Electrical Installations in Multi-storey Buildings

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The number of multi-storey buildings is constantly increasing - particularly in cities - due to the shortage of space and the high cost of land. Designers and installers of electrical systems for such buildings must also make due allowance for this changed situation.

The ready re-allocation of space within such buildings to meet changed conditions is also generally considered a desirable feature today. The electrical equipment and wiring must thus be as flexible as possible.

Department stores, offices, hotels, educational centres, hospitals and industrial plants etc. come under the category of large buildings.

The definition of a multi-storey building in West Germany is laid down in the guidelines for buildings issued by the Federal Ministry of Labour and Social Administration. According to this, a multi-storey building is one in which any floor constantly used by people is more than 22 metres above ground level.

Power requirements

The power requirements of a large building consist of the loads for lighting, power and heating. Communications, control and monitoring systems represent other loads.

An item that necessitates a very careful check is the *lighting load.*

The *power required* for operating the water, heating, ventilation and air conditioning systems must also be very carefully calculated. Lifts demand very thorough study, since they are generally driven by large motors (*Figs. 1 and 2*) the starting of which may cause voltage dips in other sections of the system if their supply system is not designed properly. In hospitals power must moreover be available for therapeutic treatment, X-ray equipment, and steri-

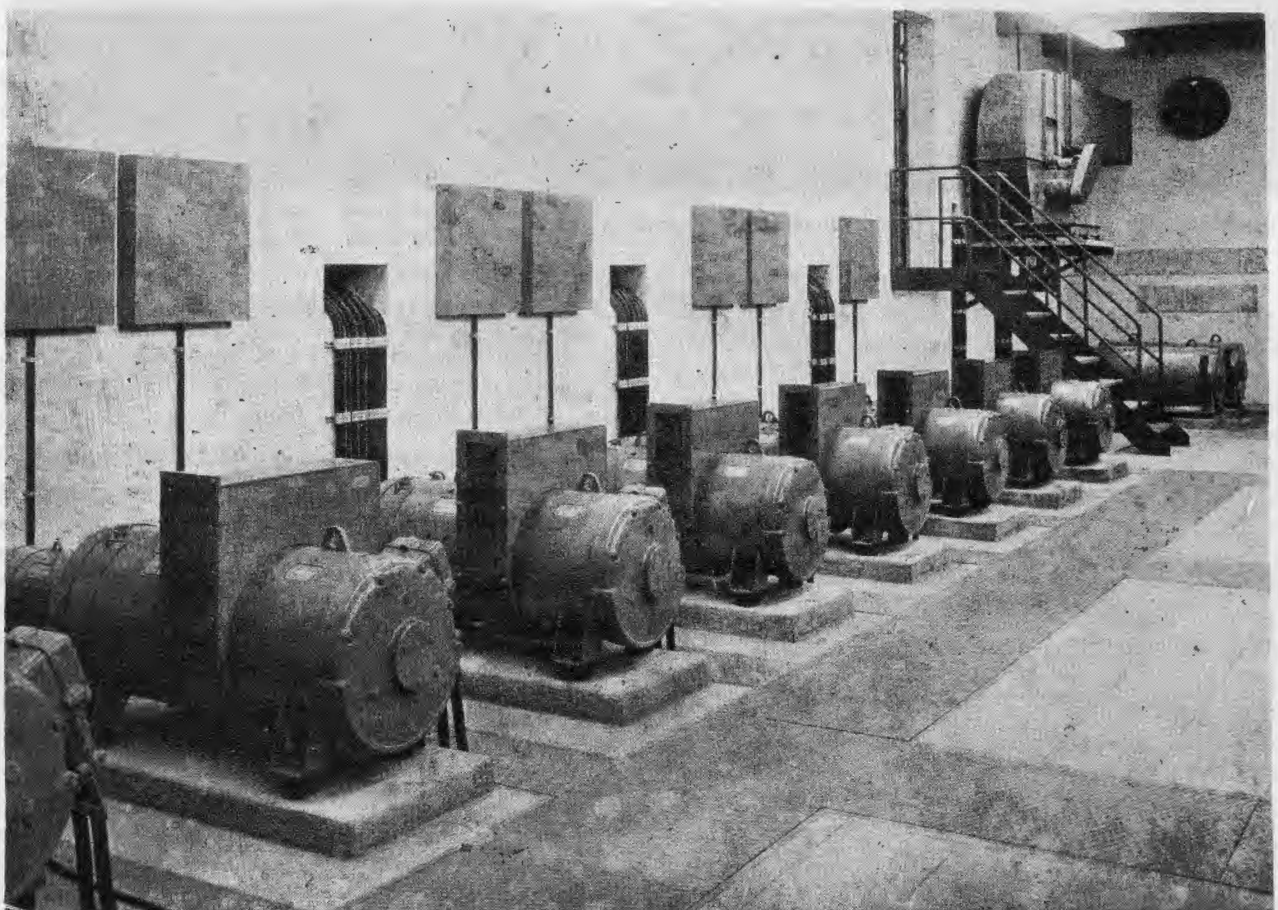

Fig. 1 M. G. sets for the lift installations in a multistorey building.

lizing units, as well as for the wards and operating theatres with their exacting safety standards.

The amount of power required for *communication equipment* (e. g. telephones, signalling, fire-fighting, clock and radio systems) is generally small, but it must also be taken into consideration in the planning work.

Cubage	125,000 m3
Total floor area	32,000 m2
Useful office floor area	16,000 m2
Number of work places	2,000
Installed transformer rating	3,6000 KVA
Load value allowing for diversity factors and power factor correction	2,250 KVA

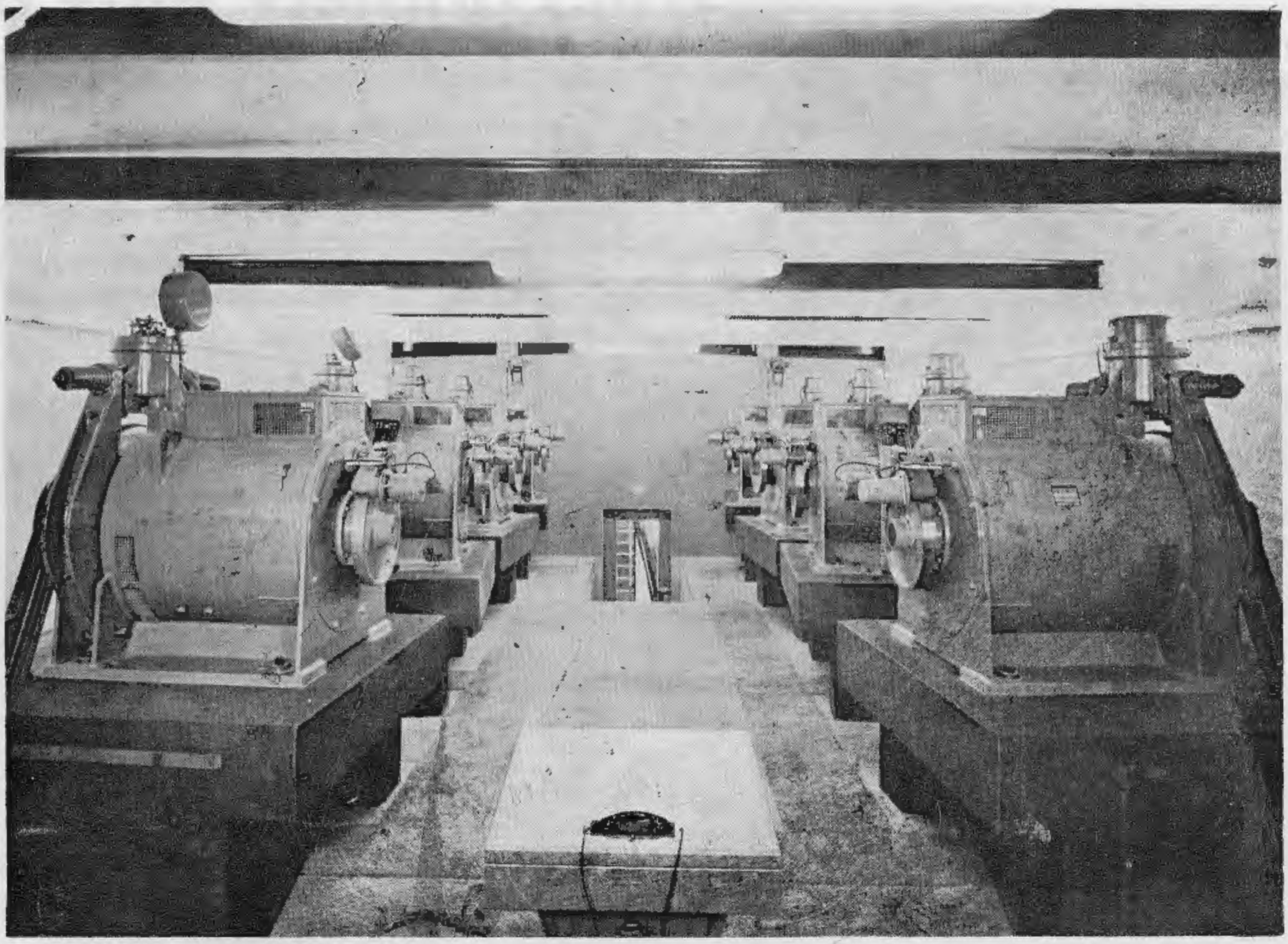

Fig. 2 Motors for the passenger lifts in a multi-storey building.

After calculation of the total connected load values, the anticipated load values are estimated on the basis of diversity factors (empirical values). Here, it will be necessary to take account of the different diversity factors of the individual sections. However, it is not necessary to add together the individual load values thus calculated since in most cases it will be clear beforehand that certain load groups will not be connected simultaneously. To determine the total requirement it is thus advisable to plot the actual load values over a 24 hour period graphically. Only by this means can the sections of the installation be properly planned to obtain maximum economic efficiency. The possibility of subsequent modifications or additions should nevertheless be borne in mind.

A few empirical values are given below in order to illustrate the actual load values of large buildings.

The figures given are based on mean values gathered from five multi-storey administration buildings erected in recent years (kitchen installations are not included).

The loads are subdivided as follows:

25% for Lighting
48% for air conditioning, heating and ventilation
22% for lifts
5% for miscellaneous loads.

The values determined for electrical power made available were 70 W per sq. metre referred to the total floor area, and 1.12 KW per work place. The costs for the power system - including lighting — were 7% of the total costs, while those for the communications systems were 1.5%.

The individual sections of the installations are dealt with below.

Incoming supply

The heavy loads of large buildings almost always necessitate the provision of a high-voltage feeder with a transformer substation to step down the voltage of the incoming supply. Such stations are generally accommodated on one of the lower floors. The

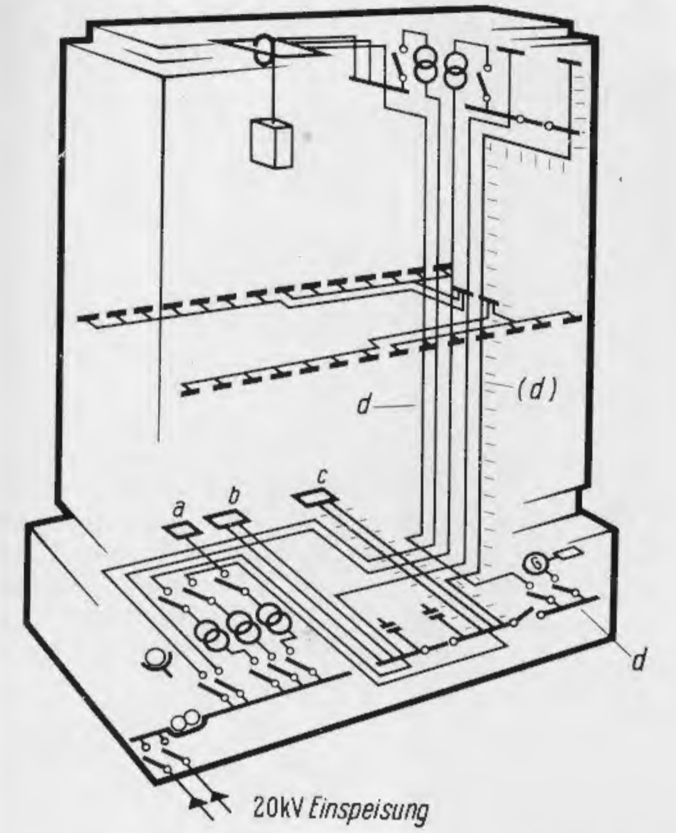

Fig. 3 Schematic layout of the power supply in a multi-storey building with high-voltage feeders to the basement and the top service floor. a) cooling plant; b) heating, ventilation, pressurized water; c) air intake, fire-extinguishing pumps; d) standby supply system. High-voltage 20-kv, low-voltage supply system 220/380 V.

space used for this purpose must comply with government and local regulations, as well as those of the power supply company concerned.

Owing to the complexity of such installations, it is essential that the architect be consulted when the building is being designed. It must have appropriate openings to admit bulky parts of the installation. Structural measures must be taken to provide for ventilation of the transformers, etc. Only early collaboration with the architect will enable the proper solution to be found and thus forestall expensive alterations which may jeopardize the general appearance of the building.

It is generally advisable to install several transformer substations in a multi-storey building, particularly on the top floors, since the loads to be fed there are mostly heavy (lift motors or m.g. sets, air-conditioning plant, electrically equipped kitchens). This problem can be solved by using transformers either of the dry type or with a non-inflammable coolant such as Clophen and minimum or no oil switchgear. *Fig. 3* shows a schematic layout of the power distribution in a multi-storey building.

Switchgear

Progress and more sophisticated techniques have led to greater rationalization in this field. In addition to factory-assembled combination switchgear units (e.g. iron-clad distribution boards), newly developed equipment is available. The use of factory-assembled units for high and low-voltage switchgear has continued to spread. A superficial comparison of costs might nevertheless suggest that factory-assembled units are more expensive than the open type of construction formerly employed. It should, however, be borne in mind that these units are now much more compact than previously and that installation work has been reduced to a minimum; it comprises little more than securing the units to the previously prepared foundation frames and connecting up the cables. All these points tip the scales in favour of factory-assembled units. The fact that they are simple to operate is another advantage in view of the present shortage of trained personnel.

The design of factory-assembled metal-clad high-voltage units with barriers and drawouts as shown in *Fig. 4* obviates the use of isolators and results in other economic advantages (compactness.) If defects occur the drawout unit can be quickly and easily replaced and the section put into service again right away. There is thus no need to shut down the whole installation in order to repair part of it. The design of the metal-clad high-voltage units *without* barriers but with drawouts is similar.

Metal-clad switchgear units with drawouts have also been developed for low-voltage systems (*Fig. 5*)

Fig. 6 shows a factory-assembled low-voltage switchboard of metal-clad design. *It* is made up of standard housings and components and can easily be co-ordinated to suit the space available and the technical requirements.

Factory-assembled units of either iron-clad or moulded-plastic design are used as distribution boards

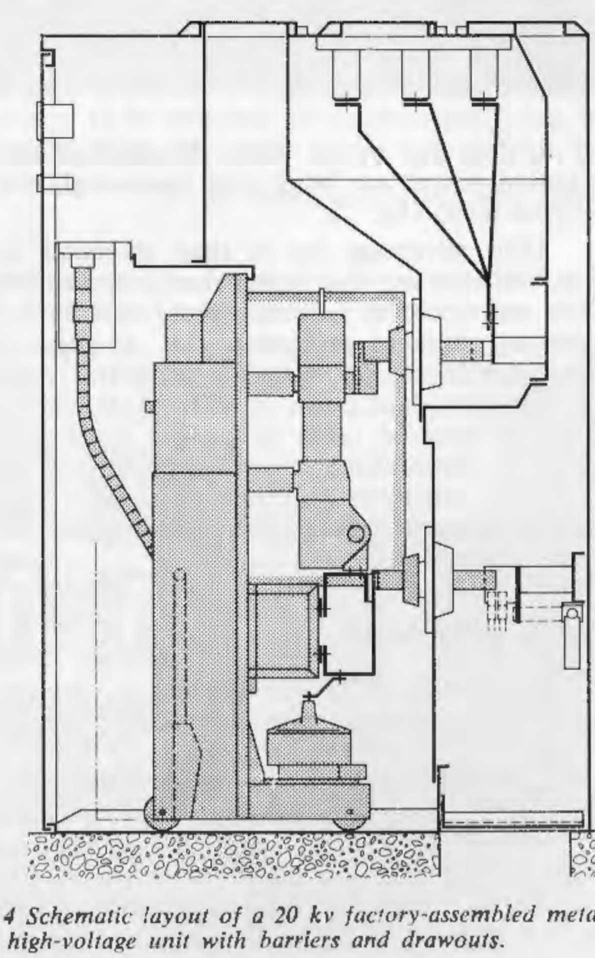

Fig. 4 Schematic layout of a 20 kv factory-assembled metal-clad high-voltage unit with barriers and drawouts.

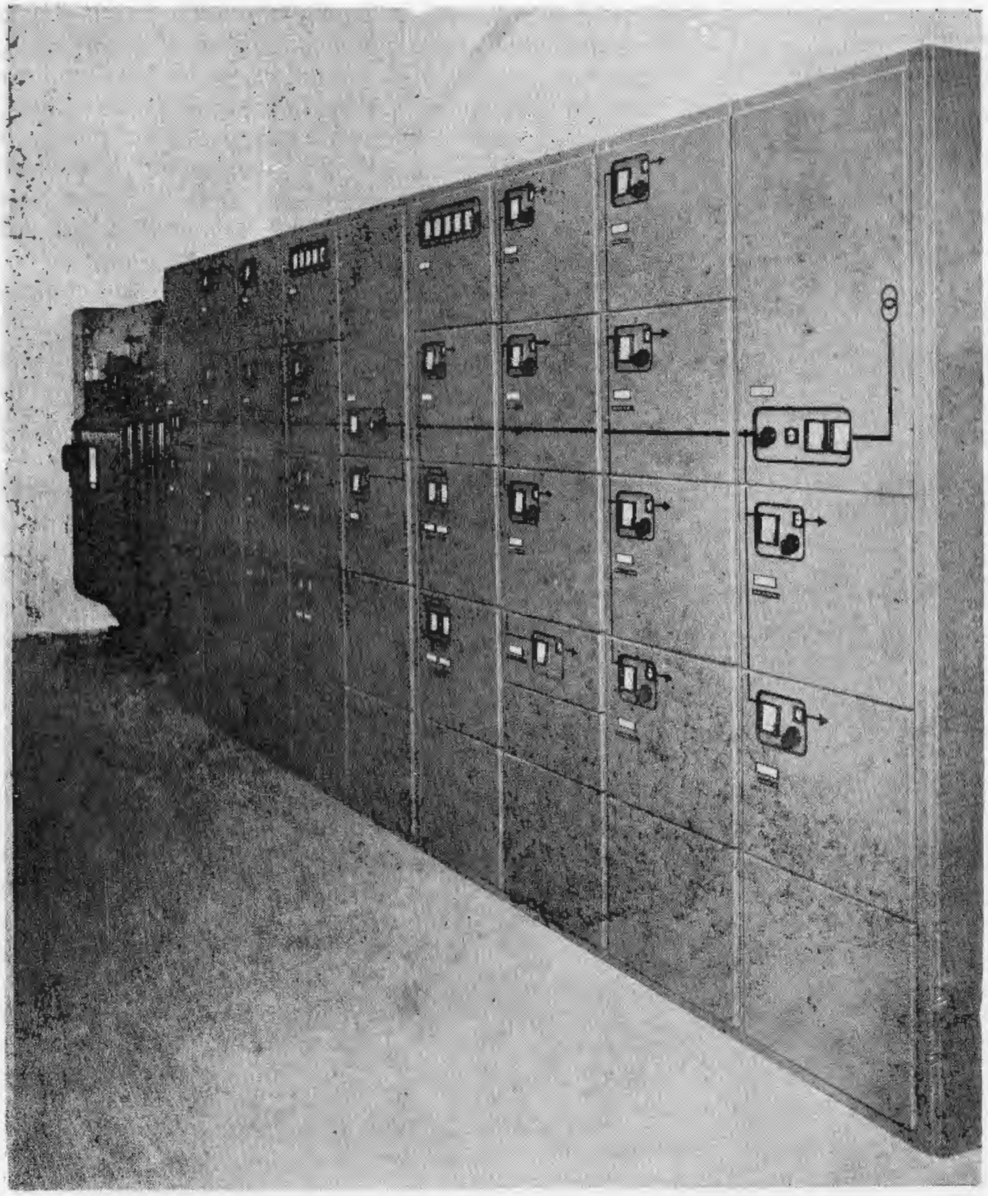

Fig. 5 4000-A factory-assembled metal-clad low-voltage units (obtainable with barriers) with drawouts rated up to 3000 A and flanged-on Clophen-immersed transformer for supplying a multi-storey building.

for lighting and power loads. Moulded-plastic distribution boards are being used increasingly for this purpose today (*Fig. 7*).

Their advantage lies in their all-round insulation, and they are also lighter than iron-clad boards. They are moreover corrosion-proof and do not require an aditional protective coat of paint. Since these boards comply with the protective measures for insulation laid down in VDE 0100, no further measures need be taken to prevent touch voltages either for the housing or contents, i.e. they can be employed where the neutral or multiple earthing scheme does not comply fully with the usual requirements.

Standby power supply

Regulations stipulate that every multi-storey building be equipped with a standby system independent of the man power supply for lighting the floors, stairways and exits, and feeding essential ventilation plant. This standby system must cut in automatically if the main supply fails. These requirements can generally be met by a simple battery installation. If there are no other standby facilities, the batteries must have a capacity of three hours. This period can be reduced to one hour if the batteries are used in conjunction with a standby generating set.

If the emergency services required exceed the minimum ones outlined above, a standby generating set of appropriate rating must be installed.

The rating is determined by the most important loads, e.g. fire-extinguishing pumps, part of the auxiliary drives for the heating system and ventilation, as well as lifts and room lighting. The priority of loads varies from case to case and is largely governed by the purpose for which the building is used and safety requirements. The power needed for standby operation may well be one third of the total for normal operation.

Division into essential and non-essential loads is necessary from the low-voltage switchboard onwards. This point is dealt with more closely in the section "Vertically-run conductors"

Fig. 8 shows a 500-kVA standby diesel generating set in a multi-storey building.
Besides the previously mentioned structural measures to admit bulky parts of the installation, the use of a standby set necessitates proper dimensioning of the foundations and appropriate layout of the exhaust pipes.

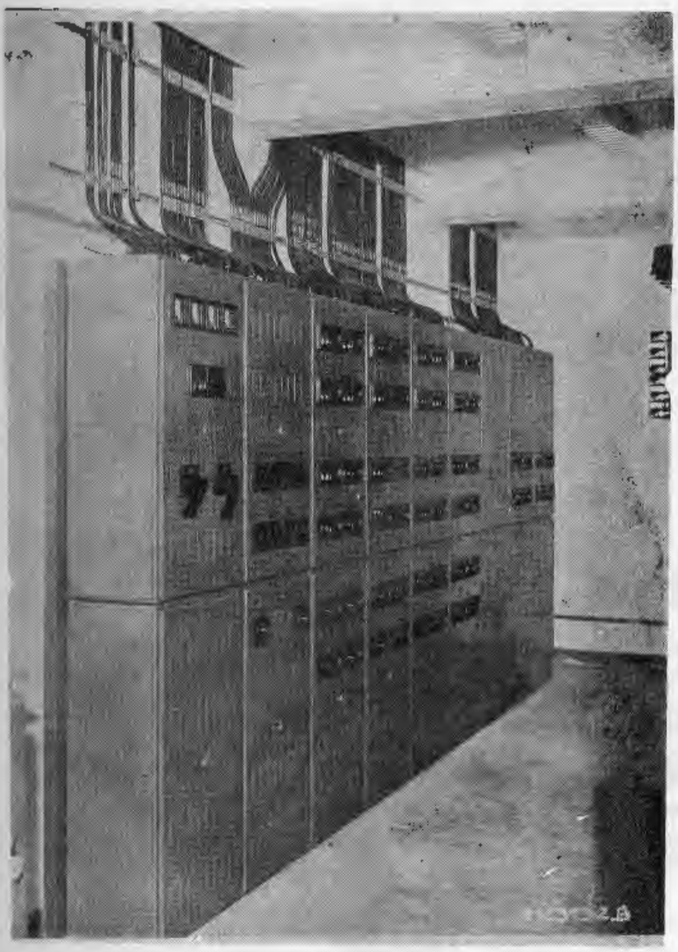

Fig. 6 1000-A factory-assembled low-voltage switchboard of metal-clad design.

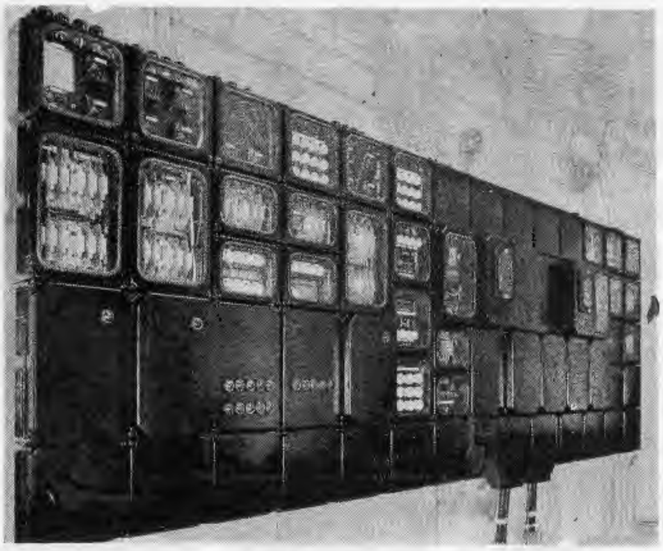

Fig. 7 Example of a 630-A moulded-plastic-clad distribution board.

Power factor correction

Power factor correction is essential in the interests of economic efficiency. Heavy loads are generally compensated individually. If heavy loads are fed from separate transformers, compensation can also be effected in the cubicles of the latter. The disadvantage of this arrangement lies in the fact that the feeder to the load must then be designed for reactive current. On the other hand, it is often easier to fit the compensating capacitor in the transformer cubicle than locally.

For fluorescent lighting tubes, group or central p.f. correction may be provided in place of individual compensation for each lamp. The *central p.f. correction* equipment (*Fig. 9*) must include a capacitor control unit which automatically cuts the capacitors in or out in accordance with the reactive current. For multi-storey buildings preference is generally given to the latter type of p.f. correction. However, nothing definite can be said as to which type of p.f. correction is best. It depends among other things on the length of the cables which in turn are governed by the size of the building and the system voltage.

Central p.f. correction equipment reduces much of the maintenance work necessary with local p.f. correction equipment; but it should be noted that the lighting distribution system carries the reactive current. When central p.f. correction equipment with an automatic capacitor control units is used, it must also be borne in mind that in emergency operation essential loads also have to be fed.

Group p. f. correction is expedient if large banks of lights have to be switched on simultaneously, e.g. in conference rooms, etc.

(*To be continued in the next issue*)

Fig. 8 500-kVA standby diesel generating set in the basement of a multi-storey building.

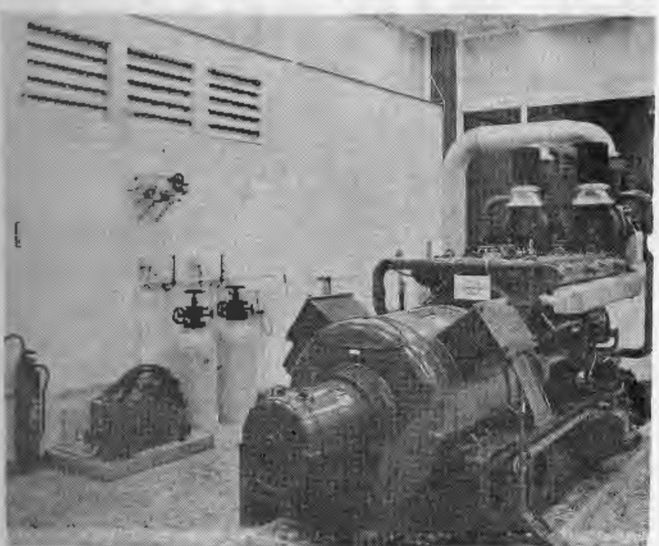

Fig. 9 Equipment for central p. f. correction. 1125 kVAr, in the basement of a multi-storey building.