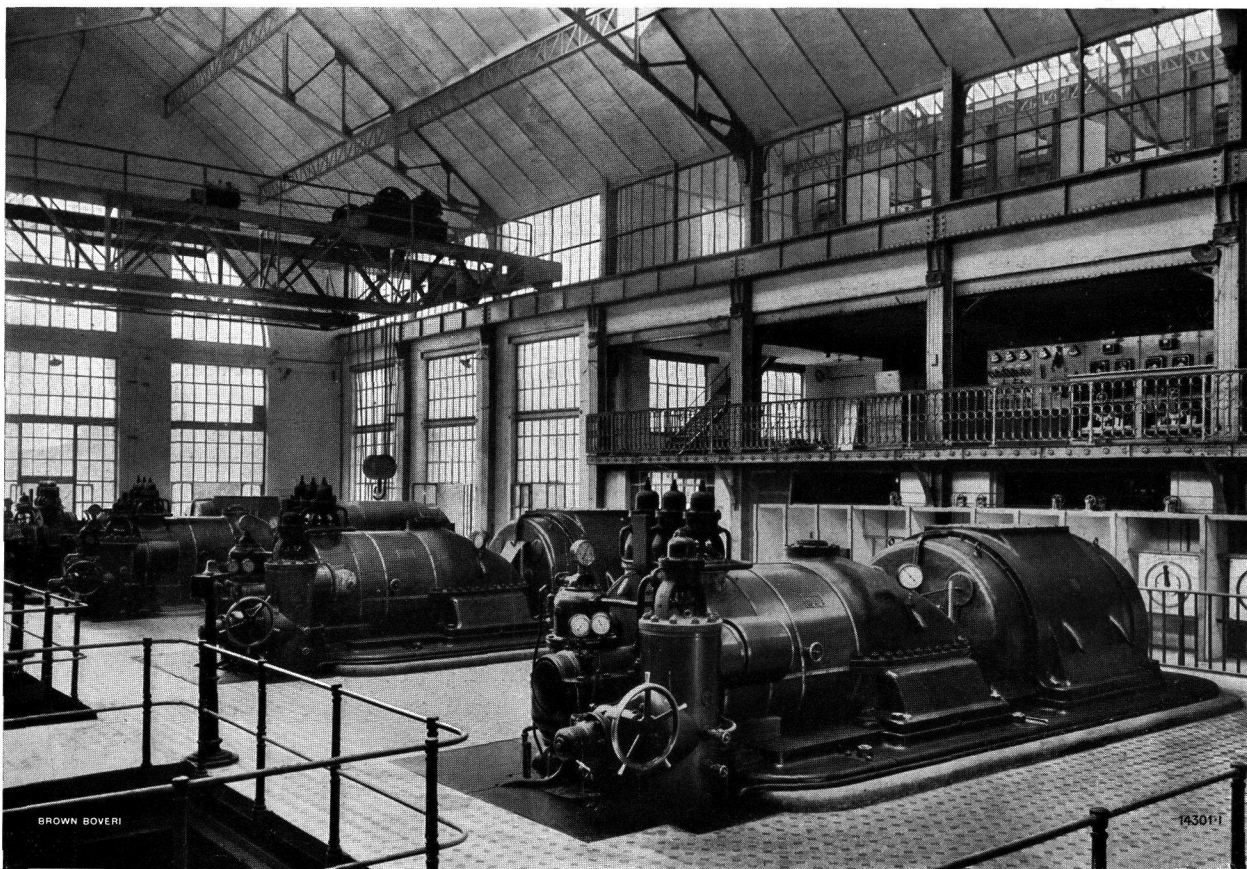


THE BROWN BOVERI REVIEW

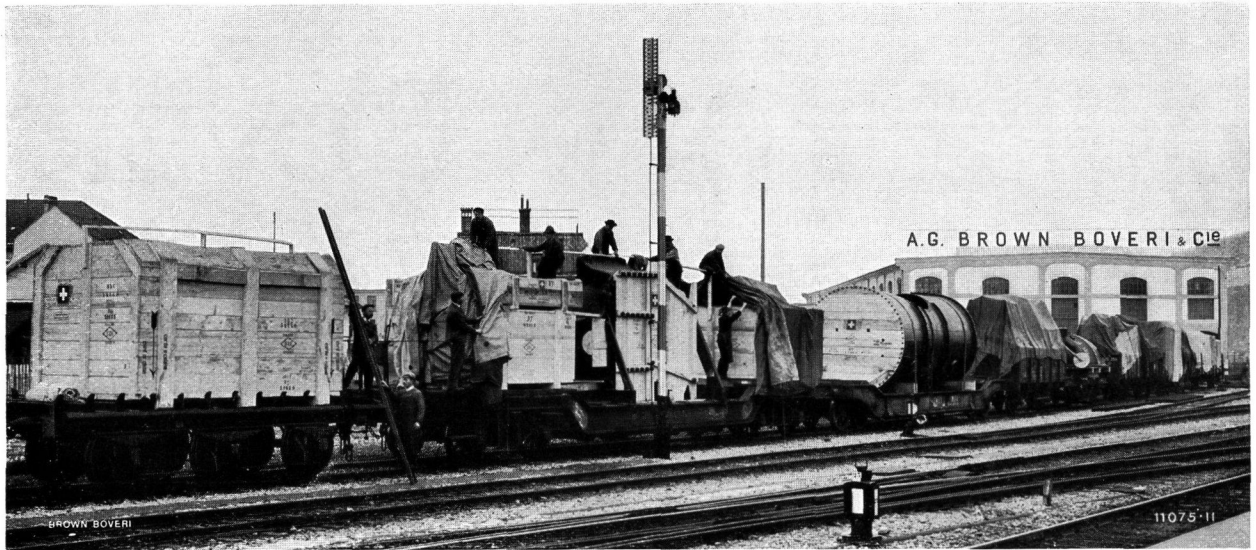
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CONTENTS:

	Page		Page
Foreword	3	Brown Boveri coupling for electric train heating	14
An important improvement in the design of electric locomotives	4	Notes:	
Brown Boveri crane motors	8	Large turbo-alternator sets for the Compagnie Parisienne de Distribution d'Electricité	18
Methods for cleaning coolers of large transformers	12		



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 Control apparatus.

THE BROWN BOVERI REVIEW

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THE COMMENCEMENT OF THE TENTH VOLUME

is a suitable opportunity for recalling the development of our house journal. When the first number appeared in 1914, the programme was very limited, as the intention was only to keep the people connected with our firm abreast of all important features relating to our manufactures and new improvements. For this reason, a relatively small circulation and a modest get-up were considered sufficient.

Time has proved, however, that the house journal is also appreciated by many people not connected with the firm. For a long time, only French and German editions were published, but a year ago The Brown Boveri Review in English made its appearance. The aggregate circulation of the three editions now exceeds 13'000 copies monthly. It is gratifying to know that they are highly appreciated by a large circle of readers in all parts of the world, and it is hoped that the interest taken in our journal will increase still further.

BROWN, BOVERI & CO.

AN IMPORTANT IMPROVEMENT IN THE DESIGN OF ELECTRIC LOCOMOTIVES WHICH IS DESTINED TO HAVE A CONSIDERABLE INFLUENCE ON THE ECONOMY OF MAIN-LINE ELECTRIC TRACTION.

THE NEW BROWN BOVERI LOCOMOTIVE WITH INDIVIDUAL AXLE DRIVE.

Decimal index 621. 334. 7.

I. INTRODUCTION.

THE constructional development of electric locomotives has become, at the present time, a problem of the greatest economic importance. This is the case not only for countries poor in coal, like Switzerland,

equipments has, in recent years, progressed in a steady manner without any outstanding developments, this is not so with the mechanisms used for transmitting the power from the motors to the driving wheels; here an advance has been made recently of which

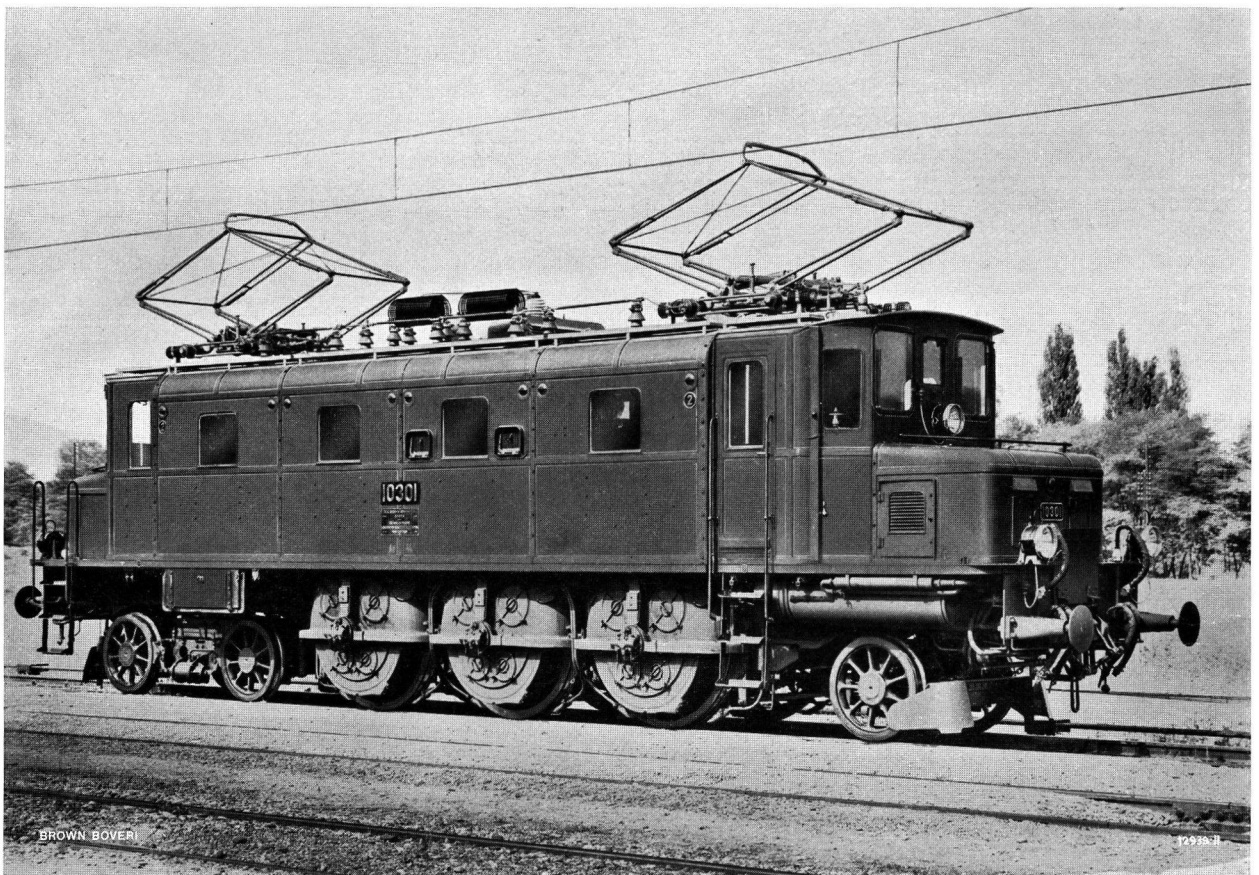


Fig. 1. — Single-phase 2C1 express passenger locomotive with Brown Boveri individual axle drive for the Swiss Federal Railways.

which can be rendered more independent of other lands by electrifying their railways, but for all civilised countries as well as those requiring better means of communication. There is no doubt that steam traction has now reached a point where a further increase in the weight and speed of trains cannot be carried out for economic reasons. While the design of electrical

the far-reaching consequences cannot yet be fully realised. The tests which have been in progress for some years with the Brown Boveri individual axle drive are now sufficiently complete to permit a fairly definite opinion being formed regarding this type of drive, and they confirm in the fullest measure all the hopes entertained when the invention was being

developed. The following particulars give a survey of the most important improvements which have been attained with the new individual axle drive; a fuller description of it is to be found in The Brown Boveri Review, 1922, No. 5, pages 91—104.

II. GENERAL ADVANTAGES OF THE INDIVIDUAL AXLE DRIVE.

Before going into the outstanding special advantages of the new Brown Boveri drive, it should be stated that, from all points of view, the individual axle drive in general — which does not require any driving and coupling rods, jackshafts, etc. — corresponds best to the characteristic feature of the electric motor, which gives a turning moment and not a uni-directional, periodically-varying force, like the steam engine. The consequence of this is that the following two serious shortcomings of all other drives are avoided:—

(a) The necessity for frequent adjustment of the bearings of the driving and coupling rods as well as those of the axles, with the consequent increase in the cost and difficulty of upkeep.

(b) The occurrence of oscillations due to the periodic reversals of the thrust in the rods together with play in the bearings and discrepancies in fitting; the additional stressing of the locomotive frame caused thereby necessitates a heavier design than in the case of the individual axle drive.

These two points lead unavoidably to the conclusion that as soon as a reliable design of individual axle drive is available, the use of clumsy coupling rods and jackshafts must soon become a thing of the past for the majority of types of locomotive.

III. DISADVANTAGES POSSESSED BY PREVIOUS TYPES OF INDIVIDUAL AXLE DRIVE.

To design a serviceable individual axle drive is, however, not such a simple matter, and it has been found that all the types previously proposed have had inherent defects which prevented them from claiming full superiority over the side-rod drive. In this connection, the well-known tramway motor suspension may be mentioned, with which half the weight of the motor is carried without springs by the driving axle, and which limits the size of the motor and the gear ratio to a considerable extent. Both these reasons prohibit its adoption on main-line and other high-speed locomotives. The “gearless” drive, with the motor armature mounted directly on the driving axle without any intermediate gearing, which has been em-

ployed in America, is even more unfavourable as regards the amount of weight not borne by springs; moreover, it has the disadvantage of preventing the employment of commutating poles and, consequently, the full utilisation of the armature. Another arrangement, the so-called “quill-drive” that has likewise been advocated chiefly in America, has tangential springs — which, however, are subjected to very complicated stresses — between the spur wheel and driving wheel. Like the tramway suspension, this drive has the disadvantage that the width of motor is limited by the gearing being within the locomotive frame.

IV. SPECIAL ADVANTAGES OF THE BROWN BOVERI INDIVIDUAL AXLE DRIVE.

The Brown Boveri individual axle drive is not only completely free from all the above-mentioned shortcomings, but possesses quite a number of advantages of its own which could not be ensured by any of the arrangements tried previously. The operation of this type of drive is briefly as follows:—

The motor transmits its motion to the driving axle through single reduction spur gearing situated outside the locomotive frame and usually only at one

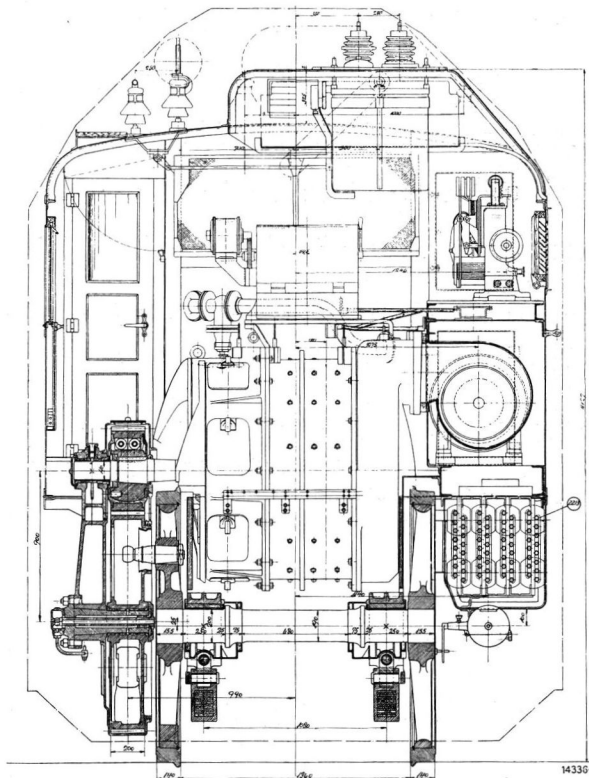


Fig. 2. — Arrangement of motors and gearing with Brown Boveri individual axle drive.

side of the same (Figs. 1, 2 and 3). An outboard bearing is provided for carrying the end of the motor-shaft extension on which the pinion is keyed, and the latter has a boss with a spherical seating, and springs for taking up tangential forces. The spur wheel is directly under the pinion and revolves on a pin carried by the gear casing, which is fixed to the locomotive frame. The spur wheel is not rigidly connected to the driving wheel, but transmits its motion by means of a special coupling device that is elastic in all directions, and which is, in fact, the keynote of the invention.

With this drive the following advantages are obtained:—

1. *Absolute regularity in the transmission of the turning moment of the motor to the driving wheels*, since no mechanism is present in which a periodical change of forces takes place. (In cases where such a change occurs, it is transmitted in a considerable degree to the driving wheels on account of the unavoidable play in the bearings.) This advantage is also attained with the American design having the armature mounted directly on the driving axle, but not with the quill-drive.

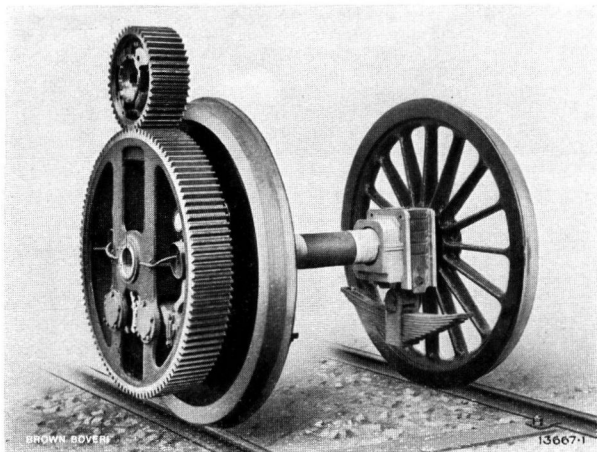


Fig. 3. — Set of driving wheels with gearing.

2. *No effect on the axle load* when relative vertical displacements occur between the driving wheel and the frame. This feature is especially to be noted when making a comparison with the quill-drive, as with the latter considerable reactions are caused in the driving springs by such relative movements.
3. *Reduced tyre wear.* With the Brown Boveri individual axle drive, a difference in the wear of

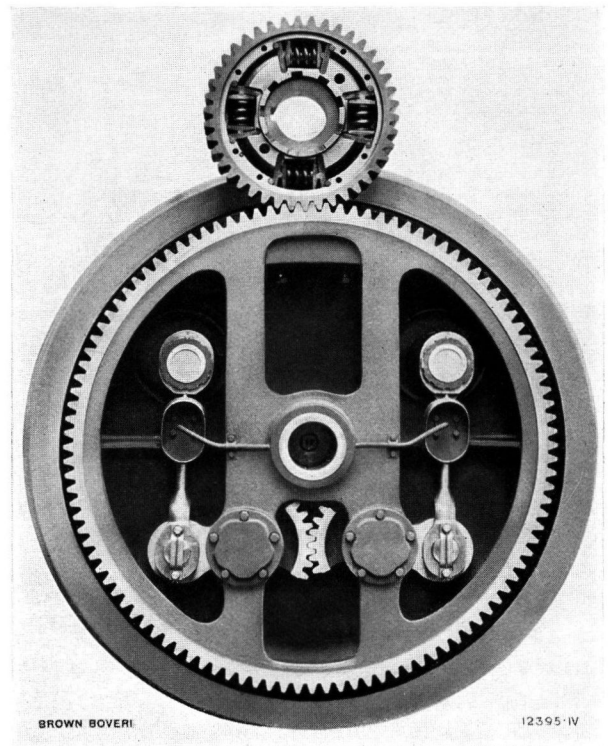


Fig. 4. — Gear wheels with Brown Boveri coupling device and driving wheel.

the various pairs of driving wheels is of no consequence, nor need the diameter to which each pair is turned down be the same, since the axles are completely independent of one another — which is not the case with the side-rod drive and other types of individual axle drive. The great saving in running costs which can consequently be effected need not be dwelt upon.

4. *Smaller wear in the gearing* than with any other system, since the pinion is carried between two bearings and, further, adapts itself as required by reason of its spherical seating.
5. *Great accessibility of the bearings, commutator and brush gear* — advantages which cannot be too highly valued — thanks to the high position of the motors, which is rendered possible by placing the pinion directly above the spur wheel, and having the centre of the latter somewhat higher than that of the driving axle.
6. *Smooth running of the locomotive* due to the high centre of gravity.
7. *Spur wheel and flexible coupling device run in an oil bath* which requires no attention.

8. *High mechanical efficiency* is attained on account of the simplicity of the driving arrangement.
9. *Greatest ease in mechanically disconnecting single motors*, as it is only necessary to remove two pins in the coupling device.
10. *Practically unlimited width of pinion and spur wheel*, on account of the gearing being situated outside the locomotive frame.
11. *Practically unrestricted width available for motor*.
12. *No overhung pinion* as adopted in most other designs.
13. *Low oil consumption*.
14. *Practically no attendance*; overhauls seldom required.
15. *Small wear of the track*, as all driving axles can have side play, which is usually impossible with the side-rod drive.
16. *Side play and radial adjustment of the axle* are possible, due to the flexibility of the coupling device between the spur wheel and driving wheel. These properties of the Brown Boveri individual

axle drive allow also of new features being introduced in locomotive design which represent a considerable advance on existing practice. These improvements are:—

(a) The use of a driving axle as guiding axle.

(b) The combination of a guiding axle and a driving axle to form an articulated truck.

The consequence is a reduction in the weight and length of the locomotive due to the elimination of bogie frames and even of guiding axles. The weight of a 2000-H.P. express locomotive for a speed of 120 km per hour, which would be of the 1B1-1B1 type when provided with a side-rod drive, would probably be reduced by at least 15% when built as a 1D1 type locomotive with individual axle drive.

Even more outstanding is the difference in the case of

locomotives designed for handling traffic on mountain sections of railways. In order to bring this out prominently, mention may be made of a very carefully worked out plan for a F-type locomotive, that is, one with six axles with individual drive and no special guiding axles; axles 1 and 6 are of the Adams

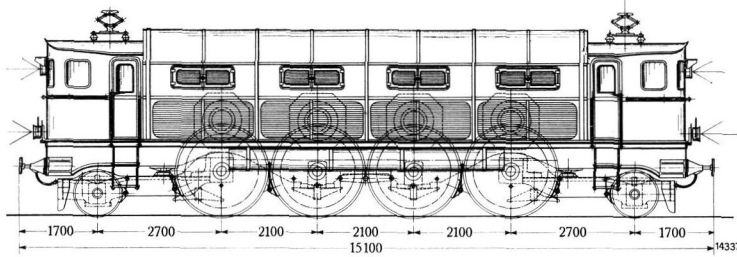


Fig. 5. — Direct-current express passenger locomotive with Brown Boveri individual axle drive for a maximum speed of 130 km per hour.

The guiding and adjacent driving axle are mounted on an articulated truck. The two central axles have side play.

One-hour rating 2'580 H.P., total weight 92 tons, diameter of driving wheels 1'950 mm, tractive effort 15'000 kg.

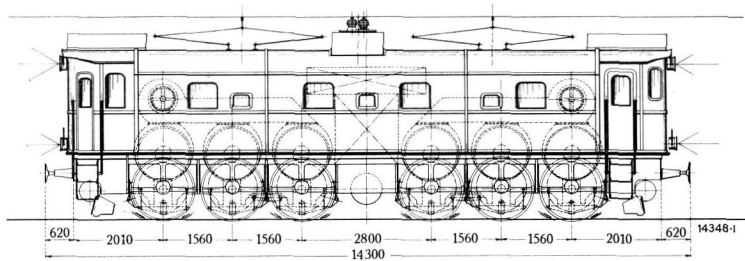


Fig. 6. — Heavy freight locomotive with Brown Boveri individual axle drive for a maximum speed of 75 km per hour.

Six driving axles, of which the two outer ones have radial adjustment, and the two centre ones side play.

One-hour rating 3'600 H.P., total weight 114 tons, diameter of driving wheels 1'350 mm, tractive effort 25'000 kg.

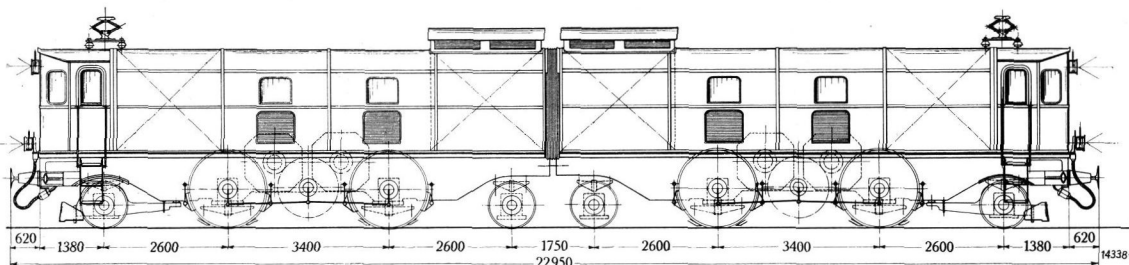


Fig. 7. — Direct-current express passenger locomotive with side-rod drive for a maximum speed of 120 km per hour.

The locomotive is formed of two articulated trucks which carry the subdivided body.

One-hour rating 2'580 H.P., estimated total weight 124 tons, diameter of coupled wheels 1'950 mm, tractive effort 15'000 kg.

type, 2 and 5 have side play, while 3 and 4 are without this feature. With a maximum axle load of 19 tons, the total weight of the locomotive is 114 tons; this is only slightly more than that of the well-known Brown Boveri locomotives of the 1B-B1 type used on the St. Gothard Railway, which have a weight of 110 tons. The latter locomotives have only four motors with a continuous rating of 500 H. P. each, while the F-type locomotive has six motors of the same output and can therefore develop 50% more power at the tread of the wheels. The weight of the locomotive, however, plays here an important part, as is seen from the fact that while the locomotive of 110 tons can haul a train of 300 tons on the St. Gothard line, the F-type locomotive, with only about 4% more weight, can haul a net load of 510

tons, that is, 70% more, with the same power per motor.

No details need be given here with regard to the testing of the Brown Boveri individual axle drive as carried out in actual service; it is sufficient to refer to the exceptionally satisfactory results obtained with the 2C1 (Ae 3/6) locomotives of the Swiss Federal Railways. The first experimental locomotive equipped by Brown, Boveri & Co. with an individual axle drive was recently overhauled in one of the workshops of the Federal Railways after having run about 110'000 km. The condition of the driving mechanism was found to be perfect in all respects, and no trace of wear could be observed, so that not only were repairs unnecessary, but there was also no need to make adjustments of any kind.

B. (J.F.L.)

BROWN BOVERI CRANE MOTORS.

Decimal index 621.39:621.86.

General.

FOR driving cranes used for light service, as in power stations for instance, it is customary to employ standard motors of the kind adopted for ordinary industrial drives. In the case of direct current, the crane motors are, however, series wound, instead of shunt or compound, so that a high starting torque is obtained. With this winding they have also the additional advantage that the speed increases automatically as the load is reduced. Consequently, in the case of the hoisting mechanism, for example, a small load or the empty hook is raised quicker than the full load. Ordinary induction motors — with the exception of single-phase ones, which are not suitable for crane drives — are provided with a special stator winding to give an extra strong field and a high starting torque. This latter should be at least two and a half times the normal full-load torque corresponding to the one-hour rating of the machine, so as to enable the rotating parts and the load to be accelerated quickly. Since a large proportion of the work of acceleration is taken up by the armature (or rotor), the flywheel effect and the normal speed of the latter should be kept low so that the starting time and current, and also the time necessary to bring the rotating parts to rest, are as small as possible.

Since a crane motor only works intermittently, it is usually rated for that power which it can develop during a period of 30 or 60 minutes when starting cold, without its temperature rise exceeding the value allowable. It is therefore possible to employ a smaller size of motor for crane and similar drives than would be necessary for an ordinary industrial plant taking the same horse-power. This feature is especially advantageous for cranes, as the space available is generally restricted.

Cranes for heavy duty, that is, those that have to be started, stopped and reversed very frequently, must be provided with motors of a more robust design than those used for light service as mentioned above. Such cranes are employed in iron and steel works, foundries, docks, etc., for instance. Very often, the motors must be of the totally-enclosed type, being provided with massive, dust-proof covers rather than the sheet-iron protection adopted by some makers for ordinary motors.

For the drives in question, the larger motors which cannot easily be handled in one piece must be constructed in such a way that repairs can be carried out without any large amount of dismantling and re-erection being necessary. Direct-current motors are therefore made with a split frame, which allows the interior of the motor to be got at, and the

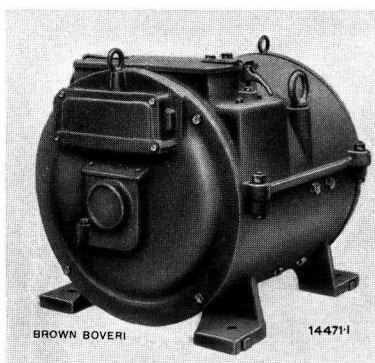


Fig. 1. — Totally-enclosed direct-current crane motor, Type GKHM 84, one-hour rating 27 kW, 750 r. p. m.

armature together with the two bearing brackets to be lifted out, after removing the top half of the frame. Since with split bearings there is a tendency to oil leakage, the use of these should only be considered for machines whose the frame cannot be divided, but where it is nevertheless essential to provide for easy replacement of the bearing bushes. The stator core of an induction motor, for instance, cannot be made in halves, so the desired accessibility is obtained by dividing the bearing bracket and bearing at the driving end. This allows the rotor to be removed without it being necessary to press off the pinion or half-coupling.

The following descriptions deal with the new series of Brown Boveri motors that have been developed on the lines indicated above, and which are specially suitable for cranes, winches, excavators, auxiliary drives in rolling mills, etc.

Direct-current motors.

These series-wound machines, Type GKHM (Fig. 1), are built in seven sizes for one-hour ratings of 8 kW, 800 r. p. m. to 75 kW, 500 r. p. m. They are of very

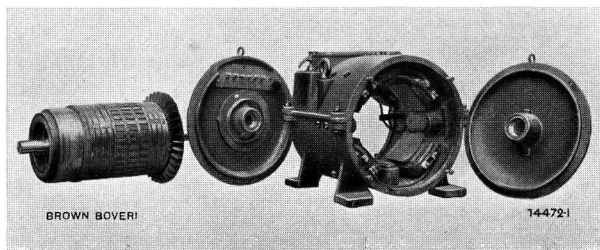


Fig. 2. — Totally-enclosed direct-current crane motor, Type GKHM 84, dismantled.

compact design with a well-stiffened frame, and are dust-proof.

The magnet frame consists of a steel casting divided somewhat above the horizontal centre line, while the bearing brackets are each in one piece (Fig. 2). Should it be specially desired, the bearing bracket together with the bearing bush at the driving end can be made split, without the external dimensions being affected.

The bearing bushes are of cast iron lined with hard white metal with a low coefficient of friction, so that wear is minimised. The bearings have automatic ring lubrication, as well as separate oil filling and emptying screw plugs.

On the sides of the motor feet, patches are cast, which are machined to the exact breadth—measured from the centre of the shaft—should the crane builder prefer to dispense with the usual tapered pins and provide a snug on the motor support against which one side of the feet can bear.

This arrangement fixes the exact position of the motor, — a stop for the axial position is not desirable, — and considerably simplifies the re-erection of the motor after removal for overhaul, or the aligning of a motor in replacement of the original one.

All these motors have four poles. A like number of commutating poles is provided, so that commutation is sparkless even on overload.

In every case, quite independent of the pressure or the output, only two brush spindles are employed (Fig. 3). They

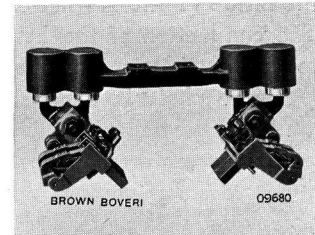


Fig. 3. — Brush gear of a direct-current crane motor.

are fitted with porcelain insulators and rigidly fixed in the upper half of the frame. All the brushes and brush holders are therefore easily accessible through the opening provided in the top of the motor near one end. This opening has a cover which is held down by lever catches, a felt liner being used to make a water-tight joint. As there are no other openings in the motor frame or bearing brackets, and the terminals are mounted above the bearing at the commutator end of the motor, it is possible to place the machine in positions where space is limited — unlike motors of other manufacture which present certain difficulties for the crane maker, as he has to see that it is possible to obtain access to brushes in the lower half of the motor.

Between the two brush spindles there is sufficient space for cleaning the commutator, or even for grinding it — should this be necessary. The springs of the right-hand brush holders are released to the right, and those of the other set of holders to the left — that is, in both cases away from the vertical centre line of the motor — which makes it very easy to inspect or remove the brushes.

The internal connections which have to be loosened for lifting off the top half of the frame are all brought to the inner ends of the studs of the terminal board, and can consequently be disconnected easily through the opening in the frame. If desired, the terminal board can be provided with a cable-end box instead of the usual terminal cover.

The field coils, which in ordinary motors as a rule suffer more than other parts due to overheating at overloads, are of flat copper strip with asbestos insulation, and are therefore insensitive to high temperatures. The packing pieces between the coils and the

frame are made of metal in order to ensure good heat conductivity.

A fan (Fig. 2), that operates effectively in both directions of rotation, is mounted on the shaft, and forces the air which is inside the motor through the armature core, round the field coils and thence on to the inside of the magnet casing and bearing brackets. The conduction of the heat developed in the motor to the outside is thus greatly assisted.

The shaft is of open hearth steel and calculated very liberally for the heavy service requirements which the motor may be called upon to meet. The armature stampings are mounted on a spider, which is provided with an extension to carry the commutator bush. This arrangement makes it an easy matter to replace the shaft, should this become necessary for any reason.

Although a conical shaft end simplifies the removal of the pinion, it is found in practice that most crane makers prefer a cylindrical shaft extension. The Brown Boveri crane motors can be furnished with either the one or the other according to customers' requirements.

The armature is designed to withstand the forces met with at two and a half times the normal speed—it is in fact run up to about three times the normal speed during the tests in the factory. This point is of great importance, as it is becoming more and more customary to employ hoisting mechanisms with a high efficiency, thus allowing the speed of the motor when hoisting light to attain a very high value.

The armature coils have moulded-on, jointless insulation, and are impregnated to withstand the effects

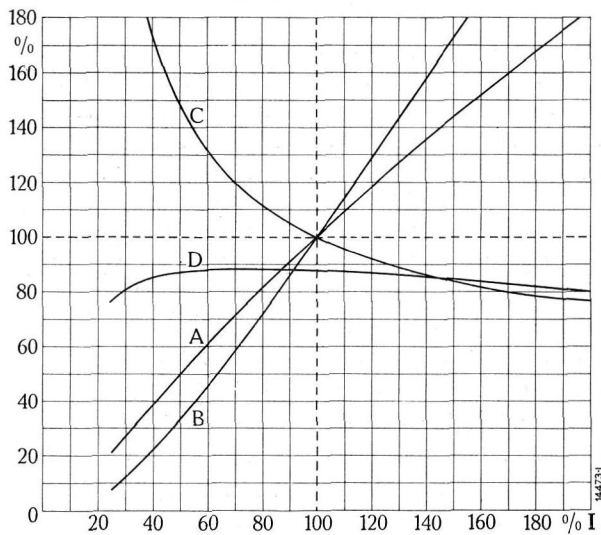


Fig. 4. — Load curves of a series-wound direct-current crane motor, one-hour rating 40 kW, 750 r. p. m. Ordinate: Output (A), torque (B), speed (C) and efficiency (D) in per cent. Abscissa: Current in per cent.

of moisture. The commutator segments are extended radially to take the ends of the armature winding without necessitating the use of lugs of copper strip, which are not suitable for motors that have to be frequently started and stopped.

The flywheel effect of the armature is low, and amounts to only about 65% of that of an ordinary direct-current motor of the same one-hour rating. Stopping and reversing of the machine is consequently easier, and the reliability, even when the plant is operated by unskilled labour, is very high.

Fig. 4 gives curves of the output, torque, speed and efficiency of a 40-kW motor as functions of the current.

The motors described can be changed into forced-ventilated machines, Type GHM, by replacing the bearing bracket at the commutator end by one with a specially arranged intake, and by providing the opening at the top of the frame with a corresponding cover. Motors ventilated in this way can give continuously about the same power as the enclosed machines can develop on one-hour rating. Such motors are used on bucket excavators, dock cranes, etc., where the running conditions are heavy, but totally-enclosed motors are not essential.

Three-phase induction motors.

Corresponding to the above line of direct-current motors, Type GKHM, a series of three-phase motors, Type MHM (Figs. 5 and 6), has also been designed to meet the special requirements of cranes destined for heavy operating conditions. These motors are made with six, eight and ten poles for outputs of 10 to 150 kW on intermittent rating. In common with the

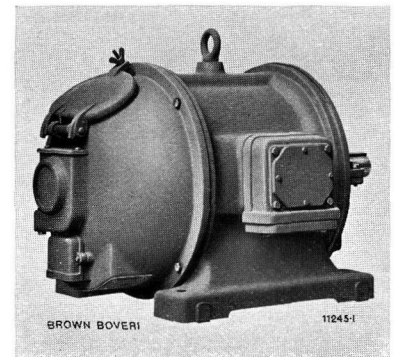


Fig. 5. — Totally-enclosed three-phase crane motor, Type MHM 148, one-hour rating 35 kW, 750 r. p. m. (slip-ring end).

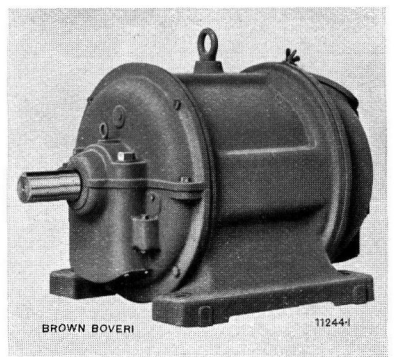


Fig. 6. — Totally-enclosed three-phase crane motor, Type MHM 148, one-hour rating 35 kW, 750 r. p. m. (driving end).

direct-current machines, they have a low flywheel effect and a high starting torque. The former amounts on the average to only about 60% of the flywheel effect of a standard motor of the same power, while the starting torque is 2.5 to 2.8 times the normal full-load torque corresponding to the one-hour rating of the machine.

The motors have in all cases a wound rotor. The windings and slip-rings are made in such a way that the danger of sparking due to a deposit of bronze and carbon dust is minimised. As the brushes are arranged for remaining continuously in contact with the slip-rings, only high-conductivity carbons with a small coefficient of friction are employed. For providing access to the brush gear, a hinged cast iron door with a felt liner is provided on the upper portion of the bearing bracket.

The stampings forming the stator core make contact with the frame over practically the whole of their periphery, so that the conduction of heat to the outside

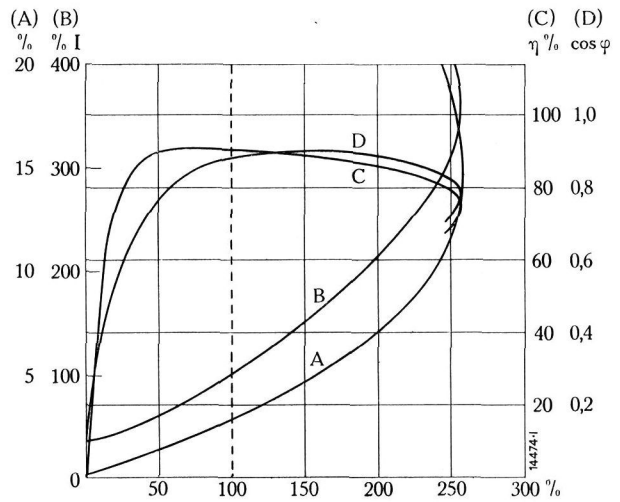


Fig. 7. — Load curves of a three-phase crane motor, one-hour rating 40 kW, 1000 r. p. m., 50 cycles.

Ordinates (left): Slip (A) and current (B) in per cent.
 Ordinates (right): Efficiency (C) and power factor (D).
 Abscissæ: Output in per cent.

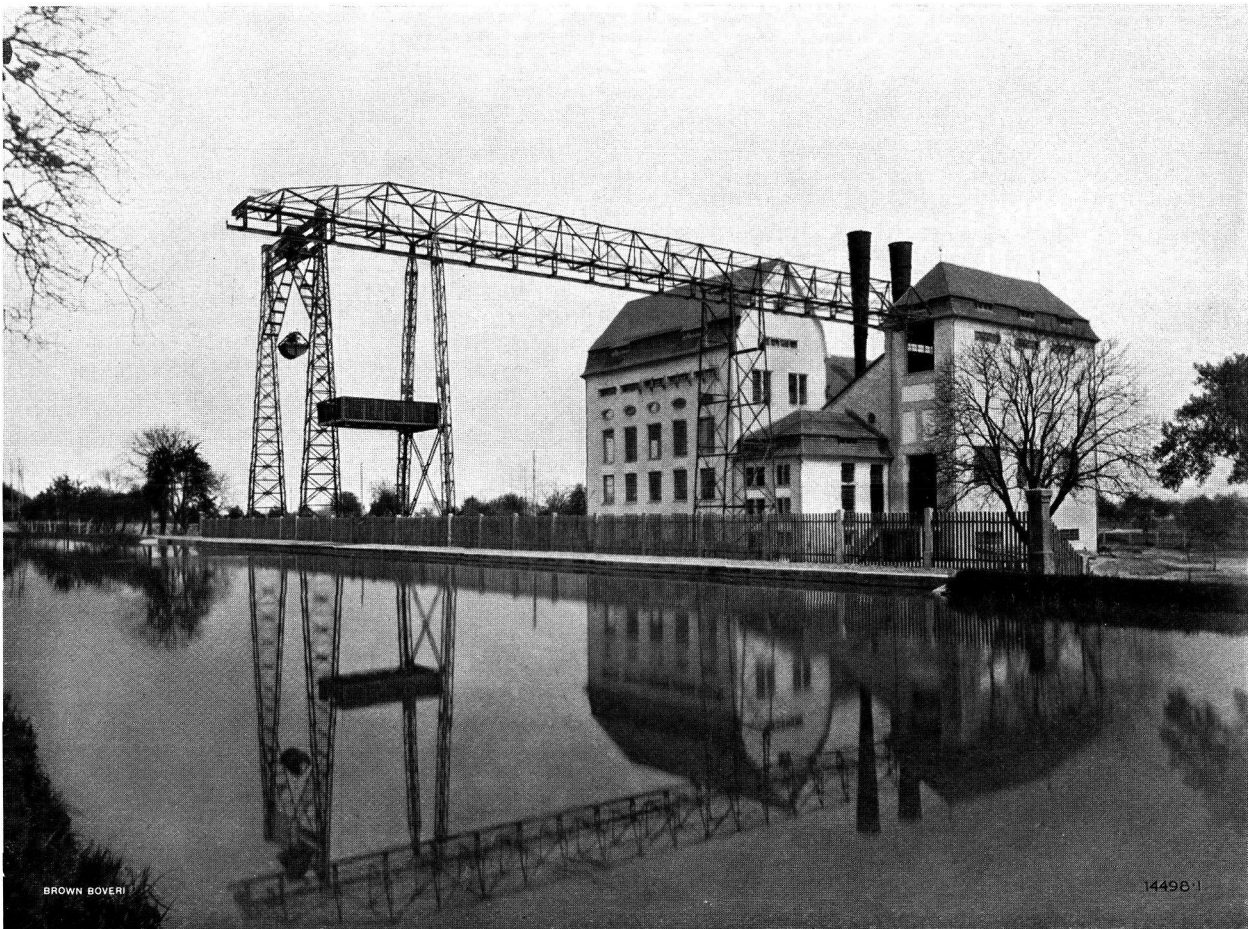


Fig. 8. — Coal transporter equipped with Brown Boveri crane motors.

is excellent. The breaks in the continuity of the contact occur only where ventilating ducts are cast in the frame, as indicated in Figs. 5 and 6. The air inside the motor is caused to circulate through these passages by a fan, which assists effectively in transmitting the heat developed in the rotor and in the stator coils to the stator frame, and thus to the outside air.

The bearing bracket and bearing bush at the driving end are cast in halves. The upper portion of the shield is further divided in such a way as to allow its easy removal, and also that of the bush, without having to press off the pinion or half-coupling. The bearings are very liberally dimensioned to keep wear down to a minimum. The air gap, which is of necessity small in comparison with that of the direct-current motors, can therefore give no cause for trouble. In order to permit of checking the air gap easily from time to time, several openings with removable covers are provided in suitable positions in the bearing bracket at the driving end (Fig. 6).

The terminals of both stator and rotor are completely enclosed. They are preferably provided with a trifurcating box when a three-core cable is employed.

The above three-phase motors, of the totally-enclosed, dust-proof type, are only suitable for intermittent rating. By removing the cover on the under portion of each bearing bracket, they can be changed into pipe-ventilated machines which may be used for continuous duty.

All crane motors, Type MHM, can, of course, be wound for *two-phase* current if desired.

Fig. 7 gives curves of the current, efficiency, power factor and slip of a three-phase motor as functions of the output.

In conclusion, attention is drawn to the line of *single-phase crane motors* now built for many years by Brown, Boveri & Co. These machines are the well-known single-phase commutator motors (Deri type) which, by reason of their high starting torque and excellent speed-regulating properties, have obtained widespread recognition. Unlike direct-current series motors and induction motors, starting up and regulation of speed are carried out very gradually and without the use of energy-consuming resistances by simply shifting the brushes, as already described in these pages.¹

J. F. Lochhead.

¹ The Brown Boveri Review, 1922, No. 2.

METHODS OF CLEANING COOLERS FOR LARGE TRANSFORMERS.

Decimal index 621.314.3.

GENERAL.

AS a consequence of oxidation and of the lowering of the temperature in the water-cooled pipes, sludge inevitably separates out of transformer oil with time, no matter how good the quality may be. These solid particles adhere to the cooling elements, and form a deposit which is composed of two layers, namely:—

The first is thin and only about 0.1—0.2 mm thick. It is in direct contact with the cooling pipes, on which it forms a skin resembling varnish, that can only be removed with difficulty.

The second, which covers the first film, may attain a thickness of as much as 5 mm. It consists of a flaky sediment, which can be easily dislodged.

These deposits of solid matter on the cooling elements hinder the heat transmission, with the result that the temperature of the transformer may exceed the permissible limits even under normal load conditions. As soon as such a state of affairs exists, the oil coolers must be cleaned without delay.

Moreover, the quality of cooling water may leave to be desired, especially when it is hard, contaminated or dirty, and sediment separates out that may have been held either in suspension or in solution, which entails a gradual falling off in the heat transmission, i. e. in the efficaciousness of the cooler.

Hence, it is usually not sufficient to clean only the surfaces touching oil, but this operation is also necessary for those coming into contact with water.

Brown Boveri transformers are cooled either internally or externally, and the designs of oil coolers differ accordingly. Those of the former description have zinc-coated, ribbed cooling pipes, whereas those for external cooling are provided with stacks of parallel tubes of small thickness, which are either of brass or copper, and contained in a cast iron vessel.

Since the removal of the thin, hard film of deposit offers difficulties, a description of the different methods of cleaning of which use is made in practice will be of interest.

CHEMICAL CLEANING OF SURFACES COMING INTO CONTACT WITH OIL.

(a) *Cooling elements for internal cooling.*

The cooler is dismantled, and the four groups of tubes are removed and placed one on the top of another in a tank, 2.5 m long, 1.2 m broad and 0.6 m deep, which is filled up to its two-thirds with a twelve-degree solution of caustic soda.

The film deposited by the oil takes about eight hours to dissolve. The parts to be cleaned have to be lifted once or twice out of the bath in the meanwhile, and flushed with water by a hose. On replacing the stacks of tubes in the bath, they should be turned over so that the portions which were formerly upmost lie nearest to the floor, because the dissolution of the oil residue is somewhat slower and less thorough on the sides facing the floor.

Part of the dissolved sediment floats, and can be skimmed off. The remainder forms a spongy mass which only adheres lightly to the cooling elements, whence it can be easily scraped away with a steel brush. Once cleaning has been carried out, the different parts must be hosed again, or placed in running water, and afterwards dried. A short-coming of this procedure is that the zinc coating is dissolved, and has therefore to be renewed every time the cooler is cleaned out in this way.

Furthermore, the base eats away any clothes or flesh with which it comes into contact. For this reason, portions of the cooler which are immersed in the solution have to be moved with the help of hooks or similar devices.

About 150 kg of 40-degree caustic soda are required for cleaning a cooler. One man is able to carry out this operation in three days.

The bath does not need renewing while one cooler is being cleaned.

(b) *Cooling elements for external cooling.*

The stacks of tubes are taken out of the cooler, and are placed in a bath of caustic soda having the same concentration as before. The sediment is loosened in five to six hours. The tubes are lifted from the bath several times during this interval, and the spongy residue still adhering is washed away by hosing. The remaining details do not differ from those enumerated above.

Cooling tubes, particularly those of copper, become black, due to the formation of a coating of patina, which, however, does no harm to the cooler.

The time required to clean a cooler amounts to about one working day.

MECHANICAL CLEANING OF SURFACES COMING INTO CONTACT WITH OIL.

(a) *Cooling elements for internal cooling.*

The cooler is dismantled, and the component parts are scoured by a jet of steam issuing from a nozzle of 5—6 mm diameter, which makes an angle of 45—60° with the surface to be cleaned. The latter should be three to four centimetres away from the mouth of the nozzle. The steam pressure should not be greater than 5 kg per cm².

This procedure is very simple to carry out; moreover, the sole implements required are a length of reinforced indiarubber piping and a nozzle.

The cleaning is very thorough, and after a little practice, it can be accomplished in about six working days.

Not only on account of its extreme simplicity is this method advantageous, but also because the zinc coating does not have to be renewed as in the preceding case. Furthermore, the cooler reassumes its clean, metallic appearance.

(b) *Cooling elements for external cooling.*

The cooler is dismantled, and the stack of tubes removed and heated to 100—120° C in an electrically-heated tank. The flaky deposit is loosened at this temperature and drops off, and the remaining hard layer is subsequently completely removed by a jet of steam, as in the foregoing case, so that the stacks of tubes regain their clean, metallic appearance.

This method of cleaning requires about one working day per cooler.

CLEANING OF SURFACES COMING INTO CONTACT WITH WATER.

In this case, cleaning is carried out by providing the dismantled cooling tubes with an extension B, so that by standing them on edge they can be filled with a weak solution of

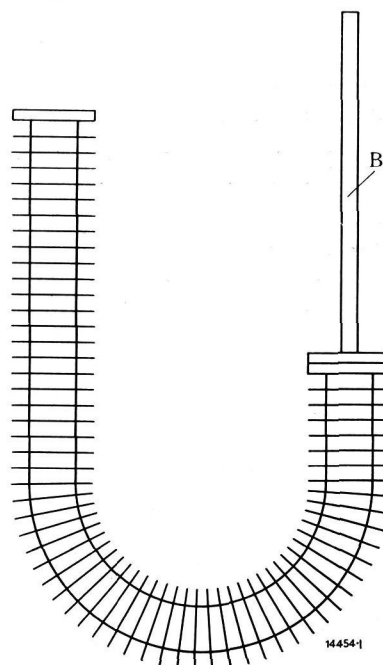


Fig. 1.

hydrochloric acid having a concentration of three to six per cent.

All the scale deposited will be thus softened in five to six hours. The solution must be frequently stirred during this operation so as to keep it continuously in motion, and the tubes should be scraped as frequently as possible with a scouring rod.

In order to prevent the hydrochloric acid from deteriorating the tubes, they should be thoroughly rinsed with clean water, a strong jet being most suitable for this purpose, and then dried in an electric oven.

When the scale is not too hard and too thick, external oil coolers can be cleaned with a special long-handled metallic brush. If the scale and sludge cannot be loosened in this way, the tube stacks have to be placed in a bath containing a three to six-per-cent. solution of hydrochloric acid. This method of removing scale occupies five to eight hours. As before, once this operation is accomplished, the tubes must be rinsed with water and then dried.

E. Schorno. (D. M.)

BROWN BOVERI COUPLING FOR ELECTRIC TRAIN HEATING.

Decimal index 621.334.4.

AMONGST the requirements that have to be met by couplings for electric train heating, the following are the most important:—

- (a) The coupling must be handy and simple, and its manipulation free from danger.
- (b) On a train dividing accidentally the electric coupling must part automatically without causing trouble either from the mechanical or electrical point of view.
- (c) Contact between the pin and socket must always be ensured.
- (d) The insulating materials must be capable of withstanding all weathers. Ample creeping distances should prevent flashovers, even under the grimy conditions to which the coupling is exposed.
- (e) If a flashover nevertheless occurs, it should be rendered harmless by suitably grounding all parts liable to be touched.

The electric couplings resembling ordinary contact plugs, as employed heretofore, are unable to cope with the severe conditions enumerated above which arise in railway practice. In particular, the heavy currents and high pressures occurring caused the pins and sockets to have an unwieldy size; moreover, since interchangeability is of paramount importance, due to the necessity of

altering the formation of the train more or less frequently, extreme accuracy was needed for the machining of devices of this description.

With the old system, a trifling amount of damage is sufficient to render the manipulation difficult or even impossible. Moreover, the spring ensuring the necessary contact pressure between the pin and socket is obtained by providing either of these with slits. This arrangement is unsatisfactory in every-day operation because it becomes slack with use—it follows that the contact is then no longer sufficient, which leads to heating and to the formation of sparks, thus rendering the coupling unfit for service.

Brown, Boveri & Co. recognised these shortcomings, and have patented a coupling device which surmounts them. Figs. 1 to 6 show the principal details. As can be seen in Figs. 3 and 4, this coupling device comprises the following parts per buffer beam:—

A coupling box, I.

A connecting cable with a plug, II.

A cable holder, III.

A sheath, IV, for protecting the plug when not in use.

The arrangement is therefore such that when two carriages are together, the coupling box of one of them always faces the connecting cable of the other, and

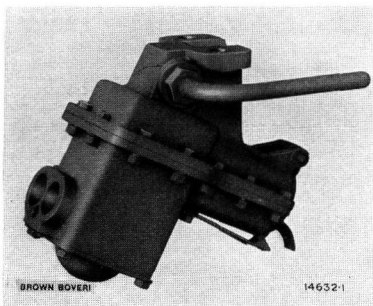


Fig. 1. — Coupling box for train heating.

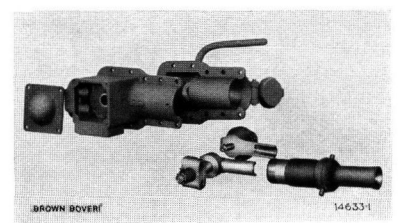


Fig. 2. — Details of coupling box and plug.

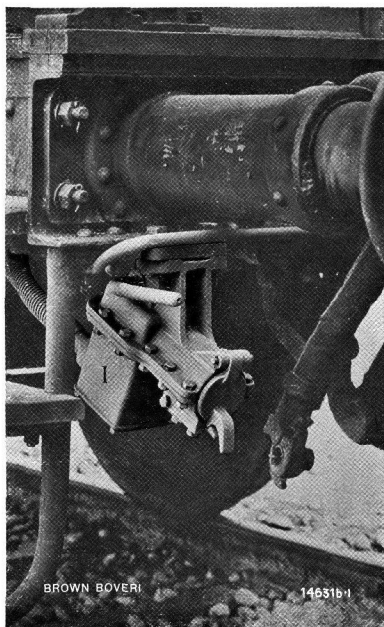


Fig. 3. — Coupling box fitted on to a carriage.

two complete coupling sets are always available. As a rule, only the set that is most accessible is connected up, the other one forming a standby.

The details of the coupling box and pin can be seen in Figs. 2 and 6. The coupling box comprises a casing, which is in two parts, and a clamp B which is also split. The two half clamps are jointed at their upper extremity, and

are bored out at the other so as to form a socket for the contact pin A. The two halves are made to come together and to hold the contact pin firmly by turning a lever D, placed on one side of the casing, which rotates an eccentric C, thus causing pressure to bear against the upper half clamp through the intermediary of the spring M. The dimensions are chosen so as to ensure an ample contact pressure by quite a moderate effort on the lever. Under these conditions, the pin A is held fast in such a way that although it cannot be pulled out by anyone grasping the handle K of the plug, the latter is immediately released without any damage whatsoever should the train accidentally part. Furthermore, in order to prevent the contact pin from working loose and the plug from falling out whilst travelling, the eccentric is disposed so that the socket is untightened when the lever D is about horizontal, it being necessary to turn the lever downwards to press the two halves of the clamp together. The eccentric is located in the upper portion of the casing, whereas in the lower are placed the terminals of the cable G connecting the coupling box to the connecting cable on the other side of the same buffer beam, of the cable H connecting the two coupling boxes of the carriage, and of the cable J going to the heaters. This centralisation of all the cable terminals in the coupling box greatly simplifies the connecting up of the heating equipment in the carriages. On lifting the hinged flap of the coupling

box, the lower extremity of the clamp B is the only live part visible, and this is amply protected against accidental contact by being recessed well within the casing.

The lower extremity of the pin of the plug is provided with an extension for soldering it to the flexible copper cable. The pin is fastened by a ring nut inside the protecting sleeve of insulating material, which

extends for some distance beyond it. It is impossible to come into contact with the live part of the plug, since an insulating tip N is provided at the upper extremity of the pin. The insulating sleeve is protected and reinforced by an iron tube, which also acts as a guide. On the latter is screwed a handle K, which at the same time serves to hold the coupling cable G. In order to prevent eddy currents, which would cause the handle to heat unduly, the latter is made in sections. All metallic parts of the plug liable

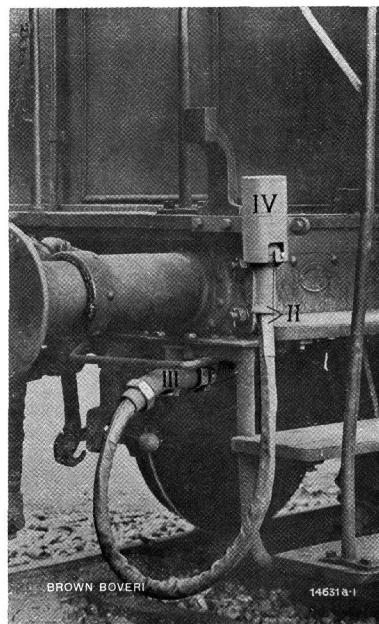


Fig. 4. — Coupling pin with sheath fitted on to a carriage.

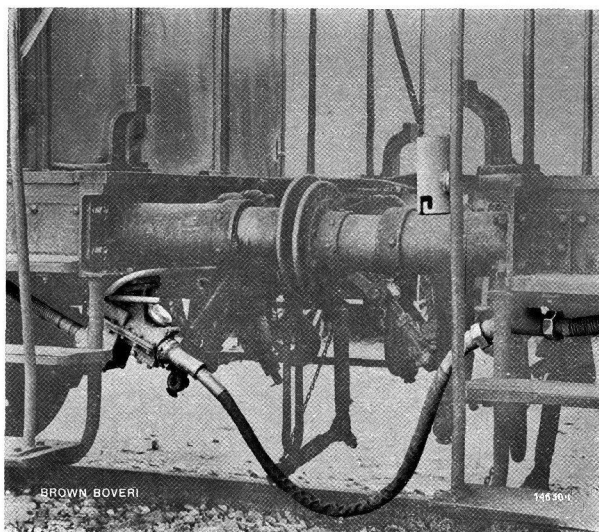


Fig. 5. — Coupling connected between two carriages.

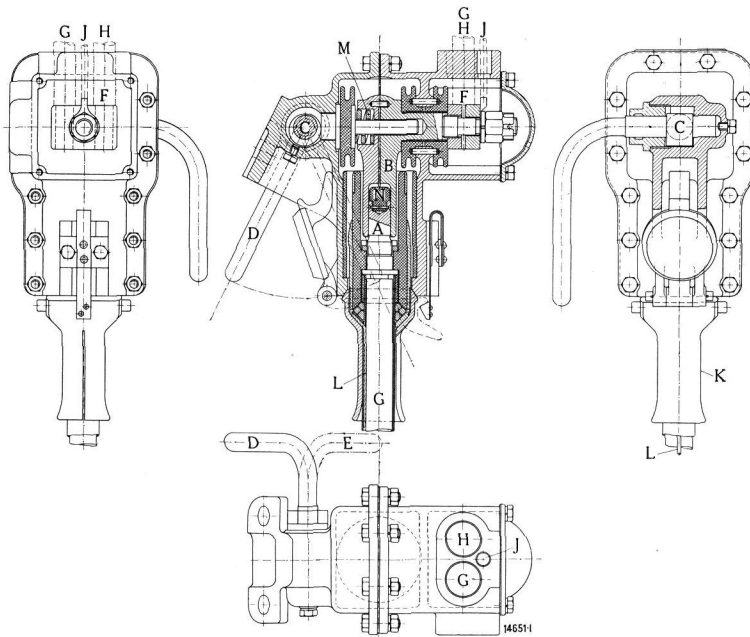


Fig. 6. — Coupling box and pin for train heating.

- | | |
|----------------------------------------------------------|---------------------------------------------|
| A. Contact pin. | H. Cable connecting the two coupling boxes. |
| B. Clamp in two parts. | J. Cable going to the heaters. |
| C. Eccentric. | K. Handle of plug. |
| D. Eccentric lever in open position (contact loose). | L. Ground wire. |
| E. Eccentric lever in closed position (contact clamped). | M. Spring. |
| F. Cable terminals. | N. Insulating tip. |
| G. Cable connecting the coupling box and pin. | |

to be touched are grounded by the wire L, which runs from the plug to the cable box, and is connected to the iron underframe of the carriage.

About 50 carriages belonging to the Swiss Federal Railways were fitted with this coupling during the winter, 1921—2. Such satisfactory results were obtained in service that 200 further carriages are to be equipped for the winter, 1922—3.

The electrical requirements to be met by the coupling are based on the following energy consumptions for heating:—

- | | | |
|--------|------------------------------|---------|
| 200 kW | with the outside temperature | + 5° C. |
| 300 kW | " " " " | 0° C. |
| 400 kW | " " " " | -10° C. |
| 460 kW | for warming up. | |

The maximum energy consumption of 460 kW for warming up is obtained by assuming that a train composed of fifteen eight-wheeled or twenty six-wheeled carriages requires 300 watts per cubic metre to be heated.

The load is adjusted on the Swiss Federal Railways, which use 16²/₃-cycle,

single-phase alternating current, by changing the pressure with different transformer tapings, so that it amounts to:

- | | | |
|--------|---------------------------------------------------|---------|
| 600 V | for an energy consumption of about | 200 kW. |
| 800 V | " " " " | 300 kW. |
| 1000 V | " " " " | 400 kW. |
| 1000 V | for warming up, when the energy consumed is about | 460 kW. |

The current which the couplings can be called upon to carry therefore attains 400 A (or 460 for short periods whilst warming up).

Experiments have shown that the coupling is easily able to meet these conditions. The ultimate temperature rises after carrying a current of 400 A during four hours amounted to:

- 38° C at the contact pin, and
- 35° C at the cable terminal.

The pressure tests were equally satisfactory, as the plug and coupling box withstood a pressure of 8'000 V for five minutes; flashovers occurred in the plug at 10'000 V and in the connecting box at 9'400 V.

Heating the coupling for eight days at 80° C in no way deteriorated the insulation.

Although the coupling is not intended for cut-

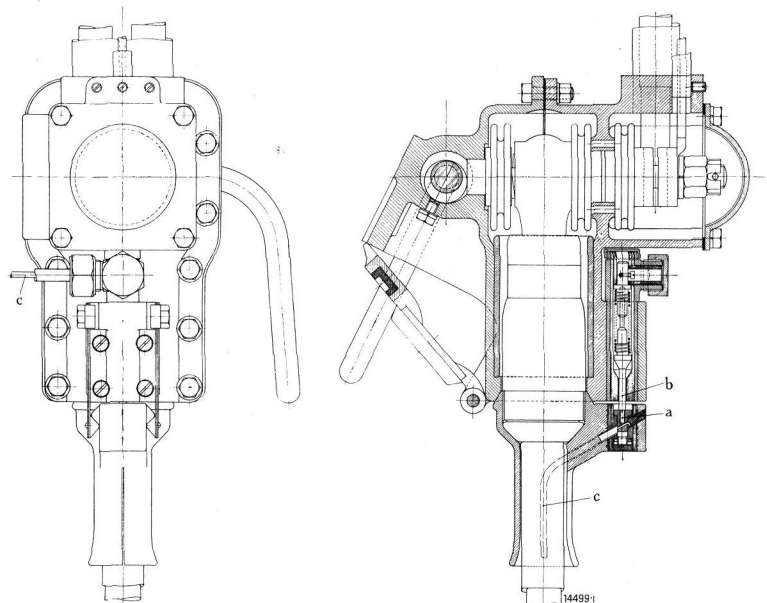


Fig. 7. — Coupling for train heating with safety interlocking device.

- | | |
|--------------------------------------|----------------------------------------------|
| a. Interlocking contact on the plug. | b. Interlocking contact on the coupling box. |
| c. Auxiliary cable. | |

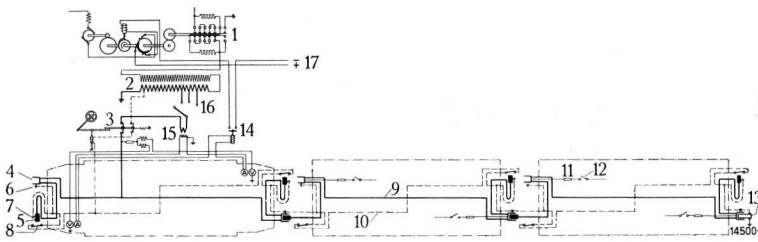


Fig. 8. — Diagram of connections showing train with coupling for train heating and interlocking device.

- | | |
|------------------------------------------|--------------------------------------------|
| 1. Locomotive high-tension switch. | 10. Auxiliary cable. |
| 2. Locomotive transformer. | 11. Fuse for heaters. |
| 3. Main switch for train heating. | 12. Switch for heaters. |
| 4. Coupling box. | 13. Tail plug. |
| 5. Coupling pin. | 14. Secondary overload time-limit relay. |
| 6. Interlocking contact on coupling box. | 15. Current transformer for train heating. |
| 7. Interlocking contact on coupling pin. | 16. Adjusting switch. |
| 8. Interlocking contact on sheath. | 17. Releasing circuit of switch 1. |
| 9. Cable for train heating. | |

ting out the current under normal conditions, the effect of pushing home and withdrawing the plug when energised was ascertained. Tests of the latter description were undertaken to find out whether the electrical requirements could be met should the train accidentally part, or should it be necessary in case of emergency to use the coupling for switching out the normal load. These tests were made with alternating current, $16\frac{2}{3}$ cycles, 1'200 V, 400 A, and showed that the aforementioned requirements could be met with perfect safety. Nevertheless, the railway regulations stipulate that the coupling must only be handled when de-energised.

From these results, it will be seen that the coupling is well adapted for alternating current having a working pressure up to 1'200 V and for carrying as much as 400 A, even if it is occasionally called upon to cut out the load.

An *interlocking device*, which prevents the coupling from being manipulated when energised, has been patented by the firm, and is shown in Fig. 7. It is suitable when the coupling is to be employed on direct-current railways having working pressures up to 1'500 V.

The wiring diagram, Fig. 8, shows that the interlocking arrangements are as follows:—

1. The train-heating switch 3, on the locomotive can only be closed when at least one of the couplings is connected between each of the different vehicles, and the plug 13 at the tail of the train is in place.
2. The train-heating switch 3 on the locomotive opens automatically if:—
 - (a) the train parts;
 - (b) any plug is lifted out of its sheath;

- (c) the coupling is disconnected;
- (d) the tail plug 13 is removed;
- (e) any plug works loose in the coupling box whilst travelling.

These requirements are met by suitably grounding an auxiliary cable 10, in whose circuit are an under-pressure relay and the tail plug 13. The cable is connected to the low-tension circuit of the auxiliary apparatus, which may be fed either by direct or alternating current at pressures ranging from about 30 to 250 V. As can be seen from the diagram, the switch 3 is opened as soon as the auxiliary cable is interrupted, whereas overloads and short circuits on the train-

heating circuit 9 operate the secondary relay 14, which trips the high-tension switch 1 of the locomotive. Hence, when the under-pressure relay opens the switch 3, only the train-heating circuit is disconnected, without interfering with the main circuit of the locomotive. Moreover, by means of this arrangement, the switch 3 is never called upon to open the circuit when there is an overload or a short circuit, which operation is always carried out by the high-tension switch 1, which has, under any circumstances, to be able to deal with such occurrences, thereby enabling the dimensions of the former switch to be considerably reduced.

Details of the coupling box and plug are given in Fig. 7. The internal organs of the coupling differ in no way from those employed on the Swiss Federal Railways, and only the following additional parts are required:—

- An interlocking contact a on the plug.
- An interlocking contact b on the coupling box.
- An auxiliary cable c.

In this case, the sheath is provided with an auxiliary contact, which temporarily opens the circuit whilst the plug is being withdrawn, thus tripping the train-heating switch on the locomotive. Another fresh item is the plug 13, which serves to ground the auxiliary cable at the tail of the train.

Both designs of coupling are equally well adapted for three-phase, single-phase or direct current. The coupling with interlocking device is particularly suitable for pressures greater than 1'200 V, as, for instance, direct-current railways having a contact-wire pressure of 1'500 V which make direct use of the current for heating purposes.

It was not deemed necessary to equip the carriages of the Swiss Federal Railways with an interlocking device, since the working pressure at no time exceeds 1000 V. Nevertheless, it was stipulated that both types of coupling should be interchangeable, so as to enable carriages belonging to foreign railway systems making use of higher pressures up to 1'500 V alternating or direct current for heating pur-

poses also to be heated electrically whilst travelling in Switzerland. As the Swiss locomotives can only supply 1000-V current, the heating of these foreign carriages would be somewhat less efficient, but sufficient in the majority of instances. It goes without saying that interlocking would be impossible with mixed trains of this description.

H. Huggler. (D.M.)

NOTES.

Large turbo-alternator sets for the Compagnie Parisienne de Distribution d'Electricité.

Decimal index 621. 165. 23 + 621. 313. 43 (44).

THE French licensee of Brown, Boveri & Co., namely the Compagnie Electro-Mécanique, Paris, secured in the beginning of August, 1922 an important contract comprising several turbo-alternator sets for the Compagnie Parisienne de Distribution d'Electricité. Since the plant to be supplied offers many features of particular interest, both from the economic and technical viewpoint, a brief description giving the leading features will not be out of place.

In order to meet the increasing demands for electrical energy, the aforementioned supply company decided to enlarge their Saint Ouen (Usine Nord) power station. Built according to modern principles, this extension will be provided with three large sets, so as to obtain a high efficiency together with low first cost and upkeep.

To begin with, the Compagnie Electro-Mécanique will supply a two-phase turbo-alternator set, having the following capacity with a 0.8 power factor:—

Continuous rating	30'000 kW.
Two-hour rating	35'000 kW.
Pressure	12'300 V.
Frequency	41 ² / ₃ cycles.
Speed	1'255 r. p. m.

This set has been designed so as to enable the frequency to be subsequently altered to 50 cycles, with the load conditions remaining unchanged, without any important alterations being necessary.

For the auxiliary services in this power station, the Compagnie Electro-Mécanique is also providing two direct-current turbo-generator sets, each for 2500 kW, formed by a 3'000-r.p.m. turbine driving through reduction gearing a dynamo for 380 r.p.m., 220 V, with an overload capacity of 10% for two hours. This arrangement allows both

the turbine and generator to run at the most suitable speeds, thus ensuring a high overall efficiency.

Besides undertaking this enlargement, the Compagnie Electro-Mécanique were also entrusted to carry out the renewal of the existing plant in Nord power station, as a notable saving of fuel can be thus realised. The old 1250-r.p.m. sets are to be replaced by 2500-r.p.m. ones. For this reconstruction, three turbines and two complete turbo-alternator sets are to be supplied. The latter are for the following capacity with a 0.8 power factor:—

Continuous rating	12'000 kW.
Two-hour rating	15'000 kW.

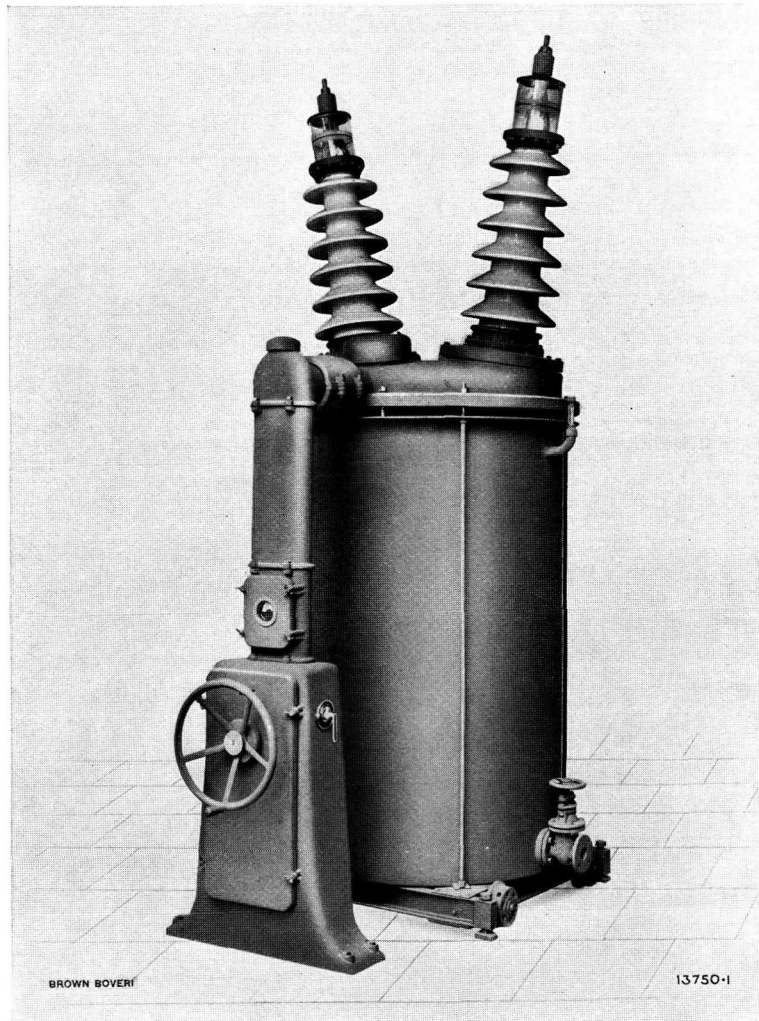
As with the 30'000-kW set just described, two-phase current having a pressure of 12'300 V is to be generated, both with the present frequency of 41²/₃ cycles and when the frequency is subsequently altered to 50 cycles. All these fresh sets will make use of the existing condenser plant. Each of these turbines drives a direct-current generator for 300 kW, 220 V, which supplies current for driving the condenser pumps, as well as the alternator with its exciter.

The steam conditions for the different turbines are determined by the existing boilers. For this reason, the pressures and temperatures are moderate when compared with those adopted in many recent installations. The 30'000-kW sets will be supplied with superheated steam at 16 kg per cm² gauge pressure, and 325° C, whereas the 12'000-kW sets will use superheated steam at 13 kg per cm² gauge pressure having the same temperature. The turbines must be capable of working up to their full capacity even with a pressure drop of about 30%. Moreover, they must be able to withstand steam superheated up to 370° C. The surface condensers are capable of maintaining a vacuum of 95%, and use the waters of the Seine for cooling purposes.

The magnitude of this contract affords ample proof of the confidence French engineers have in Brown Boveri plant, which has made for itself an excellent reputation in numerous installations both in Europe and overseas.

J. Reverdin. (D.M.)

BROWN BOVERI OUTDOOR EQUIPMENT



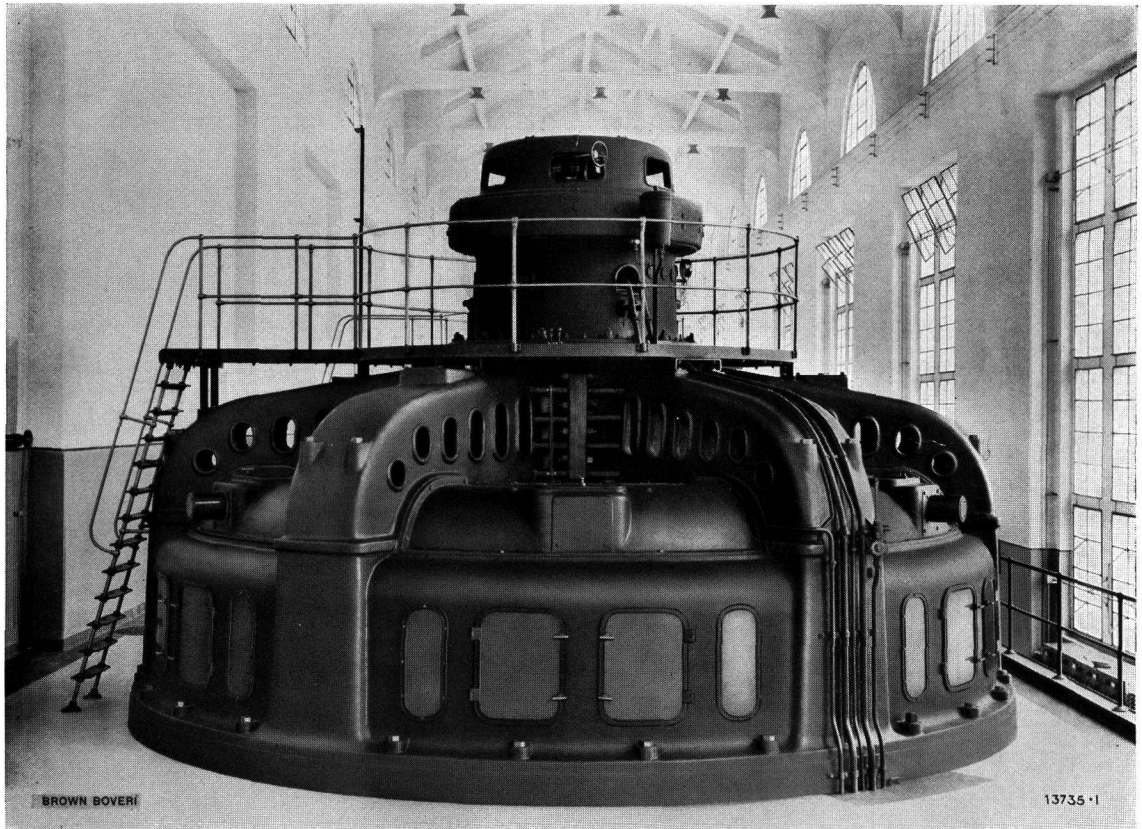
SINGLE-POLE OIL CIRCUIT BREAKER WITH CONTROL PILLAR.
Nominal pressure 110'000 V, nominal current 350 A, for outdoor installations.

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OIL SWITCHES AND OIL CIRCUIT BREAKERS
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BADEN (SWITZERLAND)

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