases very rapidly together with the intensity, and stabilises at a maximum value.

Figure 3b shows that this saturation value corresponds to the storage of a small quantity of magnetic energy Em (curve with rhombuses 4).

Consequently, although the current surge is attenuated, the power current I increases very rapidly when the saturation of the magnetic circuit of the non-optimised filtering device LPF is reached, as shown clearly in figure 3c (curve with rhombuses 5).

For the purpose of delaying the occurrence of the saturation phenomenon, the optimised filtering device LPF according to the invention comprises a magnetic circuit with at least one air gap AG.

Figure 3a shows clearly that the magnetic flow Φ then increases less strongly according to the power current I (curve with squares 3) than in the case in which the magnetic circuit does not have an air gap AG (curve with rhombuses 2). The phenomenon of saturation is also less substantial.

In this case, the magnetic energy Em stored reaches values (curve with squares 6 in figure 3b) which are higher than the values corresponding to the non-optimised filtering device LPF (curve with rhombuses 4).

The result of the implementation of an air gap AG is slow development (as shown by the curve with squares 7 in figure 3c) of the power current I after saturation, at the moment when the motor DCM is put into service, in comparison with the non-optimised filtering device LPF.

Figure 4 shows a filtering device of an inductive type, of the type previously developed by the applicant company, which corresponds substantially to a housing C, YO, CM, CM' made of magnetic material such as steel, and primary W1 and secondary W2 winding circuits.

The housing comprises a cylindrical head YO, two closure parts CM. CM' and an axial core C around which the winding circuits W1, W2 are provided.

The primary winding circuit W1 is designed to be inserted in series in the power circuit, and the secondary winding circuit W2 is short-circuited.

This secondary winding circuit W2 comprises a plurality of turns, or alternatively is produced in the form of a ring.

According to a first preferred embodiment represented in figure 5, the optimised device LPF comprises the same essential elements as the non-optimised filtering device LPF, i.e. a housing C, YO, CM, CM' made of magnetic material, and primary W1 and secondary W2 winding circuits. It differs in the presence of a median air gap AG of approximately 0.5 mm to 5 mm, in an axial direction, situated substantially in the middle of the central core C.

According to a second preferred embodiment represented in figure 6, the optimised device LPF comprises an axial core C with two end air gaps AG1, AG1' between the closure parts CM, CM'. These air gaps AG1, AG1' are preferably approximately 0.5 mm to 5 mm.

According to a third preferred embodiment represented in figures 7a and 7b, the optimised device LPF comprises closure parts CM, CM' which each have an annular air gap AG2, AG2'; AG3, AG3'.

These annular air gaps AG2, AG2'; AG3, AG3 are axially aligned either with the primary winding circuit W1 (figure 7a) or with the secondary winding circuit W2 (figure 7b), i.e. the generatrices which define them are substantially combined with those which envelop the primary and secondary winding circuits W1, W2.

An air gap AG in the magnetic circuit C, YO, CM, CM' makes it possible to reach the saturation of this magnetic circuit C, YO, CM, CM' later, and thus to supply for longer the electric motor DCM of the starter DCM, EC by means of an attenuated current level (by means of the filtering device LPF).

Thus, the electric motor DCM has reached a higher speed of rotation, and therefore generates a higher counter-electromotive force at the moment of saturation, which contributes towards limiting the power current I.

In certain embodiments of the invention, the secondary winding circuit W2 can advantageously be constituted by a conductive tube (which for example is made of copper or aluminium), which is concentric to the primary winding circuit W1, and is situated on the exterior or the interior of the latter.

A structure of this type can lead to a filtering device LPF which is simpler to produce than the secondary winding circuit W2 with a plurality of turns. It will be noted that the maintenance of a ratio of length to radius which is identical to that of a secondary winding circuit W2 with a plurality of turns will require correct dimensioning of the thickness of the tube. The electrical functioning of the filtering device LPF will not be modified as a result of the ratio N1/N2 which characterises the transformer, provided that there is transition from a resistance R for N2 turns, to a resistance $R/N2^2$ for a turn with the tube, N2 and N1 being respectively the numbers of turns of the winding circuits W2 and W1.

It will be appreciated that the invention is not limited simply to the above-described preferential embodiments.

In particular, the various arrangements in the magnetic circuit C, YO, CM, CM' of the air gap(s) AG specified are only examples of embodiments.

In the above description, the air gaps AG are implicitly free spaces between two parts of the magnetic circuit C, YO, CM, CM'.

Alternatively, the function of the air gaps AG can be obtained by means of a section which can be saturated in the magnetic circuit C, YO, CM, CM', which section is saturated either suddenly or progressively. For example a closure part CM, CM' with a section which is insufficient for passage of the total flow will be saturated starting with the centre, which is equivalent to an air gap which is formed progressively. The saturation can be determined by selecting the thickness of the closure part CM, CM' according to the radius. Similarly, throttling in the core C or in the exterior flow return can be used to create a progressive air gap effect by means of saturation.

The invention thus incorporates all the possible variant embodiments within the limit of the subject of the following claims.