

A Thyristor-Controlled Electric Motor

The present invention concerns a thyristor-controlled electric motor, such as the d.c. motor of a lift.

Thyristors are nowadays frequently associated with electric motor drives. Especially in a.c. lifts in which
5 squirrel-cage motors are used for drive motors, it is possible to regulate for instance the torque of the motor by the aid of choke elements connected into one or several of its phases. In the capacity of choke elements operate
thyristors connected to this purpose, for instance in
10 pairs.

Direct current lift drives have traditionally been Ward-Leonard drives. According to this commonly known technique, the direct current motor is controlled with a direct current generator. But with the development of
15 semiconductor techniques, it has become more economical to replace the d.c. generator with a thyristor rectifier. The thyristor bridges meant for rectifying uses which are usually employed in lift technology are commonly known, three-phase twelve-thyristor four-quadrant drives, although
20 rectifiers have also been constructed with fewer thyristors.

The thyristor drive is appropriate to be used as a lift drive in all other respects, but a problem has resulted from the uneven voltage of the thyristor control at the terminals of the hoisting motor. This voltage variation
25 gives rise in the hoisting motor to a noise, which is embarrassing to the person using the lift and to other

persons in the vicinity of the lift, thereby detracting from the quality of the product.

With a view to damping the objectionable noise, for instance the circuit of Figure 1 of the accompanying drawings has previously been used. In this circuit, thyristors make up the rectifying bridge required for the hoisting motor. Moreover, the thyristors are protected by the aid of commutation chokes, which serve the sole purpose of protecting the thyristors against excess current peaks at the times when the current switches over from one thyristor to another. The sound damping is accomplished with a sound filter, consisting of a choke connected to one terminal of the hoisting motor and a capacitor connected to both motor terminals. This sound filter operates as a low-pass filter, and the filtering improves with increasing inductance of the choke coil and with increasing capacitance of the capacitor. The drawback of this solution is its high price and its incomplete functioning. Since the choke carries the whole of the motor direct current and has a comparatively high inductance, it is obviously quite expensive. Furthermore, no complete sound deadening is accomplished with this design: a limitation is for instance imposed by the circumstance that the capacitor would need to be made infinite in size.

25 The object of the present invention is to eliminate the drawbacks mentioned which present themselves in thyristor-controlled electric motors, and to provide a problem solution enabling the said objectionable noise to be efficiently

and advantageously eliminated. According to the present invention we provide an electric motor, such as a lift d.c. motor, provided with a controlled circuit comprising at least one thyristor bridge and commutation chokes protecting the thyristors thereof against excess current peaks, and at least one series resonance circuit connected across the terminals of the motor, the commutation chokes serving additionally as a series damping choke, the arrangement filtering out voltage frequencies which would give rise to undesirable motor noise.

The invention affords the advantage, among others, that the series resonance circuit can be made to operate with comparatively low capacitance and inductance values, compared with the prior art device cited above. It is therefore possible to use considerably less expensive components. The commutation chokes may also be very nearly similar to those used in designs of prior art already, but they are assigned still another task in the capacity of series damping chokes of the sound damping. A further advantage is the circumstance that since the series resonance circuit constitutes a full short-circuit at a given frequency, which introduces the greatest amount of objectionable noise, the sound deadening will be more efficient than it is in designs of prior art, in which the damping effected by the capacitor connected across the motor terminals is not complete at any frequency. This solution is particularly advantageous in the case of a d.c. motor because for the damping out of the fundamental frequency,

that is the most objectionable frequency, one single series resonance circuit is enough. If one is compelled to damp out multiples of the fundamental frequency, one series resonance circuit each suffices for these too. It is advantageous in the case of d.c. lifts to be able to minimize the objectionable noises since d.c. drives are expensive on the whole, and therefore a very high standard of performance is required.

One favourable embodiment of the invention is characterized in that there have been connected in parallel with the series resonance circuit damping out the fundamental waves, one or several series resonance circuits damping out multiple waves of the fundamental wave. The advantage of even further improved sound deadening is then gained.

Another embodiment of the invention is characterized in that the resonance of the series resonance circuit is n times the frequency of the supplying network, with n equalling 2, 3, 6 or 12. Hereby the objectionable resonance frequency is directly overcome with the series resonance circuit.

Constructional forms of the invention will now be described by way of example with reference to the accompanying drawings wherein:-

FIGURE 1 shows a sound deadening circuit of prior art.

FIGURE 2 shows an electric motor having a sound deadening circuit in accordance with the present invention.

FIGURES 3 and 4 illustrate by the aid of graphs, the wave form of the voltage supplied by the thyristor bridge,

and the corresponding shape of the armature current.

FIGURE 5 shows a simplified circuit in accordance with the present invention, and

FIGURE 6 shows an embodiment of the present invention
5 wherein harmonics are also damped.

Although as a rule the thyristor bridges in lift application use are twelve-thyristor drives, the drawings of this text display, in the interest of clarity, only one of the two six-thyristor bridges. The principle character
10 of the present matter is not changed hereby in any way. In the circuit of prior art present in Figure 1, in the interest of brevity and clarity the same reference numerals have been used for the components as in the circuit of the present invention, in Figure 2. The components indicated by
15 the same reference

numeral may be referred to by the same name although the components are not equivalent as to their values nor their properties. The principle of operation of the design of prior art was already described before. In the design of the invention shown in Fig. 2, the thyristors 1-6 constitute the rectifying bridge 14 needed for the motor 12. The chokes 7, 8 and 9 are commonly known, thyristor bridge commutation chokes with the task: to protect the thyristors 1-6 against excess current peaks when the current changes over from one thyristor to another. In keeping with the nature of the present invention, however, these chokes 7, 8 and 9 are here assigned another task, which will be more closely described later on. The series resonance circuit 16, comprising the choke 10 and the capacitor 11 connected in series with each other, has been connected across the terminals of the motor 12. The component 13 further visible in Fig. 2 is the magnetising winding of the motor, by the aid of which magnetising of the motor is accomplished in a well-known manner.

In order that the invention might be better understood, it is first necessary to know more precisely the general nature of the waviness in the voltage and current supplied by the thyristor bridge 14. Figs 3 and 4 serve the clarification of this. In Fig. 3, the graph 17 represents the wave shape of the voltage from the thyristor bridge 14 in the case that the counter-electromotive force of the motor 12 is zero and the armature current 18 is low. Fig. 4 represents the case in which in order to overcome the counter-electromotive force 19 of the motor 12 a higher voltage 20 is required from the thyristor bridge 14, whereby the armature current 21 is also higher than in the preceding instance. However, the armature current is not dependent on the voltage level: it varies in accordance with the load imposed.

It is seen from Figs 3 and 4 that the objectionable voltage is an asymmetric triangular wave 17 and 20. If the thyristor system in question operates from a 50 Hz mains supply, the frequency components of the voltage wave 17 and 20 will be 300 Hz and multiples thereof. However, the 300 Hz component is the largest, and consequently the objectionable noise has almost exclusively the frequency of 300 Hz. The present invention is based on filtering out only the objectionable 300 Hz frequency by means of the circuit of Fig. 2. The filtering is accomplished with the series resonance circuit 16 constituted by the choke 10 and capacitor 11. Hereby, at the same time, a new task is imposed on the choke coils 7, 8 and 9. The chokes become series elements of the objectionable voltage damping, and this element may be called the series damping choke 15. This is illustrated in greater detail, though in principle, by Fig. 5. The choke 22 is the equivalent circuit of the chokes 7, 8 and 9 and it operates as series damping choke. With a view to the damping of the

objectionable voltage, one may imagine the choke 22 equally well as inserted between the thyristor bridge 14 and the motor 12. The short-circuit lead 23 represents the series resonance circuit 16 at 300 Hz frequency. It will thus be understood with reference to Figure 5, that the objectionable 300 Hz voltage remains across the choke 22, and this component is not present in the voltage across the motor terminals.

If in any particular instance the 300 Hz damping is not enough, it is possible to improve the damping by connecting a second series resonance circuit 24 in parallel with the 300 Hz series resonance circuit 16. This case is illustrated by the circuit in Figure 6. When the mains frequency is 50 Hz, the next multiple frequency giving rise to objectionable noise will be 600 Hz. Then, by properly selecting the components for the series resonance circuit 24, this objectionable noise too can be damped like the one before. The objectionable noises arising from the next multiple frequencies are already weak enough to have no practical significance.

It is obvious to a person skilled in the art that different embodiments of the invention are not exclusively confined to the examples presented above, and that they may vary within the scope of the claims following below. For instance, the sound deadening circuit of the invention may also be utilized in a.c. drives in which control of the drive motor has been carried out with the aid of a thyristor circuit.

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It should only be noted in that case that a circuit equivalent to the series resonance circuit 16 has to be separately incorporated in each phase, and likewise a circuit equivalent to the series damping circuit 15.



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CLAIMS:

1. An electric motor, such as a lift d.c. motor, provided with a control circuit comprising at least one thyristor bridge (14) and commutation chokes (7, 8 and 9) protecting the thyristors (1-6) thereof against
5 excess current peaks, and at least one series resonance circuit (16) connected across the terminals of the motor, the commutation chokes (7, 8 and 9) serving as a series damping choke (15), the arrangement filtering out voltage frequencies which would give rise to undesirable
10 motor noise.

2. An electric motor according to claim 1, characterized in that in parallel with the series resonance circuit (16) damping the fundamental waves there are connected one or more series resonance
15 circuits damping multiple waves of the fundamental wave.

3. An electric motor according to claim 1 or 2, characterized in that the resonance of the series resonance circuit (16) is n times the frequency of the supply mains network, with n equal to 2, 3, 6 or
20 12.

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