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(54) A METHOD OF SWITCHING IN AN ENERGISING CIRCUIT FOR A PAIR OF D.C. TRACTION MOTORS FROM EITHER AN A.C. OR A D.C. SYSTEM AND A POWER SUPPLY CIRCUIT FOR SUCH TRACTION MOTORS

(71) We, SOCIETE NATIONALE DES CHEMINS DE FER FRANCAIS, a French Body Corporate of 88 Rue Saint Lazare, 75009 Paris, France and ANDRE COSSIE, a French citizen of 88 Rue Saint Lazare, 75009 Paris, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The invention relates to power supply circuitry for a pair of d.c. traction motors to provide a speed regulator that can be operated with a.c. or d.c. supplies using semi-conductor equipment.

With the advent of power semi-conductors, the design of traction motors has been profoundly modified and the supply means have become static - i.e., mixed bridges (diodes and thyristors) for "single-phase" a.c. supply; and "choppers" for d.c. supply.

As is well known, mixed-bridge circuits operated by a single-phase a.c. supply have the advantage of very simple operation, since the thyristors are extinguished in a natural manner.

It is also well known that d.c. "chopper" devices, on the other hand, require special extinction means since, in this case, the direct current power supply cannot of course be extinguished naturally and the control gates cannot be used for extinction.

Methods have already been proposed for supplying "monolithic" semi-conductor assemblies from either an a.c. or a d.c. system. In such methods, the connections are changed outside the semi-conductor circuit.

The circuit proposed hereinafter can appreciably simplify a change from a.c. to d.c. operation and vice versa by allowing the connections inside the semi-conductor circuit to be altered, so that they can be energised with either a.c. or d.c.

According to the present invention there is provided a method of switching in an energizing circuit for a pair of d.c. traction motors, using the same two power thyristors with either direct current or alternating current power supplies, characterised in that:

(a) with a direct current supply, circuit connections are made so as to form two choppers comprising the thyristors and associated extinction means which are connected to the motors, and freewheel diodes connected in parallel with the motors and their smoothing inductance coils;

(b) with an a.c. supply the internal circuit connections are changed to convert the choppers and freewheel diodes into a mixed bridge including thyristors and diodes.

The present invention also provides a power supply circuit for a pair of d.c. traction motors connected in parallel comprising first and second thyristors and a plurality of diodes, first and second smoothing inductances connected respectively in series with each motor, and a plurality of switching contacts disposed in the circuit which are operable together to provide a first circuit configuration for use with a.c. supply in which at least one diode is connected in a respective one of two arms of a bridge circuit, the thyristors occupying the other arms, the output of the bridge circuit being connected across the parallel combinations of the d.c. motors and their smoothing inductances,

the switching contacts being operable together to provide a second circuit configuration for use with d.c. supply in which the thyristors are connected to provide choppers for the motors and the diodes are connected in parallel with the motors and smoothing inductances as freewheel diodes.

An embodiment of the invention will now be described, by way of example only, with

reference to the accompanying drawings.

Figure 1 shows a circuit for supplying direct current to two traction motors M1 and M2 comprising "series" field windings and connected in parallel. The two motors together are supplied by two choppers H1, H2 with interlaced operation. The diagram shows the smoothing inductance coils SL1, SL2 and the freewheel diodes D1, D'1, D2 and D'2.

Figure 2 shows a supply circuit from the secondary winding of a power transformer TFP supplied with single-phase current; each of two traction motors M1, M2 is connected in series with smoothing inductance coils SL1, SL2, the two sub-assemblies being connected in parallel between the points P and Q. The assembly is supplied by a mixed bridge (thyristor TH1, TH2, and diodes D, D' where diode D represents the diodes D1 and D2 connected in parallel, and D' represents the diodes D'1 and D'2 connected in parallel.)

Figure 3 shows the method of transition from the circuit in *Figure 1* to the circuit in *Figure 2*. It is sufficient to modify the connections to TH2. The parallel connection must be moved along the chain-line arrow and one terminal of the transformer must be connected to the central point of diodes D1, D'1 and D2, D'2.

Figure 4 shows a circuit which can be adapted to serve three purposes: d.c. traction, single-phase current traction, and rheostatic braking by operating the motors as generators delivering current to rheostats RF1 and RF2.

Figure 5 shows the motors providing traction, when energised by a d.c. system. It includes the circuit in *Figure 1*, the parts of the installation in operation being represented by continuous lines.

Figure 6 shows traction operation of the motors when supplied from an a.c. system. It includes the diagram in *Figure 2*, the parts of the installation in operation being represented by continuous lines.

The circuit in *Figure 7* shows the operation of the motors during rheostatic braking. The motors operate as generators, separately energised, and deliver current to rheostats RF1 and RF2, the separate excitation current being supplied by a set of batteries BA. The parts of the installation in operation are represented by continuous lines.

In the diagrams, the various devices are denoted as follows:

30	TFP	Main transformer	30
	TH1, TH2	Main thyristors	
	D1, D'1, D2, D'2	Freewheel diodes	
	RF1, RF2	Braking rheostats	
35	SL1, SL2	Smoothing inductance coils	35
	J1, J2	Motion reversal switch	
	l_1, l_2	Field windings of the traction motors	
40	M ₁ , M ₂	Armatures of the traction motors	40
	r ₁ , r ₂	Permanent shunting resistors across field windings	
	s ₁ , s ₂	Permanent shunting contactors for the resistors	
45	VT	r ₁ , r ₂	45
	BA	Rheostat fans	
	TH3	Set of batteries	
50	D3	Thyristor of excitation chopper	50
	HMCF (a, b, c, d, e, f, g, h, i, j)	Diode of excitation chopper	
		Contacts of switch controlling "single-phase" traction, continuous traction and braking	
55	F, F1, F2	Braking contactors	55
	L1, L2, LIM, LIC	Main traction contactors	
	CEX, CEX 1	Excitation contactors	

Accordingly, the method and circuitry which has been described has the property of using the same components to form (a) a Graetz bridge in the case of single-phase supply or (b) a "chopper" supply circuit using direct current. This property is obtained by re-arranging the various components. In other words, switching means (switches, contactors, etc.) are appropriately used as required to obtain either a circuit such as a Graetz bridge or a chopper supply circuit, using the same components, by operating switch means inside the

circuit.

WHAT WE CLAIM IS:-

1. A method of switching in an energizing circuit for a pair of d.c. traction motors, using the same two power thyristors with either direct current or alternating current power supplies, characterised in that:
- (a) With a direct current supply, circuit connections are made so as to form two choppers comprising the thyristors and associated extinction means which are connected to the motors, and freewheel diodes connected in parallel with the motors and their smoothing inductance coils;
- (b) with an a.c. supply the internal circuit connections are changed to convert the choppers and freewheel diodes into a mixed bridge including thyristors and diodes.
2. A power supply circuit for a pair of d.c. traction motors connected in parallel comprising first and second thyristors and a plurality of diodes, first and second smoothing inductances connected respectively in series with each motor, and a plurality of switching contacts disposed in the circuit which are operable together to provide a first circuit configuration for use with a.c. supply in which at least one diode is connected in a respective one of two arms of a bridge circuit, the thyristors occupying the other arms, the output of the bridge circuit being connected across the parallel combinations of the d.c. motors and their smoothing inductances,
- the switching contacts being operable together to provide a second circuit configuration for use with d.c. supply in which the thyristors are connected to provide choppers for the motors and the diodes are connected in parallel with the motors and smoothing inductances as freewheel diodes.
3. A power supply circuit as claimed in claim 2, including a braking rheostat associated with each motor and connectable therewith by respective switching contacts, the motors being disconnectable from their field windings enabling the motors to operate as separately energisable generators for the braking rheostats.
4. A method of switching for energising a pair of d.c. traction motors substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.
5. A power supply circuit for a pair of d.c. traction motors substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

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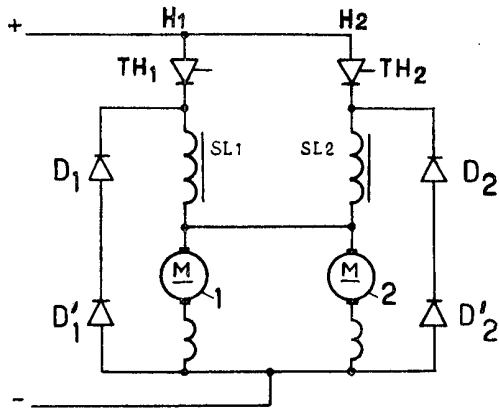


Fig. 1

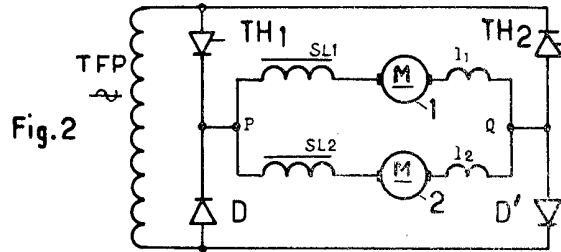


Fig. 2

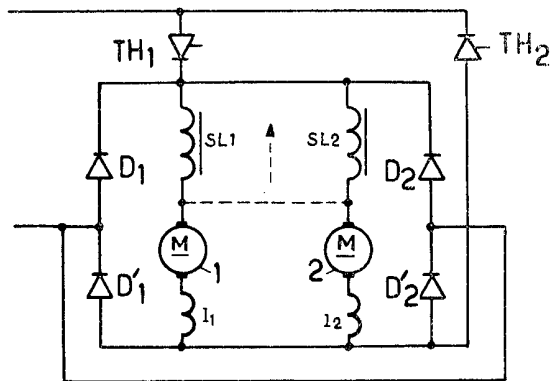
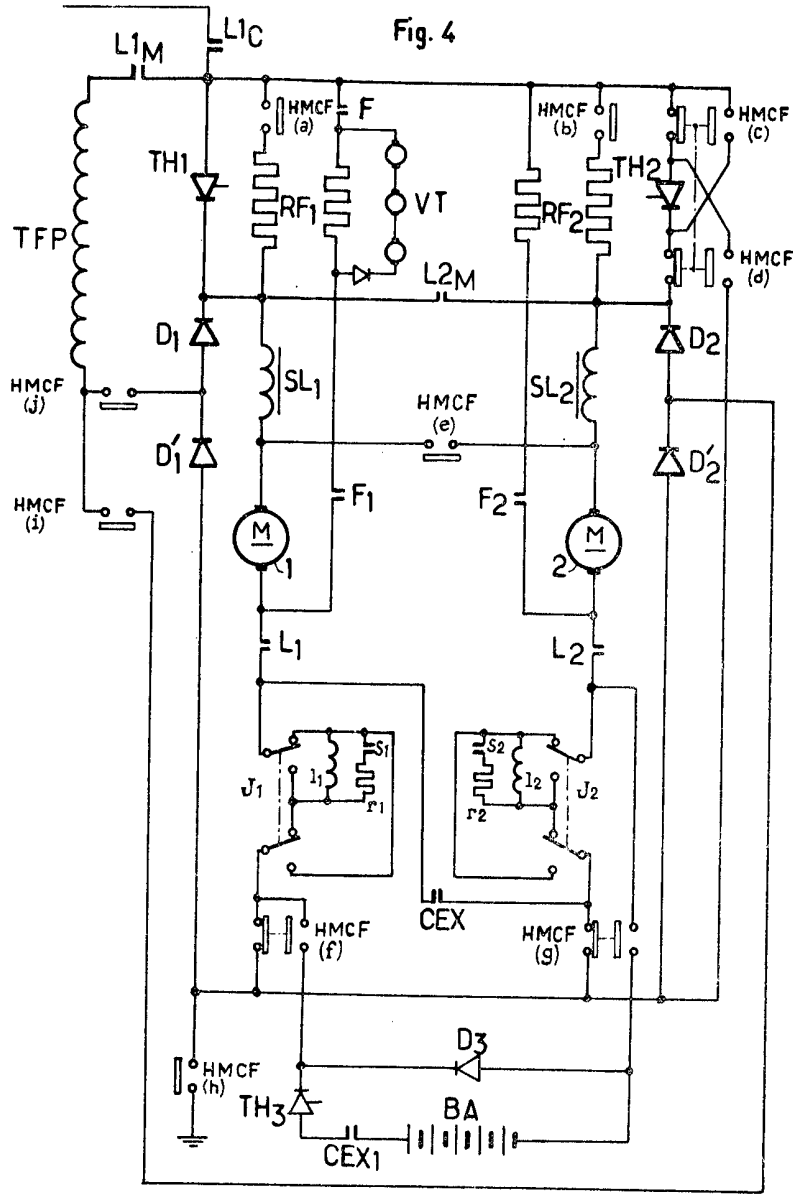


Fig. 3



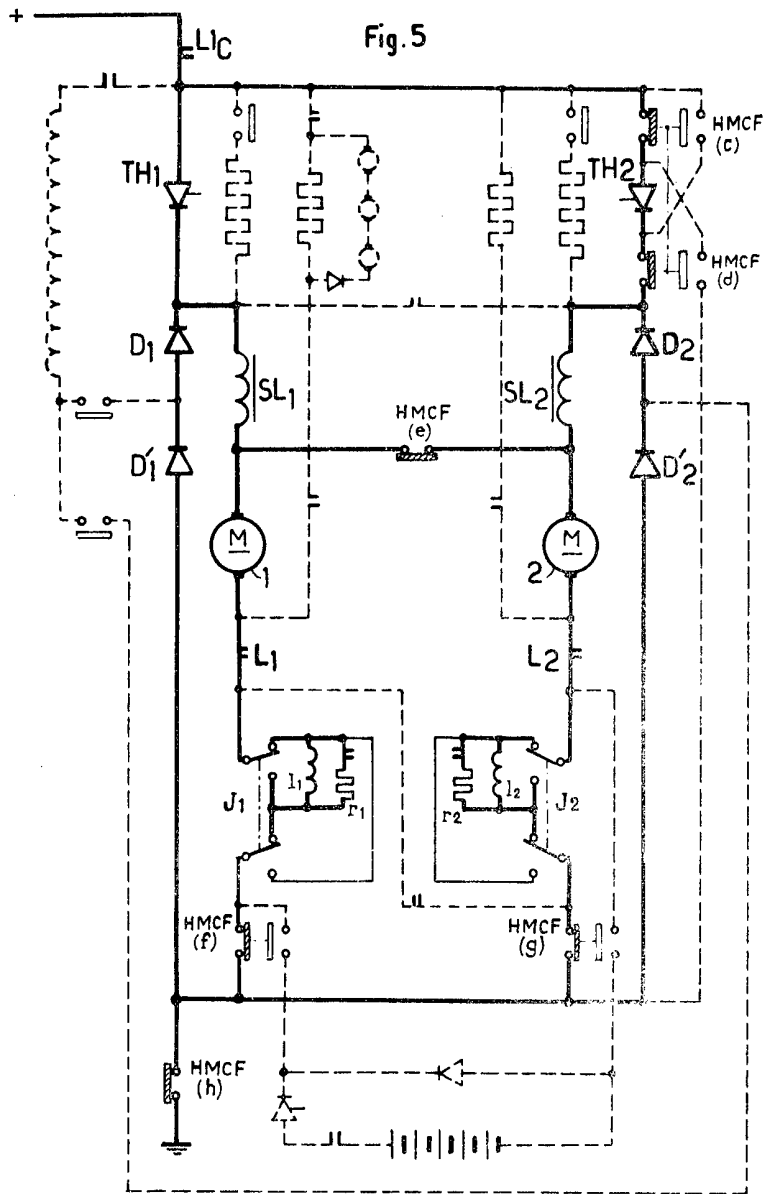


Fig. 6

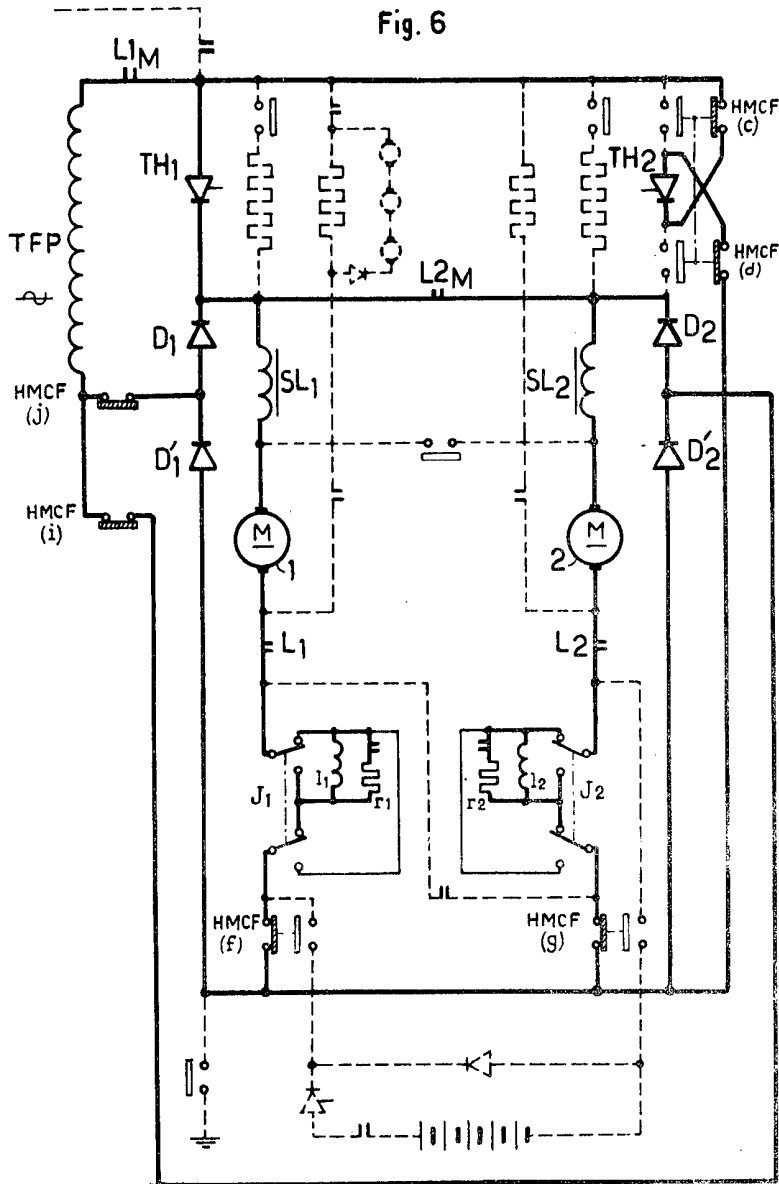


Fig. 7

