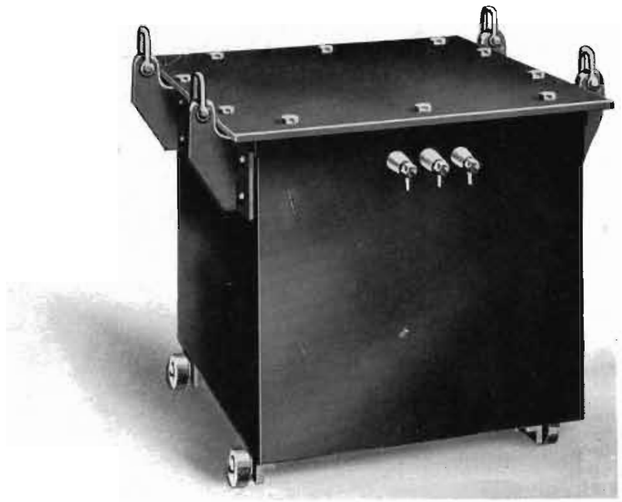
Dubilier - Mansbridge Condensers

for

Power-Factor Improvement *in* A. C. Power Circuits

DUBILIER CONDENSER CO. (1925) LTD.
Ducon Works
VICTORIA ROAD, NORTH ACTON, W.3



A Dubilier-Mansbridge Condenser for Power-Factor Improvement

55 kVA 600 Volts 50 cycles

DM.1 JUNE 1926

DUBILIER-MANSBRIDGE CONDENSERS

for

Power-Factor Improvement

WITH an alternating current power system, the power-factor of the various loads connected to that system needs careful consideration, not only from the point of view of the power station engineer, but also for the benefit of the consumer. The connection to the circuit of small induction motors, lightly loaded transformers, reactance coils or other inductive apparatus, draws current usually at a low power-factor, and the current is always a lagging one with respect to the voltage. The actual energy absorbed by the load is the product of the in-phase component of the current with the line voltage, and the out-of-phase component of the current merely represents "wattless" current which does no useful work, but merely heats up the cables, switchgear, etc., unnecessarily. Furthermore, these increased currents, necessitated by the low power-factor load, must be carried by the sub-station transformers, transmission lines or cables, and by the power station generators themselves, unless steps are taken to improve the power-factor. The magnitude of this increase of current may be gauged from the curves plotted in Fig. 1.

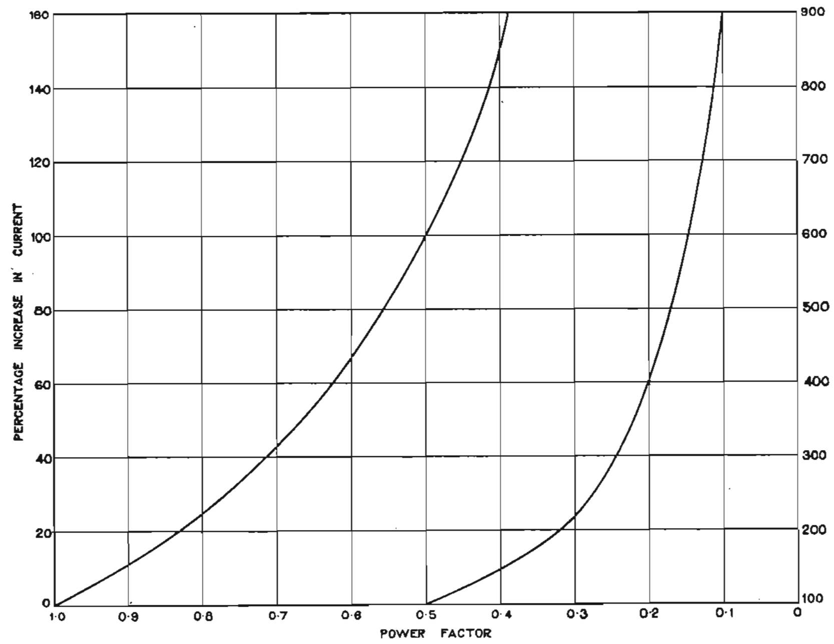


Fig. 1

Curves showing increase of current brought about by low power-factor.
This excess current can be saved by the use of static condensers.
The left-hand curve refers to the left-hand scale, and the right-hand curve to the right-hand scale.

In this diagram the percentage increase in current, as compared with unity power-factor, is plotted against the power-factor. For convenience in reference, the curve is plotted in two parts, the left-hand part relating to the left-hand scale and the continuation on the right-hand side being plotted to a different scale.

The increased copper loss in the cables and transformers, etc., carrying these increased currents will be proportional to the square of the increased current in each case. Thus, with a power-factor of 0·6, this copper loss will be approximately 180% greater than at unity power-factor.

Improvement of the power-factor of the supply network is, therefore, able to make that supply system capable of supplying a larger load to the extent indicated by the above current ratios, and it is for this reason that in many places special tariffs are in force which tend to penalise those consumers who take energy at a low power-factor and to encourage those who take it at near unity. In most cases where such special tariffs are in force, the saving which can be effected by improving the power-factor will usually cover, in a very short time, the cost of the condenser installation necessary to produce the improvement.

An additional advantage obtained by the installation of equipment for power-factor improvement, is the better voltage regulation obtained with varying loads, on account of the reduced currents flowing in the cables and transformers. Furthermore, when planning new installations, the saving that can be effected in the cost of the cables themselves is a not inconsiderable item and offsets part of the cost of the condenser equipment.

Static condensers have the great advantage over other methods of improving the power-factor in that they involve the use of no running machinery or attention, and when once installed no further maintenance is required. They can also be connected at the points which are the actual sources of the low power-factor, *i.e.*, directly across the terminals of motors, etc. The condenser unit can thus be treated as part of the motor and switched on and off with the motor.—Fig. 2.

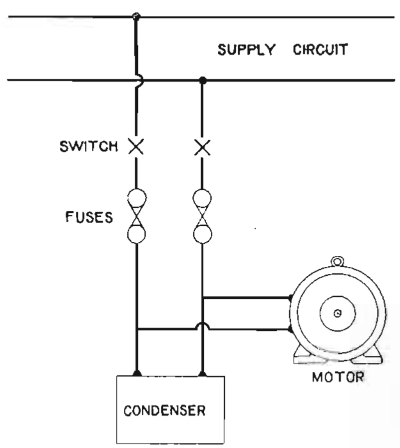


Fig. 2

Connection of static condenser to motor.

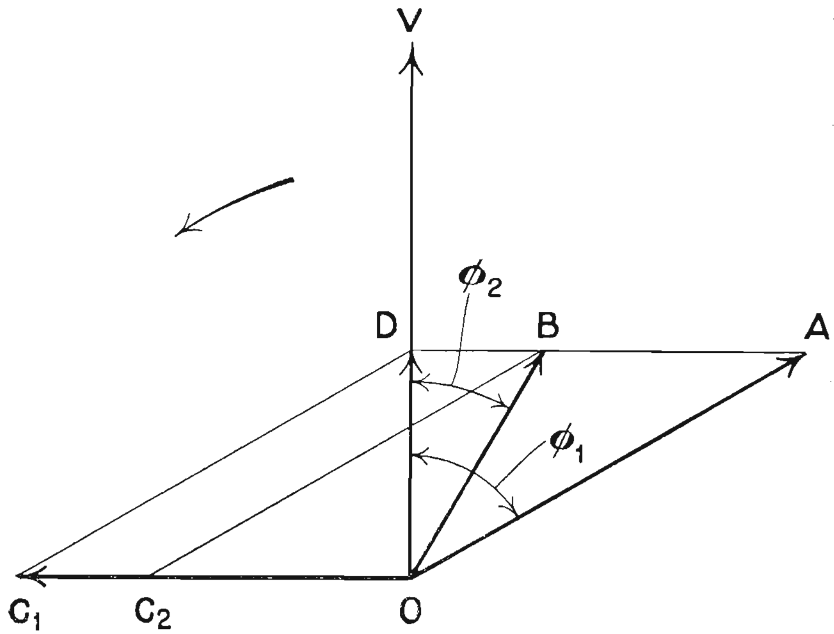


Fig. 3

Vector diagram of circuit using condenser for power-factor improvement.

The size of the condenser that is required for any given installation is determined by the load on the circuit, the existing power-factor of that load and the amount by which this power-factor is to be raised. The condenser size is directly proportional to the load to be corrected, but is a more complex function of the power-factors. It may be calculated by reference to the vector diagram of the circuit which has the general form drawn in Fig. 3.

In this diagram O V represents the voltage vector, and O A the load current vector, lagging at the angle ϕ_1 behind the voltage vector O V. The current drawn by the condenser is represented by the vector O C_2 and the resultant of these two is the line current O B which is drawn from the supply circuit. This resultant current lags by an angle ϕ_2 behind the voltage vector O V. The initial power-factor is cos ϕ_1 and the resultant power-factor is cos ϕ_2. If the capacity of the condenser is increased so as to take an increased leading current O C_1 the power-factor of the resultant line current can be brought up to unity as indicated by the vector O D.

An estimate of the size of the condenser required for any given installasion can be made from the curve plotted in Fig. 4, the ordinates of which are expressed as the ratio of condenser kilovoltamperes to load kilowatts. Thus, for example, by referring to the curve, it is seen that to raise the power-factor of a circuit from 0·6 to unity, requires a condenser kVA of 1·33 per kilowatt of the load. If it is desired to improve the power-factor to 0·95 only, this may evidently be obtained by subtracting the condenser kVA required to raise the power-factor from 0·95 to unity, from the initial value as given by the curve. Thus, taking the above example, if the power-factor is to be raised to 0·95 only, the following result is obtained :—

Condenser kVA to raise p.f. from 0·6 to unity	1·33
Condenser kVA to raise p.f. from 0·95 to unity.. ..	0·33
Resultant condenser kVA required to raise p.f. from 0·6 to 0·95	1·00

This is the condenser kVA which is required per kilowatt of the load.

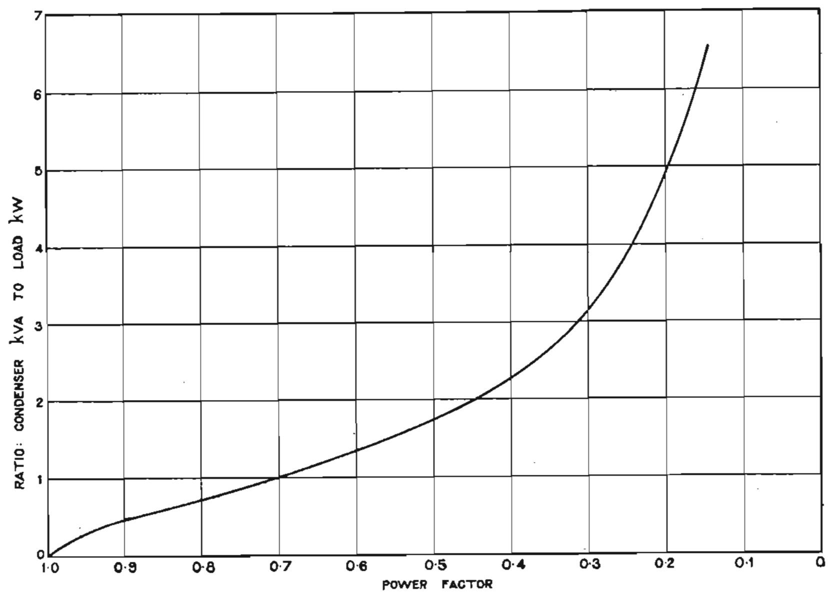


Fig. 4

Curve for estimating size of condenser for effecting power-factor improvement.
This curve gives total condenser kVA in terms of the load kW, and applies equally to single, two, and three-phase circuits.

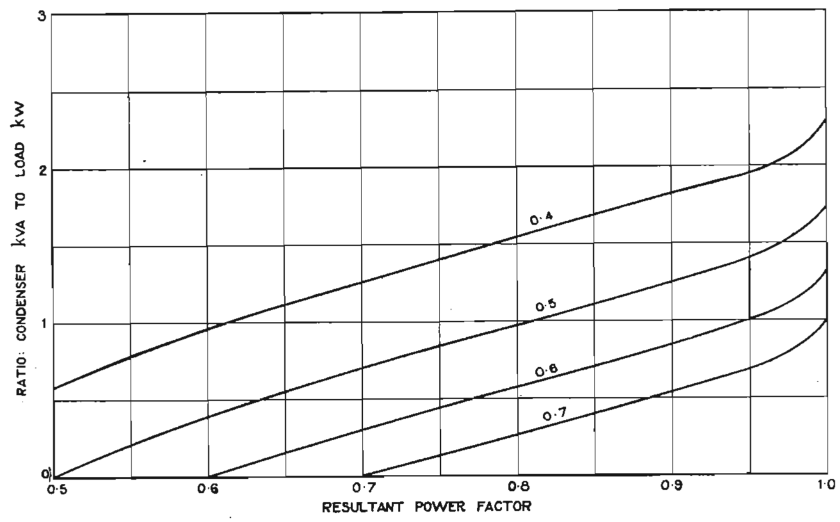


Fig. 5

Curves expressing size of condenser required for power-factor improvement for various initial and resultant power-factors.

Values of the initial power-factor of the circuit are marked on the curves.

As a general rule, it is not economical to raise the power factor of a circuit beyond about 0·95. A reason for this is brought out in the curves plotted in Fig. 5, which express the required condenser kVA necessary to raise the power-factor of a given load (kW) to various final or resultant power-factors. These curves are plotted for different initial values of the power-factor (marked on each curve), and the sharp rise at the end of each curve should be noted. Up to a value of the resultant power-factor of 0·95, the curves are nearly straight.

These curves apply equally to single, two, and three-phase circuits, and give the total condenser kVA in terms of the load kW in each case.

For a two-phase circuit the total condenser kVA is divided into two equal parts for connection one across each of the phases; while for a three-phase circuit it is divided into three equal parts mesh connected to the supply circuit. The cost of the condenser for a given power-factor improvement is therefore very little affected by the number of phases of the circuit to which the condenser is connected.

Dubilier-Mansbridge Condensers constructed for power-factor correction have a specially prepared paper dielectric which is impregnated with high quality insulating oil, and the condensers are permanently immersed in oil contained in a suitable tank.

The condensers are constructed in a number of small units rigidly mounted inside the tank and appropriately connected together and to the output terminals. Specially constructed supports are used for these condenser units designed to hold them firmly in place and to prevent movements due to mechanical vibration, while at the same time insulating them from the tank in which they are mounted. Throughout the condenser substantial conductors are used to distribute the currents between the various units to prevent over-heating and excessive losses.

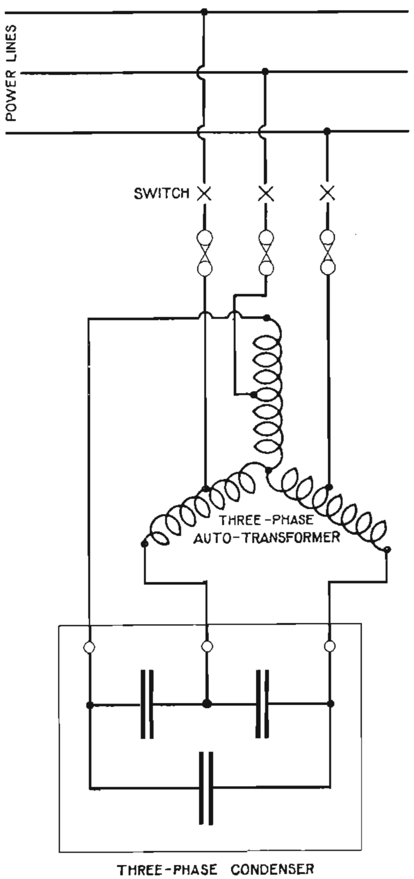


Fig. 6
Connections of condenser to circuit through auto-transformer.

The whole manufacture and impregnation of the units is carefully carried out to ensure a high quality condenser dielectric that will operate satisfactorily under all normal working conditions. By these means the electrical energy losses in the condenser have been brought down to a very low figure, with the result that the temperature rise of the condenser tanks is very small even with prolonged or continuous use.

The condensers are constructed for single, two or three-phase circuits and suitable for various voltages. For low-voltage circuits, it is sometimes more economical to insert an auto-transformer between the condenser and the circuit, so as to raise the voltage at the condenser terminals—Fig. 6—to a value which enables a more efficient use to be made of the condenser dielectric.

Wherever possible, the condensers should be connected directly across the terminals of the motor or other apparatus with which they are used, as this arrangement renders unnecessary the provision of any special means for discharging the condenser. If this arrangement is not possible, the condenser control switch should be fitted with a discharging resistance which is brought into circuit when the switch is opened; unless the condenser is connected directly to an auto-transformer as in Fig. 6, in which case it can discharge through the transformer windings.

Dubilier-Mansbridge Power-Factor Condensers are usually fitted into steel tanks provided with the necessary terminals and can be fitted for floor or wall mounting (in the smaller sizes) as required. They can also be supplied in special tanks suitable for mounting outdoors for direct connection to overhead power distribution lines.

When sending enquiries for condensers for power-factor improvement, please give full details with regard to the following points:—

CIRCUIT VOLTAGE
FREQUENCY
NUMBER OF PHASES
LOAD ON CIRCUIT (KILOWATTS)
EXISTING POWER-FACTOR OF CIRCUIT
REQUIRED POWER-FACTOR.

DUBILIER-MANSBRIDGE CONDENSERS
for
POWER-FACTOR IMPROVEMENT

Some typical Dubilier-Mansbridge Power-Factor Improvement Condensers are shown in Figs. 7, 8, 9 and 10 of various sizes up to 55 kVA. Those intended for single-phase circuits have only two terminals; for three-phase work three terminals are provided.

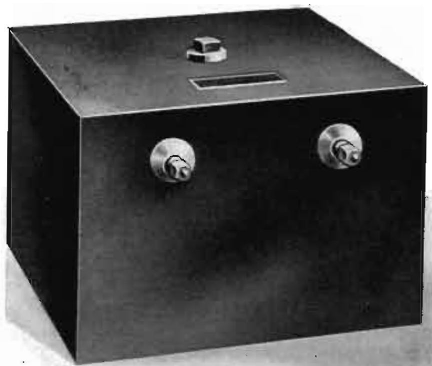


Fig. 7

Fig. 8

Dubilier-Mansbridge single-phase condensers for Power-Factor Improvement, for 600 volts 50 cycle circuits. Fig. 7 condenser for 2½ kVA Fig. 8 condenser for 17 kVA.

Fig. 9

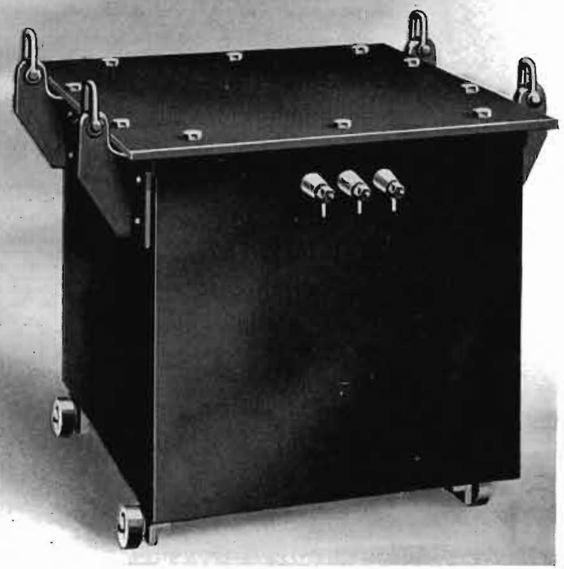
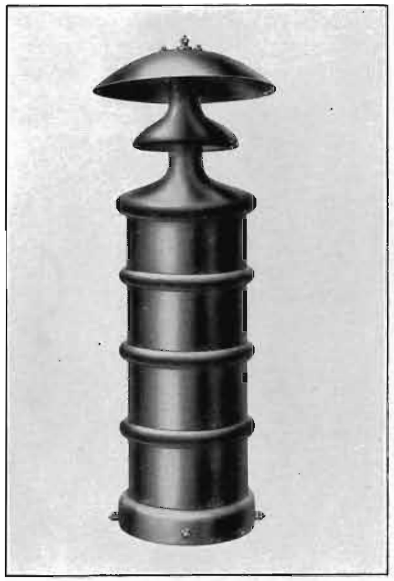


Fig. 10

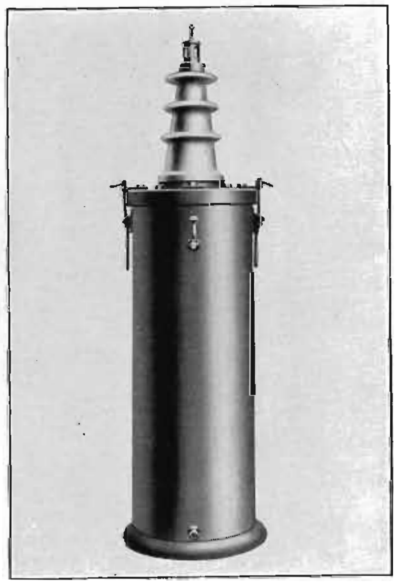
Dubilier-Mansbridge three-phase condensers for Power-Factor Improvement, for 600 volts 50 cycle circuits. Fig. 9 condenser for 45 kVA; Fig. 10 condenser for 55 kVA.

DUBILIER CONDENSERS *for* HIGH TENSION POWER LINES

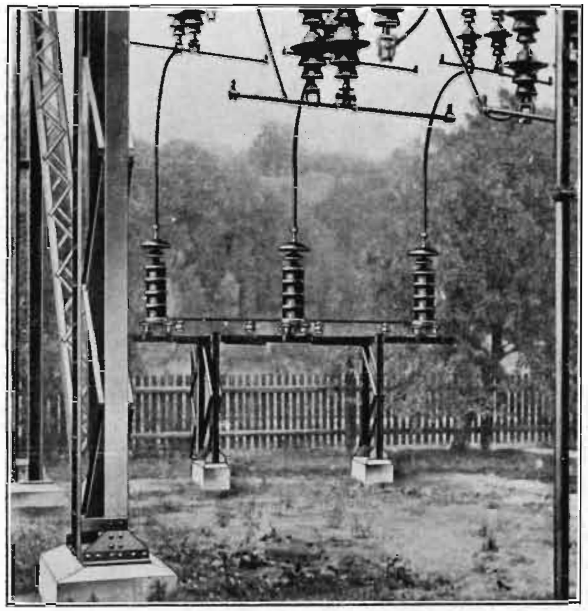
Dubilier Condensers are manufactured in a variety of sizes and patterns for use in conjunction with high voltage overhead transmission and distribution lines. They provide a valuable protection against damage by lightning, and surges. Other patterns are also manufactured for underground cable systems.



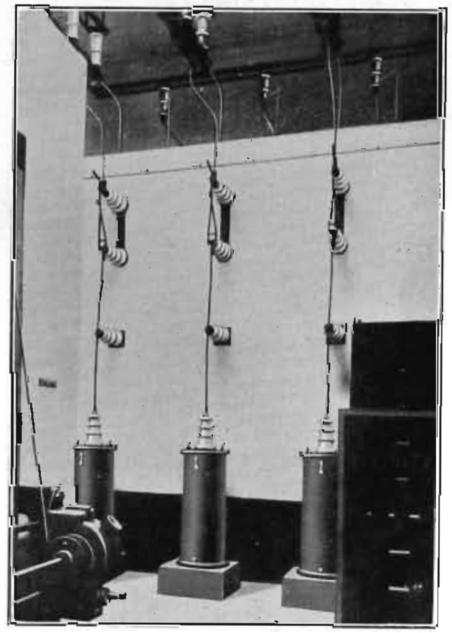
Outdoor type of condenser for use up to 100,000 volts, totally enclosed in porcelain.



Indoor type of condenser mounted in oil-filled steel tank.



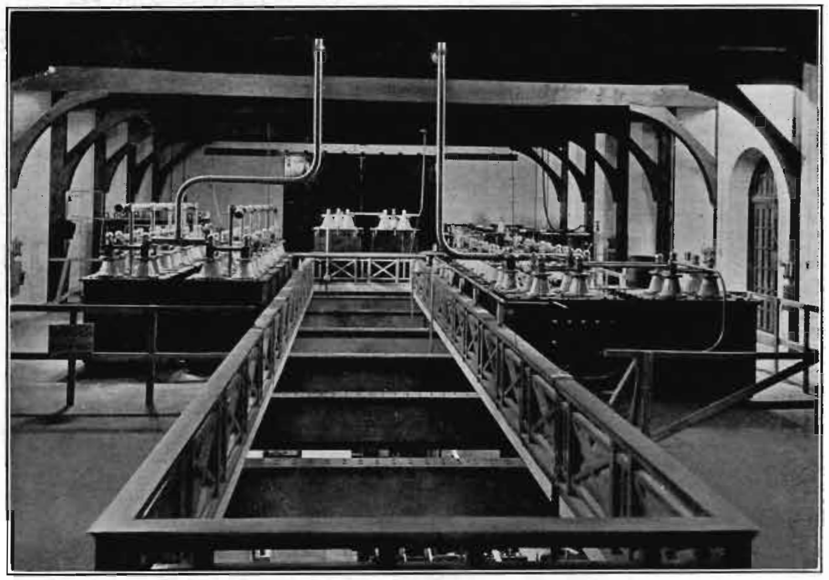
A three-phase installation of Dubilier condensers connected to a 90,000-volt line in Switzerland.



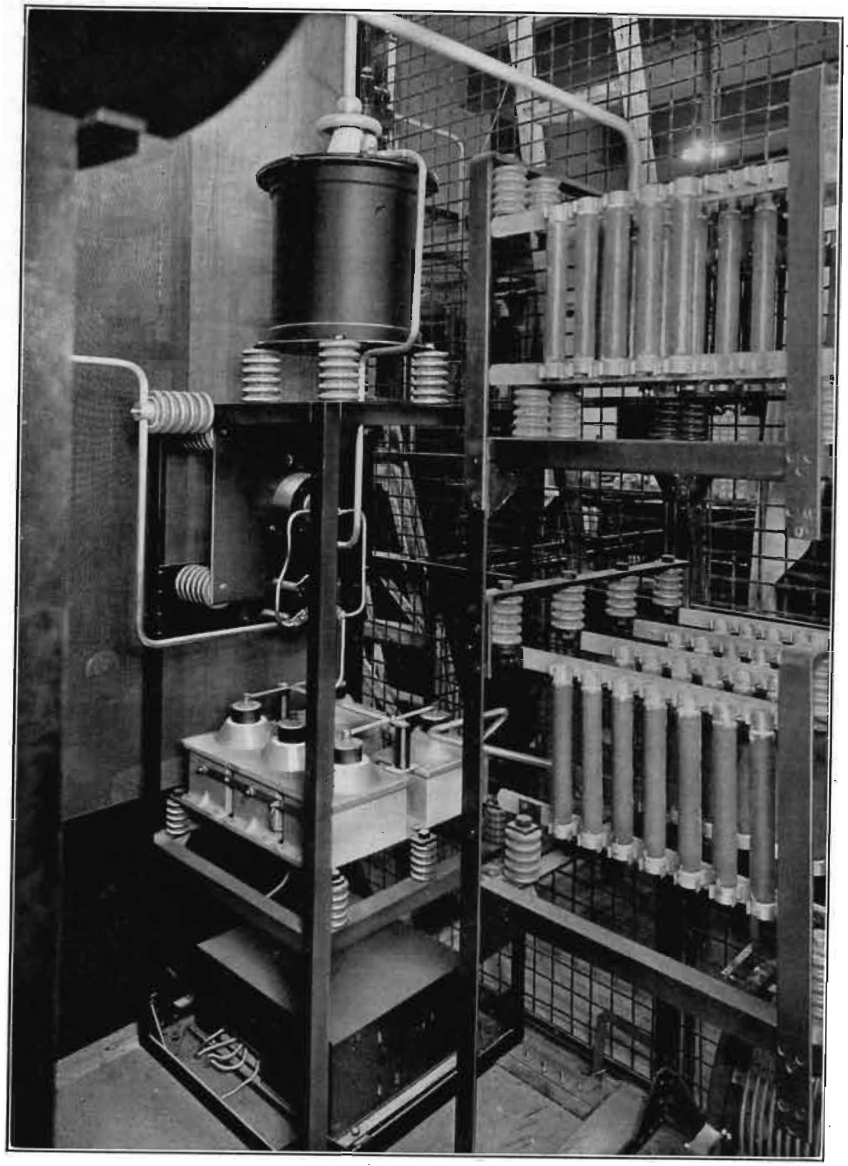
Arrangement of Dubilier protective condensers inside a sub-station.

Dubilier Condensers *for* Radio Transmitting Stations

Dubilier Condensers are manufactured for all kinds of radio and other uses, and the largest mica dielectric condenser banks in the world have recently been completed by us and installed in the Rugby Radio Station.



Four large banks of condensers at the Rugby Radio Station, each bank consisting of a number of units connected in parallel, and handling about 30,000 kVA.



Part of the wireless telephone transmitting plant at Rugby, showing various Dubilier condensers in the circuits.

DUBILIER PRODUCTS

include

DUBILIER MICA CONDENSERS
FOR RADIO TRANSMITTING STATIONS

DUBILIER MICA CONDENSERS
FOR HIGH TENSION POWER LINES

DUBILIER-MANSBRIDGE CONDENSERS
FOR POWER-FACTOR IMPROVEMENT

DUBILIER MICA CONDENSERS
FOR RADIO RECEIVING SETS

DUBILIER VARIABLE CONDENSERS
FOR RADIO RECEIVING SETS

DUBILIER-MANSBRIDGE CONDENSERS
FOR RADIO RECEIVING SETS

DUBILIER RESISTANCES AND PROTECTIVE
DEVICES FOR RADIO RECEIVING SETS

ETC., ETC.