

THE BROWN BOVERI REVIEW

EDITED BY BROWN, BOVERI & COMPANY, LIMITED, BADEN (SWITZERLAND)



TRAIN ON THE CHILIAN TRANSANDINE RAILWAY IN THE ANDES.

1C + C1 combined rack and adhesion locomotive. One-hour rating 6×235 kW, 3000-V direct current.

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THE COMBINED RACK AND ADHESION ELECTRIC LOCOMOTIVES ON THE CHILIAN TRANSANDINE RAILWAY.

Decimal index 621.334.2 : 625.3 (83).

THE first and only through railway line to be laid across South America is the one from Valparaíso to Buenos Aires via Mendoza. It traverses Chile and Argentina and provides an overland connection 1400 km long between the Pacific and Atlantic Oceans. In the west the railway crosses the backbone of South America, the Cordilleras de Los Andes, at

an altitude of 3207 metres at the Chilian-Argentine frontier. The section of railway from Los Andes to Mendoza constitutes the Transandine Railway, which was put into full service in 1910. It is laid for combined rack and adhesion service and has a metre gauge. The railways with which it connects up, viz., the Chilian State Railway and the Buenos Aires and



Fig. 1. — Caracoles Station (3194 metres above sea-level), the highest station on the Transandine Railway, at the foot of Mt. Aconcagua (summit 7035 metres above sea-level).

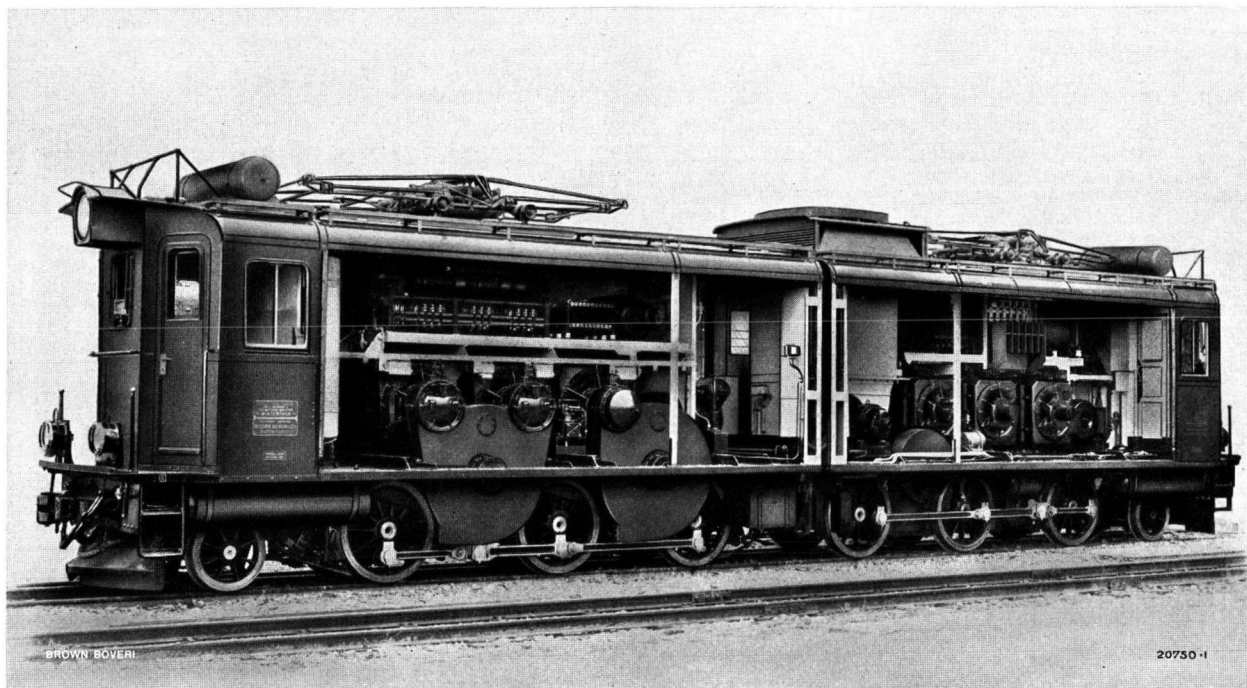


Fig. 2. — View of one of the locomotives with side panels removed.

Pacific Railway, have a gauge of 1676 mm. 70.55 km of the Chilian Transandine Railway, from Los Andes to the Argentine frontier, are laid in Chilian territory, and 178.9 km, from Mendoza to the Chilian frontier, are in Argentina.

There are five rack sections on the part of the railway in Chile, the longest being nine kilometres; the maximum gradient on any of the sections is 8% and the maximum gradient encountered on the pure adhesion sections is 2.5%. On the line in Argentina there are six rack sections with similar lengths and gradients (max. gradient = 6.1%). The operation of this railway is often rendered very difficult in winter by heavy snowfalls (the total depth of snow in the higher altitudes of the Andes during a normal winter is as much as 6.5 metres), by avalanches, and the accompanying falls of rock. In very severe winters it has sometimes been necessary to close down the line completely for as long as 60 days. This is a serious drawback on a railway of such great political and strategic importance, and to avoid a recurrence of such an event extensive protective works and galleries were built. These were, however, very difficult to ventilate, and when steam traction was employed the smoke proved to be a great nuisance to both passengers and staff and was even dangerous, partic-

ularly as the locomotives were fired with Chilian soft-coal which is very productive of smoke and soot. It is hoped to be able to guarantee continual service all through the winter by using electric traction and by protecting the exposed parts of the line still further. Electric traction also enables the speed and weight of the trains to be increased. This is a very important point in view of the nature of the traffic on the Chilian Transandine Railway, large numbers of cattle being transported from Argentina to Chile, and big consignments of perishable fruit in the opposite direction. The elimination of the need for hauling coal to a height of over 3000 metres (Los Andes is 834 metres above sea level, Caracoles 3194 metres and Mendoza 768 metres) also improves the efficiency of the railway. It should not, however, be concealed that the actual volume of traffic on the line did not, in itself, justify electrification. At the most, only two goods trains pass daily in each direction and, twice a week, one passenger train in each direction.

Both Transandine Railways, the Chilian and the Argentine, are owned by a British company with head office in London, and are run by an administration in Los Andes.

The two lines connecting up with the Transandine Railway on the Chilian side, namely, those from

Valparaiso and Santiago to Los Andes, are electrified, and are operated on direct current at 3000 V. As they had been in completely satisfactory service for several years it was to be expected that the same kind of current and pressure would be chosen for the line across the Andes, although it is not possible for the locomotives to run from one set of rails on to the other on account of the different gauges.

The Abt rack system with three bars each 20 mm wide is used on the Transandine Railway. The heaviest combined rack and adhesion locomotives weighed 96.5 tons and could haul loads up to 120 tons. It was stipulated that the new electric locomotives should be capable of hauling eastward-bound trains of 150 tons trailing weight, and trailing loads of 200 tons in the westward direction. The greatest axle load was not to exceed 12 tons. The maximum stipulated speed on the adhesion sections was 40 km/h and on the rack sections

16 km/h (on open sections). In stations and on sidings the speed was to be 20 km/h. A locomotive weight of 85 tons was permitted.

At present, only the Chilean part of the railway across the Andes has been electrified and of this only the actual mountain section from Rio Blanco to

Las Cuevas, which is the section already provided with a rack. A converter substation had to be built at Juncal, 51 kilometres along the railway from Los Andes, for supplying the electrical energy for the line. The substation is fed through a 100-km long transmission line from the Fuerza y Luz Santiago Company with three-phase current at 44,000 V, 50 cycles; this is converted by means of two 1500-kW motor generators into 3000-V direct current, with which the contact wire is fed.

According to an agreement made in March 1925, an order was placed with Brown, Boveri & Co. in conjunction with the Swiss Locomotive and Machine Works, Winterthur, for three combined rack and adhesion locomotives.



Fig. 3. — Situation of the Transandine Railway.

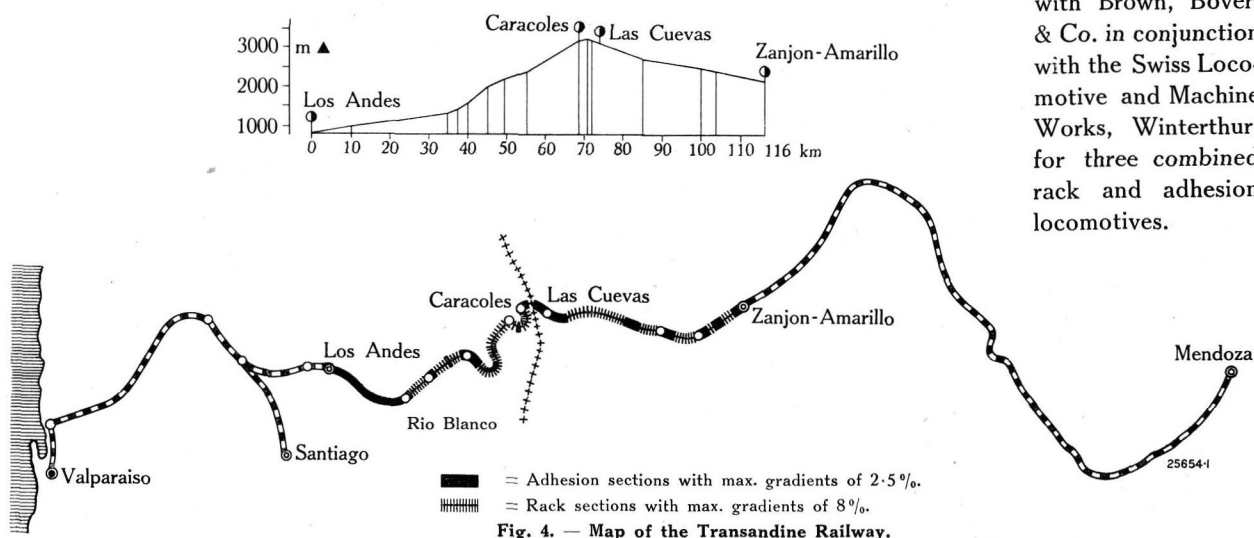


Fig. 4. — Map of the Transandine Railway.

The gradient of 8%, a trailing load of 150 tons and a locomotive weight of approx. 85 tons call for a tractive effort of about 21 tons at the tread of the wheel. As the maximum permissible load on the rack teeth is about 85 kg per millimetre, the teeth should not be loaded with a tractive effort per rack pinion greater than $85 \times 60 = 5100$ kg. It is therefore obvious that the machine must be provided with two rack pinions and six adhesion axles to divide the tractive effort of 21 tons equally between the rack and rails. With an adhesive weight of $6 \times 12 = 72$ tons, the adhesion coefficient will then be $\frac{72}{10.5} = 6.8:1$, which is quite high enough.

On account of the numerous curves and the small radii of curvature — 80 to 100 metres on adhesion sections and 180 metres on rack sections — the locomotives had to be fitted with pony axles. Abnormal wear of the tyres and rails is not, therefore, to be expected. The 1C+C1 axle arrangement was accordingly chosen, and, to ensure that the rack pinions engage with the rack as smoothly as possible, the locomotive was built up of two articulated parts and not with a single frame.

These locomotives are the largest and most powerful combined rack and adhesion locomotives that have ever been built.

I. GENERAL.

The following are some particulars relating to the locomotives:—

Gauge	1 metre
Minimum radius of curvature:	
On open sections	100 m
At points	80 m
On rack sections	180 m
Abt rack system with three bars	
Maximum gradient on adhesion sections	2.5 %
Maximum gradient on rack sections	8.0 %
Diameter of driving wheels	1000 mm
„ „ pony wheels	710 mm
„ „ rack pinions	840 mm
Number of rack pinions	2
Maximum load on driving axles	12 tons
Total wheelbase	13.05 m

Total length over buffers	16.12 m
Kind of current	Direct
Maximum contact-wire pressure	3000 V
Mean contact-wire pressure	2700 V
Minimum contact-wire pressure	2100 V
Number of driving motors	6 (4 adhesion motors 2 rack motors)
One-hour rating of each motor: 235 kW at 740 r.p.m. and 2700/2 V	
Continuous rating of each motor: 195 kW at 790 r.p.m. and 2700/2 V	
Reduction ratio: Rack-pinion drive	8.13:1
Adhesion wheels	4.67:1
Weight of mechanical part	52.75 tons
Weight of electrical part	32.85 tons
Total weight	85.60 tons
Adhesive weight	72.3 tons
Weight per metre of total length	5.35 tons

II. MECHANICAL PART.

For a contact-wire pressure of 3000 V it is convenient to connect two driving motors permanently in series; two motor groups, one in each half of the locomotive, are then used for driving the adhesion wheels, each group driving three axles. The third group, which drives the two pinions, is divided, there being one motor in each half of the locomotive. The rack motors also are only coupled electrically and not mechanically as long as the locomotive is not on a rack section.

The three motors in each half of the locomotive are bolted together into one block. The two adhesion motors drive the three driving axles through a common double-reduction gear and a crankshaft by means of horizontal driving and coupling rods. Each rack pinion is driven by a motor through double-reduction gearing.

The motors are mounted high up in the locomotive frame well away from snow and ice.

For guiding the machine round curves, a pony axle with a lateral movement of 2×70 mm and leaf-spring centring device is provided at each end. The central driving axle of each locomotive-half has 2×10 mm side play. The driving axle sets are all similar and also the pony axle sets, and are therefore interchangeable.

The locomotive-halves are coupled closely together and each is provided with a cab at the outermost end. The locomotive bodies, which form the machine rooms, are connected up to these cabs. Both bodies are connected by flexible gangway-bellows.

The locomotive frame in each half is supported at three

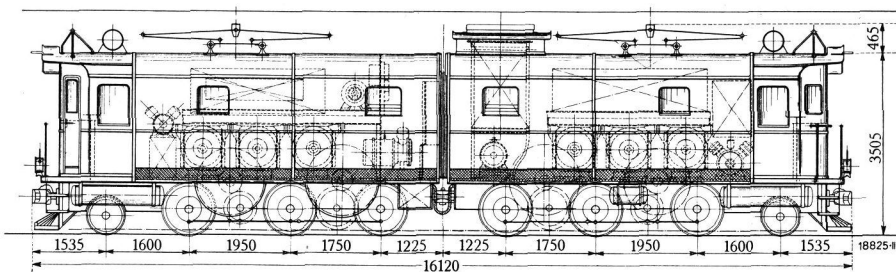


Fig. 5. — Sketch showing arrangement of the locomotives for the Transandine Railway.

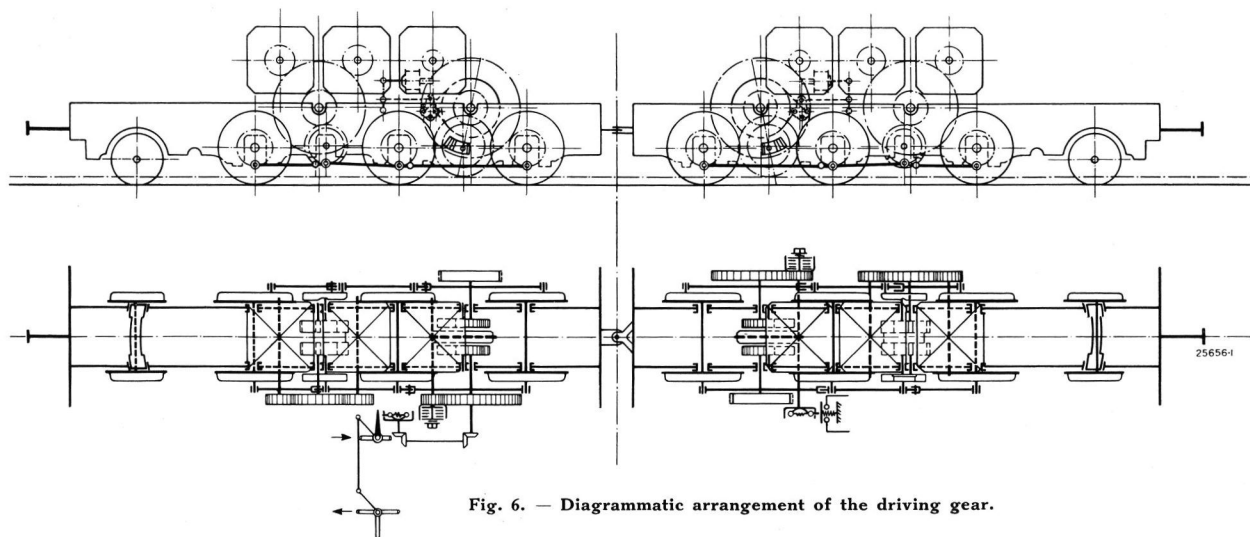


Fig. 6. — Diagrammatic arrangement of the driving gear.

points. Three-point suspension enables the load to be uniformly divided amongst the various axles and ensures that the distribution remains unaltered, even when travelling over bad rails. To give the rack pinion as little vertical movement as possible, the two inner driving axles, between which it is situated, are stiffly sprung, while the springing of the pony axles and of the driving axles underneath the driver's cab is more flexible.

The following particulars regarding the drive are worthy of note:— On the driving side of each locomotive-half, pinions are keyed overhung on the ends of the shafts of the adhesion motors. These pinions are spring driven and engage with a common gear wheel on the shaft of the reduction gear. The maximum movement of the pinion relative to its shaft, measured at the pitch circle, is about seven millimetres when a torque corresponding to a current consumption of double the normal is being transmitted. The first reduction gear has a ratio of 3.404:1 and the second 1.371:1. The second reduction gear comprises two pairs of gear wheels. The teeth of one pair are circumferentially displaced with respect to those in the other pair by half a pitch. All the gears have straight-cut teeth. The crankshaft is made of nickel steel. It carries a drum, in the middle of which the tooth rims of the second reduction gear are mounted; on the extremities of the shaft are the cranks with balance weights. The crankshaft is mounted 11 mm above the axles of the adhesion wheels so that the coupling rods are approximately horizontal when in their central position.

The pinions for the rack motors, each provided with a friction clutch, are also arranged on the driving side of the locomotive. The clutches comprise circular cast-iron discs which are pressed apart by adjustable springs. The discs are fixed alternately to the driven and driving sides, i. e., to the hub and the tooth rim of the pinion, respectively, by keys. Chekko facings are fixed to the discs on one side. Chekko is a material made of pure asbestos with interwoven brass wires; it gives a high coefficient of friction with iron, and is fire-proof. It is very frequently used on automobiles.

The friction clutch provides a flexible connection between the rotating motor armature and the rotating

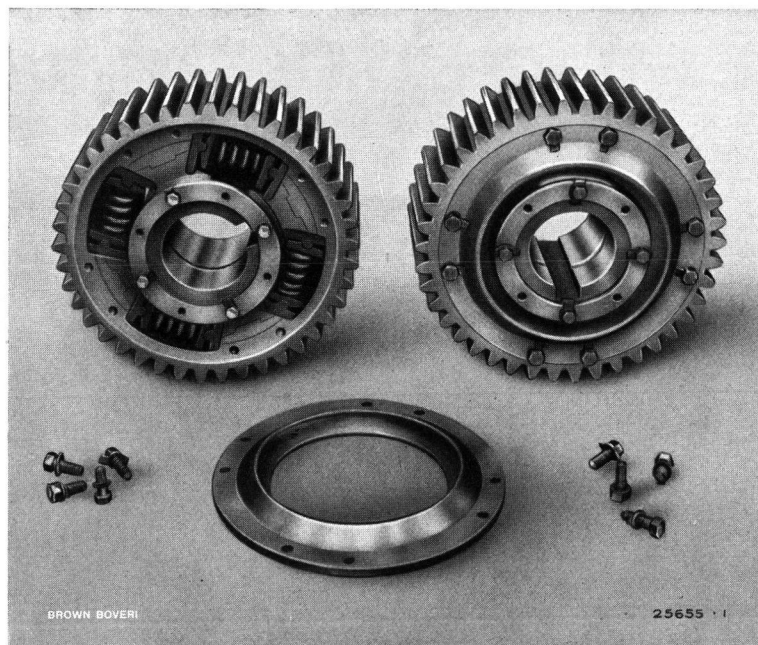


Fig. 7. — Spring-driven pinion for the adhesion drive.

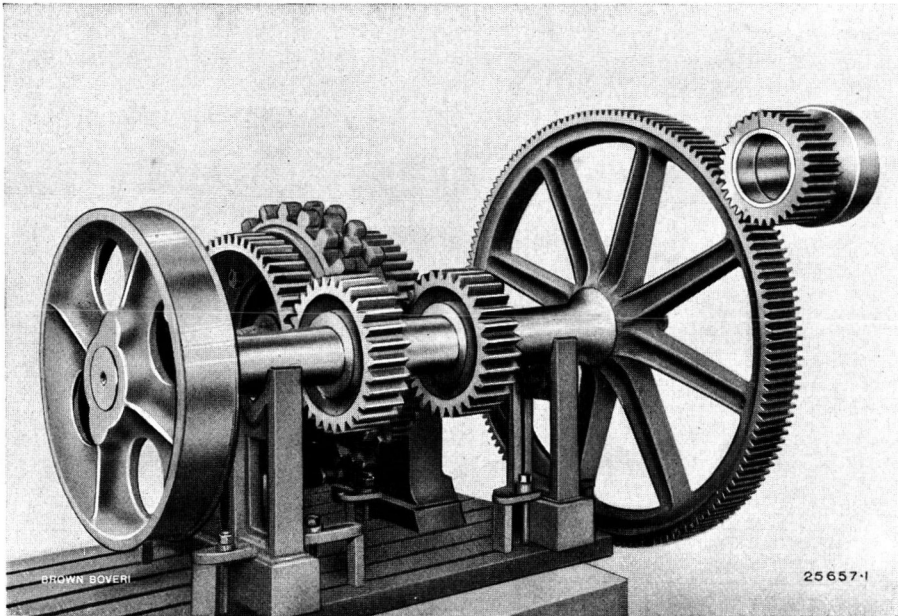


Fig. 8. — Drive for the rack pinion.

mass of the reduction gear and rack pinion. Thus variations in the torque produced by current rushes or mechanical shocks are not transmitted to the rack pinion, but are slipped by the clutch. The clutch is adjusted to slip at about double the torque corresponding to the one-hour output of the motor; it operates when the pressure on the teeth of the pinion has reached 10,000 kg.

The rack motor drives the pinion through the clutch, the pinion engaging with the large gear wheel which is mounted overhung on the end of the reduc-

tion-gear shaft. The reduction ratio is 4.6:1.

A brake wheel for the rack brake is mounted at the other end of this reduction-gear shaft. As in the adhesion drive, the second reduction gear (ratio 1.766:1) for the rack pinion comprises two pairs of gears with a relative circumferential displacement of half a pitch. All the teeth are straight cut.

The cast-steel drum transmits the torque through three groups of eight helical springs to three tooth rims, which are mounted loose on the drums. The springs serve to take up inequalities in the pitch and to distribute the torque as equally as possible to the three rack bars.

The teeth on the three rims have a displacement relative to each other of a third the pitch, like the Abt rack.

The shafts of the rack pinions run in solid bronze bearings lined with white metal. These bearings are mounted as the blocks in systems of levers arranged in circular formation with the shafts of the reduction gears as centres. As the tyres of the adhesion wheels wear away, the whole locomotive is lowered, and, consequently, the rack pinions engage deeper with the rack. In the extreme case the tops of the pinion teeth would run on the bottom of the rack. By

changing over four distance pieces from one side of the bronze bearings to the other, and then securing them with keys, the centres of the rack pinions can be raised a total distance of 24 mm above the top of the adhesion rails. The adjustment is made when the locomotive is being overhauled, the amount depending on the wear of the tyres, which can have 30 mm turned off the radius. When the tyres are new, the pitch circle of the rack pinion is three millimetres above the pitch line of the rack, and, when they are worn down by the maximum amount, three millimetres below.

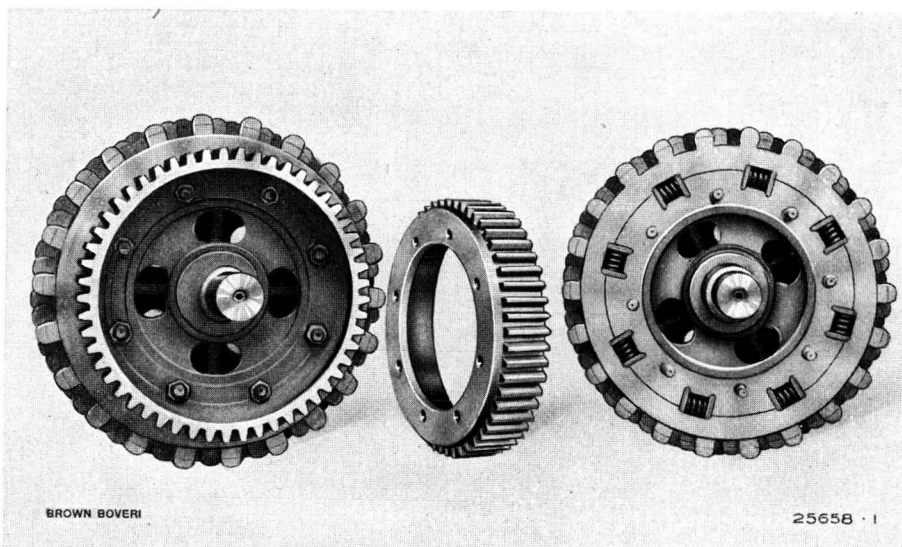


Fig. 9. — Abt rack pinion with spring drive.

On a rack locomotive the brakes are as equally important as the driving gear. On the machines under consideration they have been constructed with particular care. They are as follows:—

(1) *The brakes on the adhesion wheels.* — These are separately arranged for each locomotive-half and can be operated either by compressed air or a hand lever.

Only the driving wheels are braked. With compressed air, up to 90% of the adhesion weight of the whole locomotive is braked, and, when the brakes are applied by means of the hand lever, up to 60% of the adhesive weight of the particular locomotive-half.

The compressed-air adhesion brakes can be employed as automatic brakes if one brake valve is used, or they can be applied with varying force by using a second brake valve.

All the wagons are fitted with Westinghouse automatic and adjustable double-pipe brakes. There are two brake cylinders per wagon, one 6" and the other 8" in diameter. The small cylinder is used when the wagon is empty (weight 10 tons), the large cylinder when the wagon is half full (20 tons) and both together when the wagon is fully loaded (30 tons). In every case 75% of the total weight is braked.

(2) *The rack brake.* — This is an emergency brake and is not used for continuous braking. It is made as a direct-acting compressed air operated band brake and can be hand-controlled by means of a special valve in each driver's cab or is automatically applied by the action of the speed regulator if the speed of the train exceeds about 18 to 25 km/h. In this case the automatic brakes on both locomotive and train are applied simultaneously. The braking force on the rack pinion is 7000 kg.

(3) *The electrical brake.* — This is described further on.

III. ELECTRICAL PART.

Traction motor circuit. — The output of the locomotive on the maximum and medium gradients with maximum trailing load is as follows:—

Total weight of train in tons	Gradient %	Total tractive resistance kg/ton	Tractive effort at wheel tread kg	Speed km/h	H.P. at wheel tread	H.P. at motor shaft
150+85	8.0	10	21200	14	1100	1220
200+85	6.1	10	20200	14	1040	1160
200+85	2.0	5	7100	28	740	820
150+85	2.5	5	7050	28	730	810

Maximum tractive effort at wheel tread:
 On rack sections 32,000 kg.
 On adhesion sections 16,000 kg.

The output of the locomotive is developed by six motors, each with ratings as follows:—

One-hour rating: 235 kW (320 H.P.) at 740 r.p.m., 2700/2 V, 187 A.

Continuous rating: 196 kW (265 H.P.) at 790 r.p.m., 2700/2 V, 155 A.

(1) *Motor connections used.* — All six motors are the same both electrically and mechanically and can, therefore, be interchanged among themselves or with a reserve motor.

The four motors for the adhesion service are divided into two groups, the two motors in each group being connected permanently in series and supplied at the contact-wire pressure of 2700 V. The two rack motors are also connected in series and connected directly with the contact wire. The connections used when running on the adhesion and rack sections, and also when entering or leaving the rack sections, are as follows:— When either starting or running on the *adhesion sections* the two groups of adhesion motors are connected in series-parallel.

For *running on the rack sections* all three motor groups are first connected in series; then the two adhesion motor groups — still connected in series — are connected in parallel with the rack motor group. Each adhesion motor is thus supplied at half the voltage of the rack motors and therefore runs at half the speed, corresponding to the reduced speed on the rack sections. The diameters of the driving wheels and the reduction gear for the rack motors have been so chosen that the adhesion and rack motors take about the same current when connected in this way.

Bridge connections are used when changing from series to parallel connections on either adhesion or rack sections.

When *running on to or off rack sections* the fields of all the motors are connected in series and the rotors in parallel. Then, all the fields being of equal strength and the terminal pressure on the rotors the same, the various motor sets will all run at the same speed, although at first only the adhesion motors are loaded, the rack motors running empty. It does not follow, however, that the two rack motors, which are connected in series, will develop the same torque. To accomplish this, the middle points of the rotor windings of the four adhesion motors are connected up to the middle points of the windings of the rotors of the two rack motors (equalizing leads). To equalize the speeds of the still unloaded rack

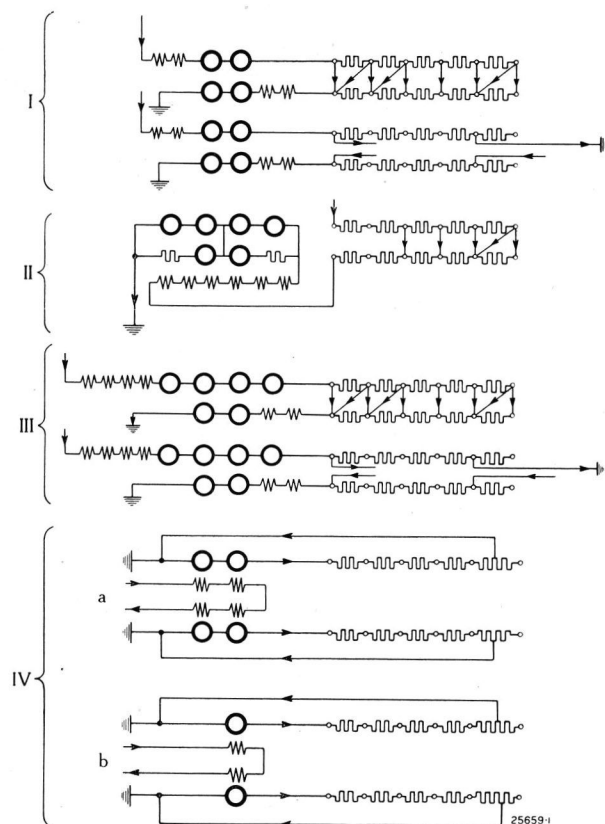


Fig. 10. — Diagram of running connections.

- | | |
|----------------------------------|---------------------------|
| I. Running on adhesion sections. | IVa. Braking on adhesion. |
| II. „ „ to or off rack sections. | IVb. „ „ rack. |
| III. „ „ rack sections. | |

motors and the loaded adhesion motors, a series resistance is connected to the rotor of each rack motor, corresponding approximately to the voltage drop in the rotor. This resistance is also for damping the current rushes which occur when connecting up the rack motors, which are at rest, with the running adhesion motors.

When about to enter on a rack section when travelling either up or down a gradient, the rack motors must always be started up about 30 metres before the rack is reached to give them time to synchronize with the adhesion motors. Synchronism is effected independently of the load on the locomotive or the speed at which it is travelling. When both rack pinions are in engagement with the rack, the controller is moved to the position for running on the rack and the connections changed from series to parallel to increase the speed. The locomotive must not be run off the rack section with the controller in the position

for running on the rack or the motors will accelerate when suddenly relieved of their load and the automatic speed regulator will be brought into action. The locomotive can be run directly on to the rack section from rest when the controller is in the position for running on to the rack.

For braking electrically a resistance of eight ohms is put into the circuit of each motor, on adhesion sections only the adhesion motors being braked and on rack sections only the rack motors. The total electrical braking capacity is 340 kW continuously, i. e., 146 A per braking current circuit. Any other braking effect greater than the 340 kW must be

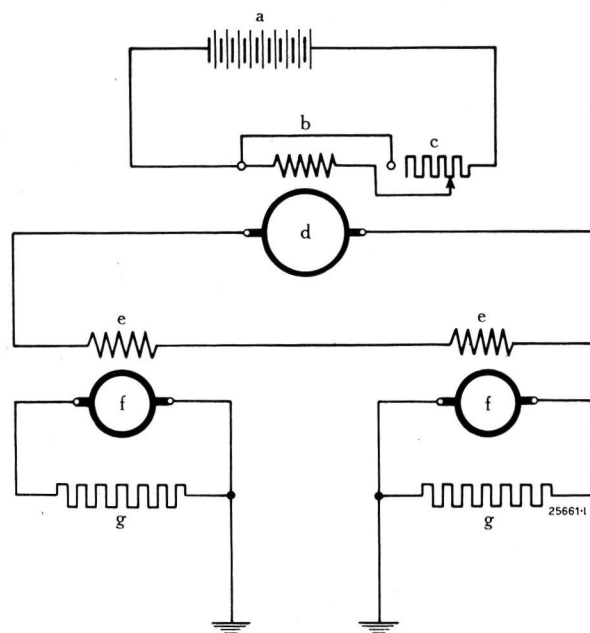


Fig. 11. — Diagram of connections for electrical braking.

- | | |
|-------------------------|------------------------------------|
| a. Accumulator battery. | d. Rotor of exciter. |
| b. Exciter field. | e. Field winding of driving motor. |
| c. Field regulator. | f. Rotor of driving motor. |
| | g. Braking resistance. |

obtained by means of the mechanical brakes. When braking electrically the fields of the motors are separately excited by means of an exciter, which, in turn, is excited from the accumulator battery. A field regulator mounted in the driver's cab is used for regulating this weak exciting current by a large number of steps, and thus the braking force can be regulated up to the heaviest braking current and until the desired speed of the train is reached.

(To be concluded.)

(MS 525)

E. Schroeder. (E. J. B.)

ELECTRIC DRIVE OF ROTARY PRINTING MACHINES AT MESSRS. RINGIER & CO., ZOFINGUE (SWITZERLAND).

Decimal index 621.39 : 655.

INTAGLIO printing is now used very extensively, for one reason because it is a relatively cheap method of printing, and for another because pictures produced by this method, even when printed in large editions, are of a superior quality. In addition to high-quality photo-engravings for illustrated works, at the present time all kinds of illustrated newspapers, and catalogues — often in colour — for large business houses, are printed almost exclusively by the intaglio process. A well-known firm specializing in this kind of printing is that of Messrs. Ringier & Co., Zofingue. This was the first firm in Switzerland to use rotary intaglio printing, which they introduced when they began the publication of the "Schweizer Illustrierte Zeitung". They now have 18 sets of intaglio cylinders for single or multi-colour printing, in addition to several relief printing machines and a large number of flat and multi-colour offset machines. The printing works, where approximately 600 people are employed, is housed in a modern building equipped with the latest transport appliances and affording particularly good working conditions for the employees.

The drives for all the intaglio rotary presses, for which only a.c. commutator motors were used, were supplied by Brown, Boveri & Co., Baden. Expe-

rience had shown that only commutator motors would be suitable for the severe working conditions of these rotary machines and capable of withstanding the strenuous nature of the drives in this plant. The motors are series wound, and their torque can be gradually increased from rest to the required working speed without any shock. The speed can be readily adjusted for all printing speeds. Gradual starting is particularly important for intaglio rotary presses because, should the paper tear frequently, much time would be lost and material wasted. In intaglio rotary presses, the paper is not unrolled by means of a rubber belt, as in newspaper machines, but merely by the tension on the paper itself. The perfectly gradual regulation enables the printing speed to be accurately adjusted to suit the various factors on which the printing process depends, such as the quality of the paper, com-

position of the ink, temperature and moisture of the air, etc. In addition, commutator motors also have the advantage that they can be regulated without loss. This is of very great importance for intaglio rotary machines on which such widely different work is done as the printing of pictures for illustrated papers, colour printing, or the printing of catalogues, calling for a very big range of speeds.

The drives are of the most modern type, with

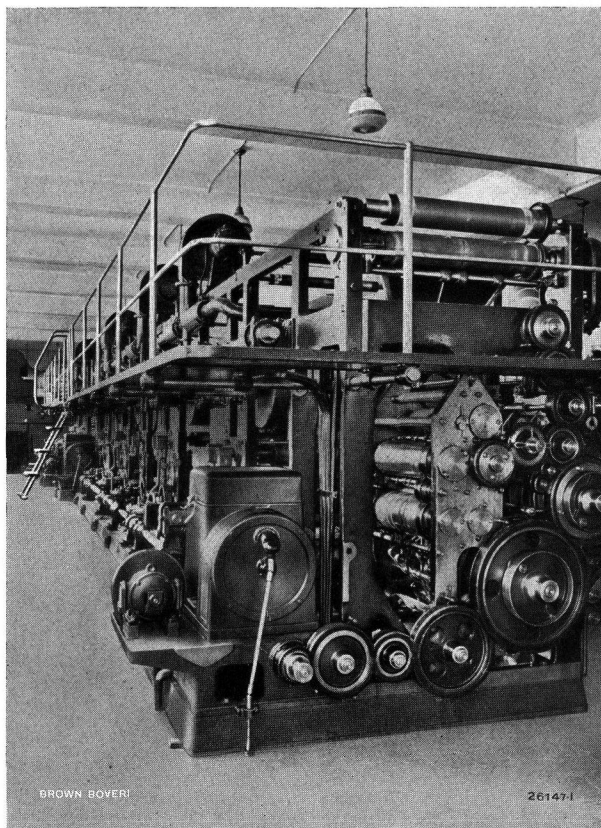


Fig. 1. — Four-colour intaglio double rotary press.

auxiliary motors for introducing the paper, semi or fully-automatic control, and with complete safety appliances for the attendants and the machine. Fig. 1 shows the drive, comprising two three-phase commutator motors and semi-automatic control, for an intaglio double rotary press with five sets of printing cylinders for four-colour printing. The drive for a single rotary press, also by means of three-phase commutator motors, but with fully-automatic push-button control, is illustrated in Fig. 2. The control apparatus for these drives is, in both cases, mounted on a switch-board seen in the background of the pictures.

In addition to the rotary machine drives, Brown, Boveri & Co. have supplied drives, with a.c. commutator motors, for the offset machines in the plant. These drives have also proved very satisfactory. Much the same requirements are placed on the drives for offset machines as on those for the intaglio rotary presses.

Messrs. Ringier & Co. obtain their electricity from the Olten-Aarburg Power Supply Company, but they also have a power station of their own for

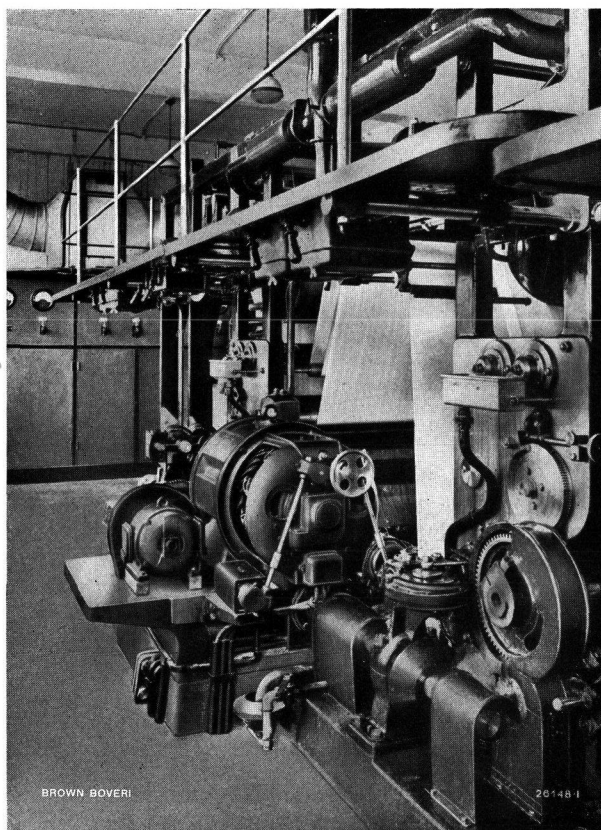


Fig. 2. — Intaglio single rotary press.

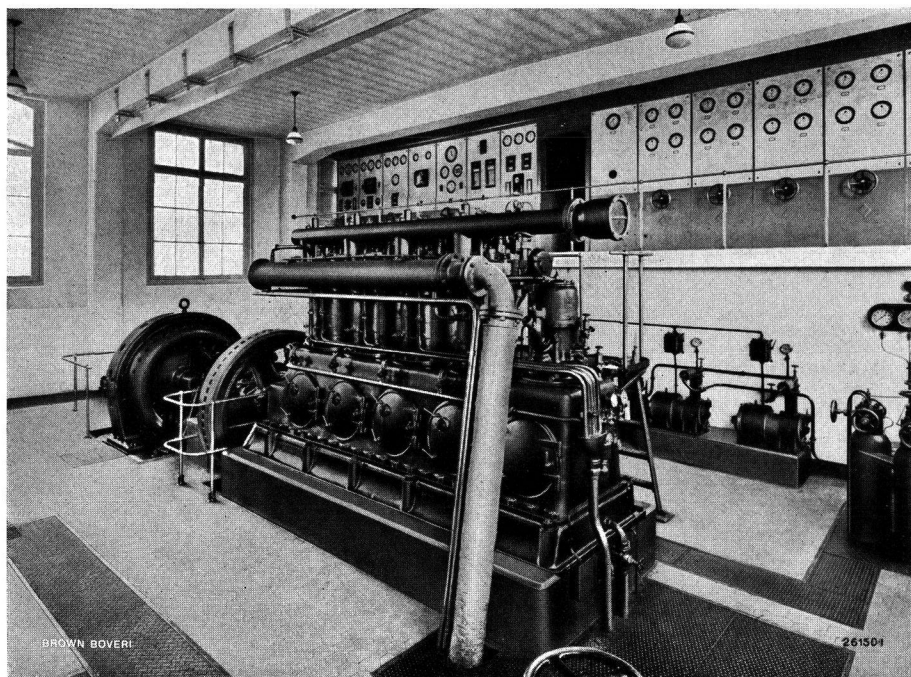


Fig. 3. — Power plant in the printing works of Messrs. Ringier & Co., Zofingen.

Diesel engine direct coupled to three-phase alternator.

equalizing the load peaks, which would have a disturbing effect on the network at morning and evening during the winter. Fig. 3 shows one of the two Diesel engines in the power plant coupled to a Brown Boveri alternator.

The installed horsepower in the printing works is about 1000, and the energy consumed per year about 1,600,000 kWh. The annual consumption of paper is about 4000 tons.

(MS 539)

A. Auer. (E. J. B.)

NEW MOTOR COACHES ON THE MILAN-GALLARATE TRAMWAY.

Decimal index 621.331.34 (45).

THE region served by the Milan-Gallarate Tramway lies to the north of Milan. In the vicinity of this city there are numerous towns and villages from which large numbers of workers travel daily into Milan. The traffic in the morning and evening is thus particularly heavy, whereas during the intermediate hours it is comparatively light. At the other end of the route remote from Milan the tramway passes through Legnano, Busto-Arsizio, Castellanza and Gallarate—industrial towns of some importance with numerous works and factories, particularly cotton mills. The passenger traffic is now very brisk, a marked increase having occurred after the rolling stock described in the following pages was put into commission, as it was then possible to increase both the number and speed of the trains. The works in the district also make use of the tramway for conveying their products to Milan; there is thus a fair amount of goods traffic to be catered for.

The line is 40 kilometres long and passes through level country with a slight general rise of 0.3 to 0.5 ‰; at a few crossings, short gradients of about 3 ‰ are encountered. For the greater part of the way the track is laid along the main roads, above the level of which it is slightly raised, and for a few short sections on its own groundwork.

In 1914 the line was electrified with direct current at a pressure of 750 V. A description of the electrical equipment supplied by the Tecnomasio Italiano Brown Boveri for the two substations, of the six two-axle locomotives, and of the five four-axle motor coaches

was published in the Revue BBC, 1917, No. 5, page 109. All the plant and rolling stock proved to be perfectly satisfactory, and were well able to meet the demands of the greatly increased traffic after the War. It must be pointed out that soon after the locomotives and motor coaches had been put into service much heavier trains than originally intended had to be hauled. For example, in the article already referred to the average and maximum weights of the passenger trains were given as 34 and 41 tons respectively; at the present time the weight of a normal train is about 50 tons and of heavy trains 70 tons or more. To supply sufficient power to run such trains it is obviously necessary to keep all the plant in the substations in continuous operation. In view of the increase in the traffic, the distance which the motor coaches were scheduled to run per day had to be raised to 300 km. For tramway vehicles with a mean travelling speed of only 20 km/h this is a very high figure.

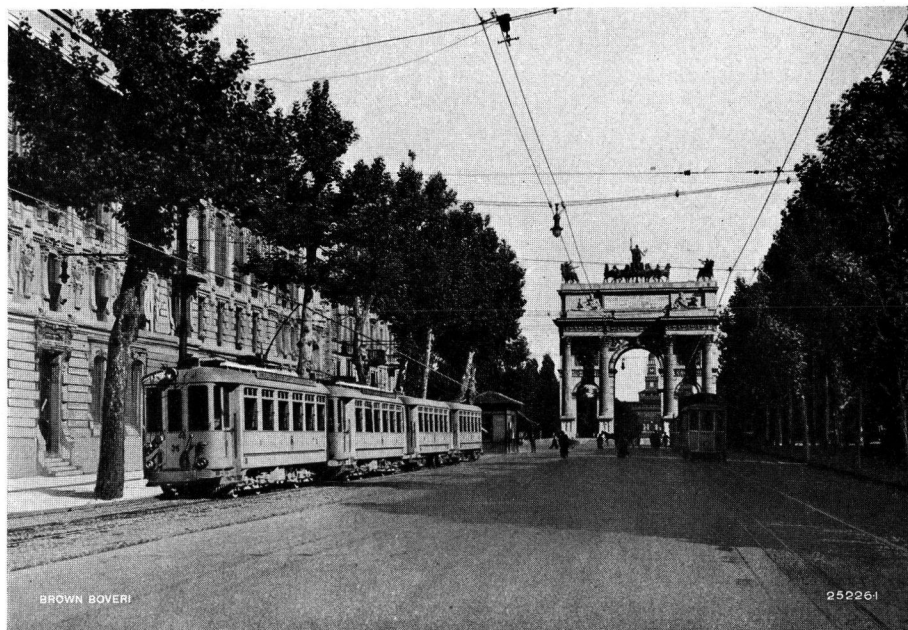


Fig. 1. — Train at the Milan terminus.

The train consists of two motor coaches and two trailers. When traffic is heavy, up to six vehicles are combined into one train.

Due to the increased traffic it was hardly possible to carry out the necessary periodic inspections, and therefore, in 1923, the tramway company decided to purchase two new motor coaches. Very satisfactory service was obtained with these vehicles, and as a result three more were ordered in 1926. The Tecnomasio Italiano Brown Boveri supplied all five motor coaches (Fig. 1).

As already mentioned, the traffic between Milan and the neighbouring towns is very heavy during certain hours. It was therefore decided to double the size of the morning trains coming from the north end of the line when they arrived at stations near Milan and then, in the evening, to reduce the down trains at about the middle of the journey. The five new motor coaches have accordingly been fitted out for multiple-unit control. Besides introducing a reduction in the number of men required to run the trains, this system of control enables the rolling stock to be much better employed and motor coaches of comparatively low power to be used.

The motor coaches are all fitted with two motors, type GTM 32, each having a one-hour rating of 60 H.P. at 750 V and 660 r. p. m., and similar to those used in the locomotives supplied fifteen years ago. This is certainly excellent testimony to the superior qualities of Brown Boveri tramway motors. Both motors are mounted in the same bogie. The second, non-driving bogie is, however, of exactly similar design to the motor bogie.

The control apparatus specially developed for these motors is very simple in spite of the fact that it is designed for automatic acceleration as well as for multiple-unit control. The arrangement of the principal pieces of apparatus and the direction in which the current passes will be seen from the diagram in Fig. 2.

The current passes from the current collector 1 through the usual lightning arrestor 2 and a Brown Boveri automatic switch 3, with adjustable over-current release and hand-operation from the driver's cab, to a coupling 4 and a switch 5 with remote electric-control. From here it is led through a fuse 6 to the reversing drum 7 in the driver's cab and

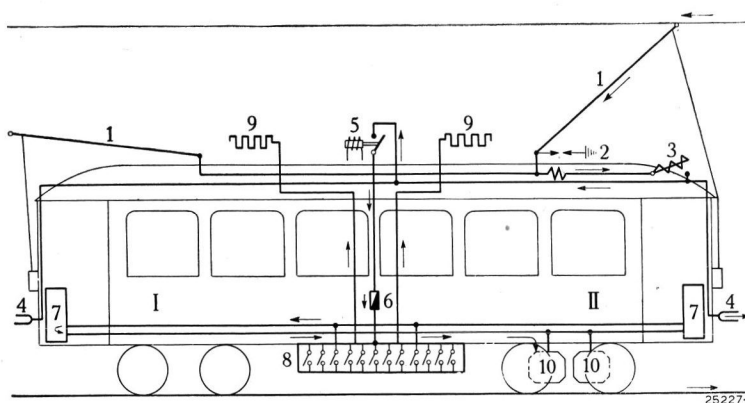


Fig. 2. — Diagrammatic arrangement of the principal apparatus of a motor coach.

- | | |
|---|--------------------------|
| 1. Current collector. | 6. Fusible cut-outs. |
| 2. Lightning arrestor. | 7. Reversing drum. |
| 3. Switch with over-current release and hand control. | 8. Main controller. |
| 4. Coupling sockets. | 9. Starting resistances. |
| 5. Remote-controlled switch. | 10. Motors. |

to the main controller 8 mounted beneath the coach; then to the starting resistances 9 and the motors 10.

Current collectors of the trolley type are used on this tramway. For this reason the current cannot be taken directly from the contact wire for every



Fig. 3. — Driver's cab with master controller and reversing drum combined.



Fig. 4. — Arrangement of the main controller underneath the coach.

motor coach, as is the usual practice where multiple-unit control is employed; special couplings are therefore provided so that all the motor coaches can be supplied from the current collector of the first motor coach. If the trolley current collectors on all the motor coaches were used, one of them could very easily leave the contact wire without the driver becoming aware of the fact, and cause considerable damage. With the arrangement adopted, if the first and only current collector leaves the wire, the current supply to the whole train is cut off.

The remote-controlled switches on the roofs of the coaches work in combination with each other. They are not used for tripping out excess currents, but for opening or closing the motor circuits in the individual coaches. All the switches in a train consisting of several motor coaches are operated from the master controller in the leading coach. By means of a system of interlocking contacts on the main controllers and reversing drums, they can be closed only when the controllers are at zero and all the reversing drums are in the correct positions. By means of a push button with opening contact in the circuit of the operating solenoid, the switches can also be used for tripping the current in emergencies. The remote-controlled switch is provided with an auxiliary contact for inserting additional resistances. When the switch is open, the auxiliary contact short-circuits the resistances in series with the operating solenoid so that when the control-current circuit is closed the armature of the switch is powerfully attracted. When

the switch is once closed, very few ampere-turns are required to keep it in this position. Therefore when the closing operation is complete the auxiliary contact opens, and thus the resistances are no longer short-circuited.

The reversing drum, which is designed for hand control as in the usual type of tramway controllers, is combined with the master controller into one apparatus. As already mentioned, such an apparatus is provided in each driver's cab (Fig. 3).

The reversing drum has seven running positions. Six are for travelling forwards or backwards with either or both motors, and the seventh is for use

with multiple-unit control. The foremost reversing drums of all the trailing motor coaches must be moved to this seventh position. False switching operations cannot be made, because, should the reversing drum be moved to an incorrect position, the remote-controlled switch cannot be closed.

With the arrangement employed, a train can be driven in a reverse direction only by means of the two motors in the leading motor coach. This is, however, rarely done, and then only on short sections, due to the inability of the driver to see along the track from the front coach when travelling backwards. The two motors mentioned are therefore quite sufficient. If a train has to be run for any distance in the reverse direction, the driver simply controls the train from the motor coach at the other end.

The Brown Boveri main controller has cam-operated hammer contacts with individual blow-out. The controller is mounted in a horizontal position beneath the floor of the coach. To enable inspections to be made easily and quickly, the coach was built without any supports underneath the controller; thus the accessibility of the controller is not impaired and the protection covers can be readily removed. A view of the open controller with arc shields removed is shown in Fig. 4. There are altogether twelve switch elements, providing four series and three parallel starting positions and enabling the connections to be changed over from series to parallel. They also give two field-weakening positions when the motors are connected in parallel.

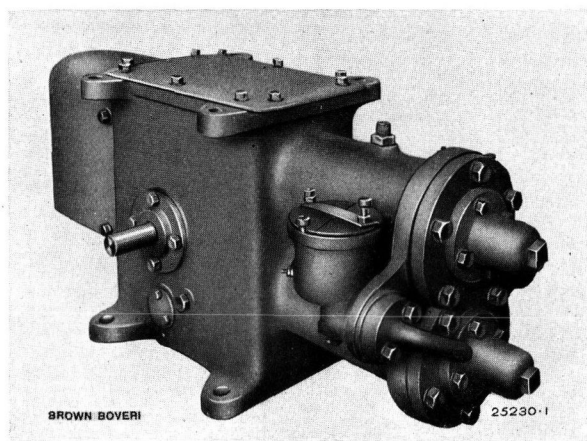


Fig. 5. — Electro-pneumatic control apparatus for main controller.

The controller is automatically operated by a direct-coupled electro-pneumatic control apparatus (Figs. 5 and 6). This consists essentially of two compressed-air cylinders, one of which is used for the gradual rotation of the controller camshaft while the other serves to return the shaft to the zero position. The controller can be moved forwards to any position by the control apparatus. The return movement is, however, always made completely, i. e., the controller always moves right back to the zero position.

The two auxiliary control circuits for operating the main controller are regulated by means of the master controllers already described and which have only a few contacts for low tension (Fig. 3). Interlocking contacts on the master and main controllers prevent false switching operations.

When the master controller is in the switched-out position, the auxiliary circuit is completely broken and the remote-controlled main switch is open. It is only in this position that the reversing drum can be operated or the control levers removed. In all other positions the main switch remains closed and the levers are interlocked.

Under normal conditions, acceleration is automatic and continues until the last series or parallel position with field weakening is reached, according as to whether the driver has turned the master controller on to the series or parallel position. The starting current is adjusted by an acceleration relay

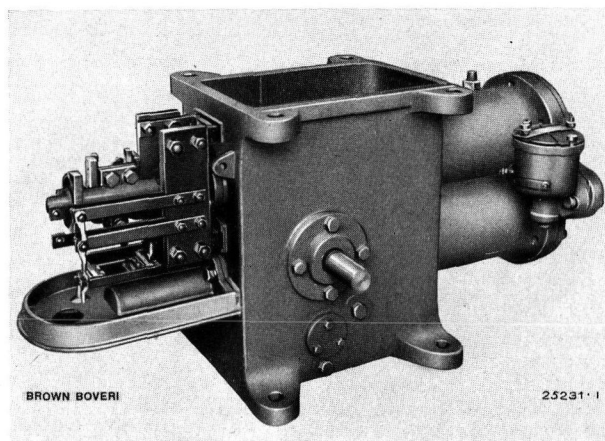


Fig. 6. — Electro-pneumatic control apparatus with cover removed.

so that the main controller can only be moved to the next position when the motor current has fallen to a certain value, thus preventing the load peaks at starting from exceeding a predetermined maximum. If a higher mean draw-bar pull is desired when starting particularly heavy trains, the acceleration relay can be regulated from the master controller to enable a heavier starting current to be supplied. For this purpose an additional winding is provided on the armature of the acceleration relay. As soon as this winding is energized, it produces a field in the opposite direction; the armature thus already falls at heavier motor currents and causes the controller to move to the next position earlier.

The controller also enables non-automatic starting to be used, in which case the controller is moved forward through each step by the driver as with an ordinary controller. The acceleration relay, however, remains in operation to prevent the starting current exceeding the value which would cause the wheels to skid. For non-automatic starting, a neutral and a starting position are provided in the master controller. Immediately after the driver has turned the master controller from the neutral position to the starting position, the main controller is rotated through a further step. When the lever is released it returns automatically to the neutral position and is ready for another movement. In this manner the driver can gradually cut out the resistances and bring the controller to rest in any particular position. Special

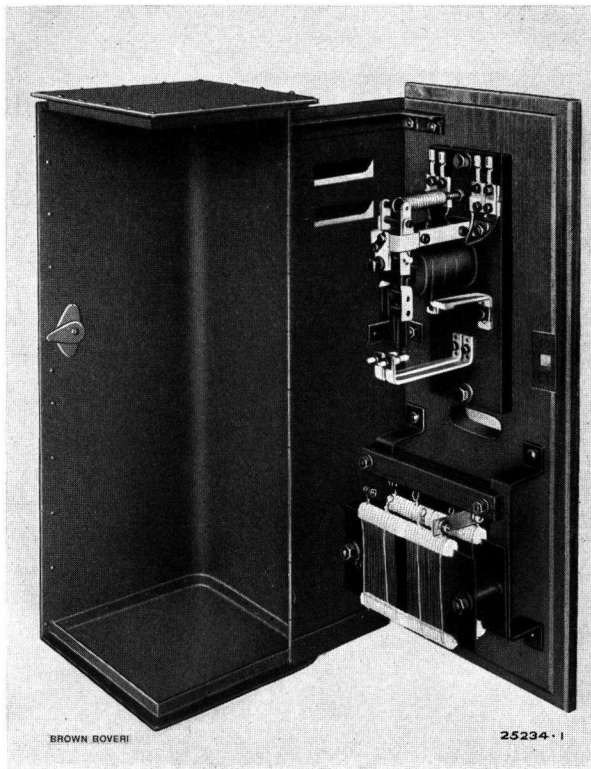


Abb. 7. — Acceleration relay with cover open.

auxiliary contacts prevent the control apparatus remaining in an intermediate position when changing over from series to parallel connections.

When automatic acceleration is being used, the controller can also be brought to rest at any position. As soon as the desired position is reached, the driver must merely turn the handle of the master controller back to the neutral position; the main controller remains in the correct position. A signal lamp provided in the driver's cab remains illuminated as long as there are any resistances in the motor circuits. This is to prevent the driver from running the motors uneconomically for an unintentionally long time, i. e., with resistances in the motor circuit.

The main controller cannot be moved back to the zero position in steps. It turns through the complete angle immediately the driver has moved the control lever over to the zero position. The previously-mentioned remote-controlled switch remains switched in on this position of the master controller; all further movements must be made from this position.

The switching operations described are the same for all motor coaches, independently of whether one is working alone or whether several are combined in one train and controlled together. With automatic acceleration all the motor coaches in a train work independently of each other, and according to the settings of the acceleration relays.

Only seven control wires are required for connecting up the control equipments of the various motor coaches; they are all combined in one cable. The current for the control circuits is obtained from a 24-V accumulator battery, which had to be provided in any case for supplying the headlamps.

A Brown Boveri reciprocating compressor type GC 2 supplies the compressed air for the electro-pneumatic control apparatus. It has a suction volume of 560 litres of air per minute at a motor rating of 6 H. P. and at 750 r. p. m. The delivery pressure is from 5.5 to 6.5 kg/cm² abs. The air for the automatic Westinghouse brake is also obtained from this compressor.

The compressor motor and the lighting and heating equipment are connected directly at the 750-V contact-wire pressure.

The coaches have now been in use for a considerable time, and in spite of the rigorous service to which they have been subjected are proving completely satisfactory. This is conclusively shown by the fact that extraordinarily few spare parts have been required; what replacements have been made were necessitated almost exclusively by normal wear and tear.

The staff accustomed themselves to the new control system very quickly, and the automatic acceleration is particularly favoured by the drivers, as it enables them to give their full attention to looking out for signals, etc.

The bogies were manufactured at the Vado Works of the Tecnomasio Italiano Brown Boveri. They provide excellent springing for the coaches and run very smoothly even at speeds of 50 to 55 km per hour, whether the motor bogie or the non-driving bogie is running first. This unsymmetrical arrangement has proved satisfactory in every respect.

(MS 504)

H. Lutz. (E. J. B.)

NOTES.

Spinning with variable speed in England.

Decimal index 621.39 : 677 (42).

EVEN in England, the home of the spinning industry, the advantages of using variable-speed drives for ring spinning frames are fully realized.

Twenty-one ring spinning frames with variable-speed individual drive by means of Brown Boveri a.-c. commutator motors have now been in service in a large English cotton mill for four years. The motors and the automatic gear are giving complete satisfaction

and have enabled production to be increased, on an average, by 7%, which, in view of the very strict organiza-

tion and supervision in English mills, is an excellent achievement.

Different spinning speeds are easily obtained without the use of a controller and without loss; thus the most suitable speed can be chosen for all counts. Due to the smooth and well-controlled starting there are fewer thread breakages, in spite of higher spinning speeds. By regulating the speed automatically to suit the building up of the cop, the tension on the thread is more uniform and the output of the machine appreciably increased.

Nearly 9000

drives of this kind are in satisfactory service all over the world. (MS 537)

W. Foster. (E. J. B.)

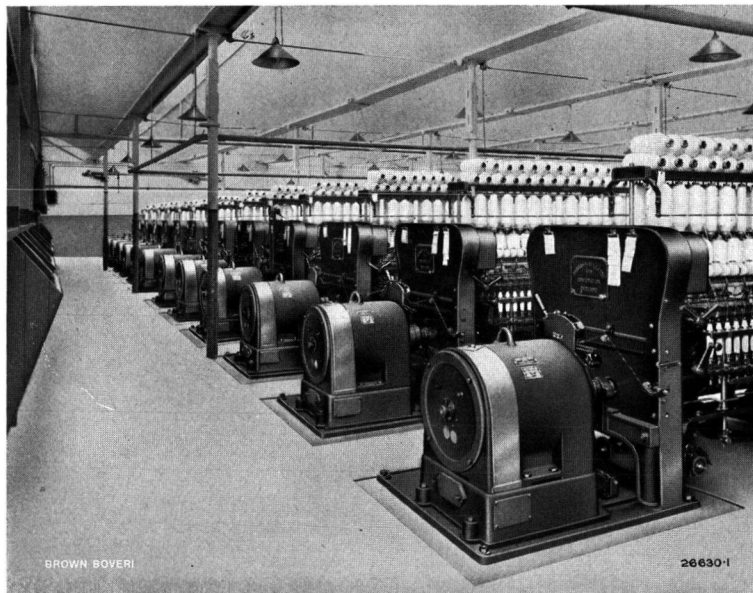
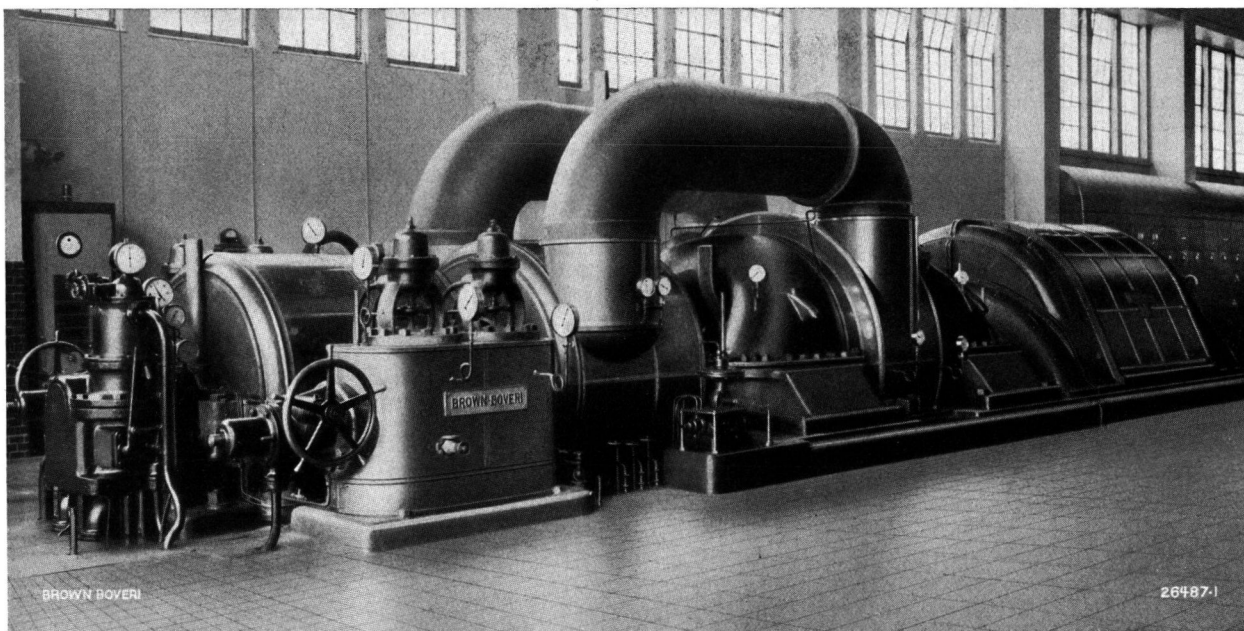
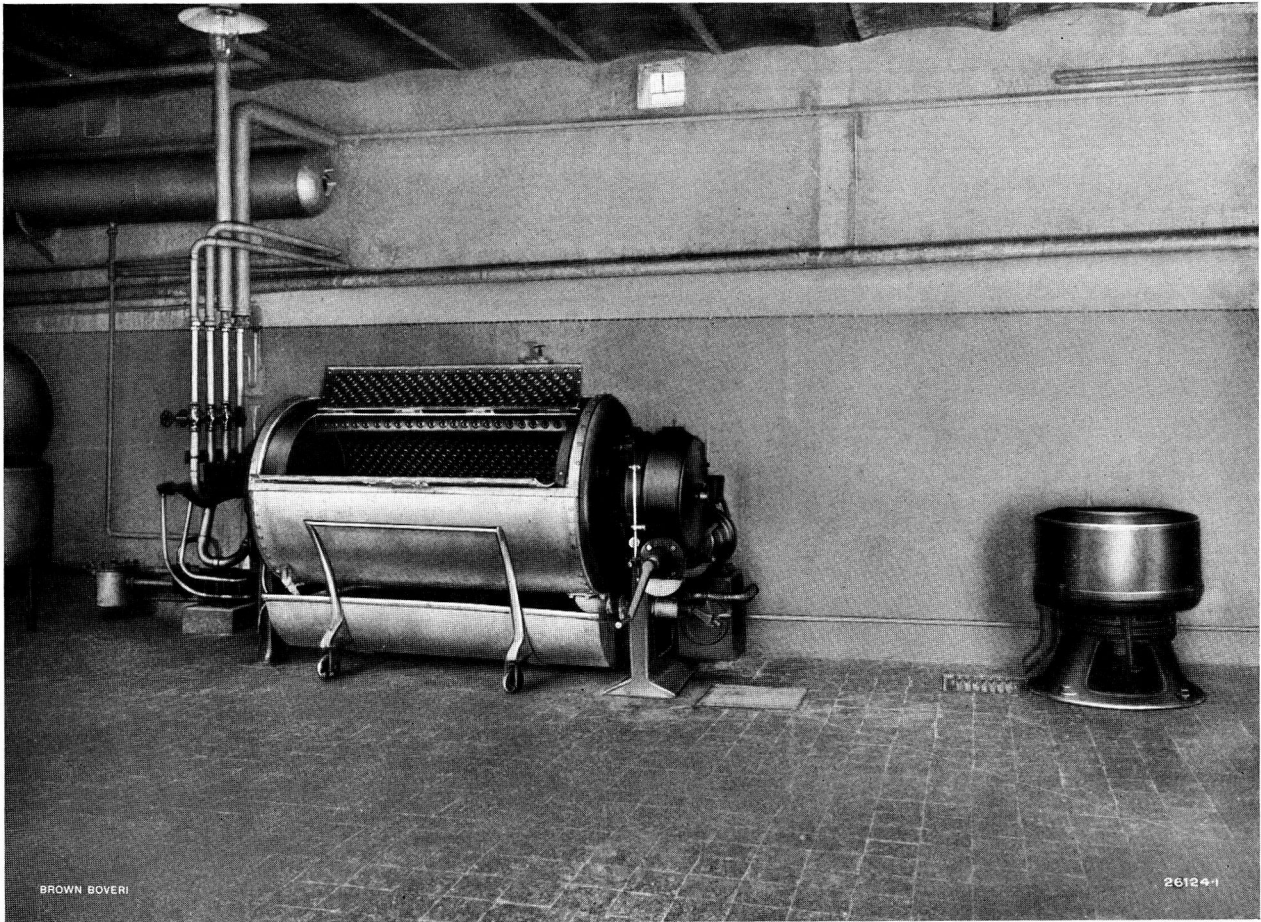


Fig. 1. — Variable-speed drive of ring spinning frames in an English cotton mill.



Mannheim Super Power Station. Three-cylinder turbo-alternator set, 20,000 kW, 3000 r. p. m., 18 kg/cm² abs, 350° C, 25,000 kVA, 5250 V, 50 cycles.

ELECTRIC DRIVES IN LAUNDRIES



TUBERCULOSIS HOSPITAL, HEILIGENSCHWENDI, CANTON BERNE.

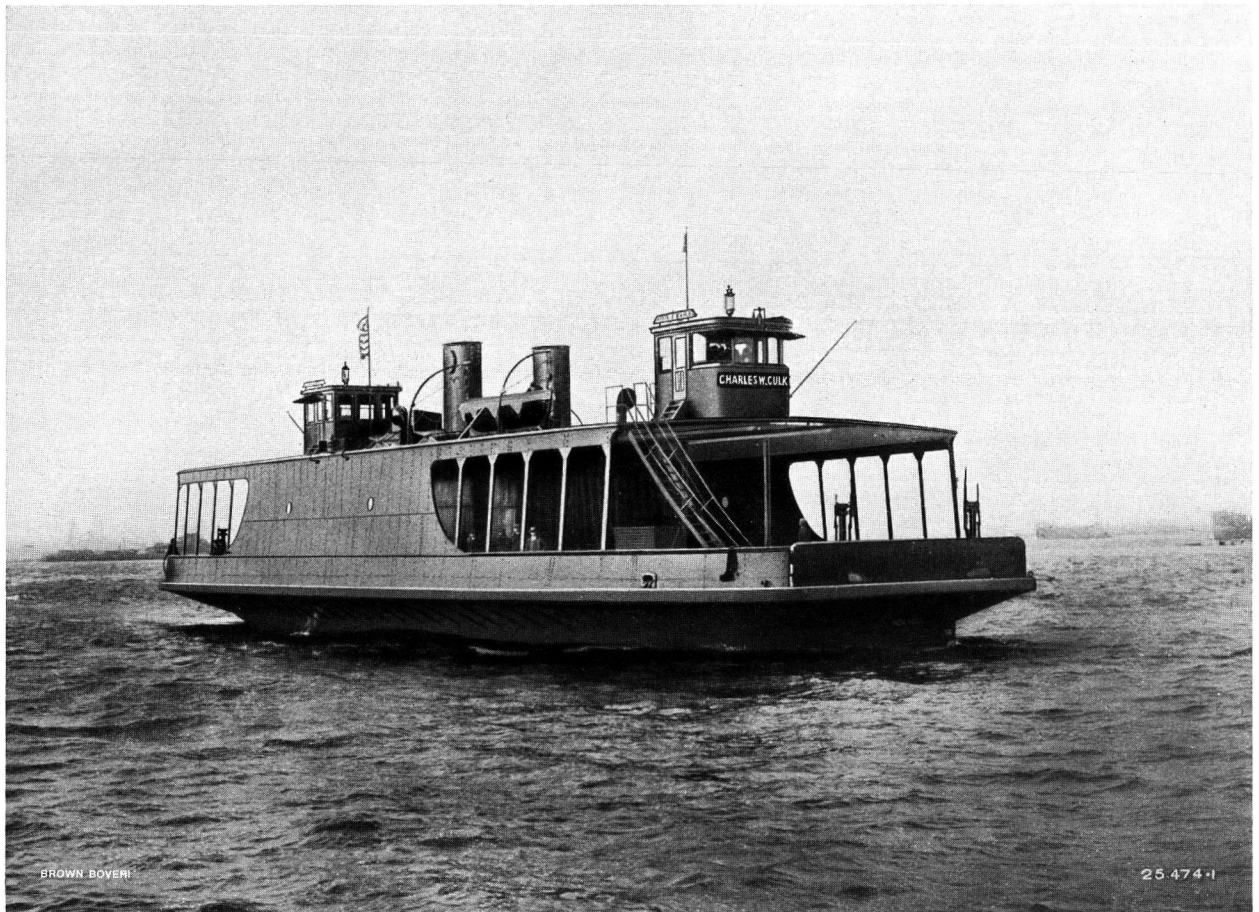
Washing machine, made by Messrs. Ad. Schulthess & Co., Zürich, with Brown Boveri automatic reversing drive, and washing centrifugal, by the same firm, built on to a Brown Boveri vertical-shaft motor. On the left, near the washing machine, a Brown Boveri Sulzer lye pump.

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FOR
HOUSEHOLDS, HOTELS, HOSPITALS
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(6 ferryboats of this type have been built by the American Brown Boveri Electric Corporation, Camden, for service in New York Harbour.)

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