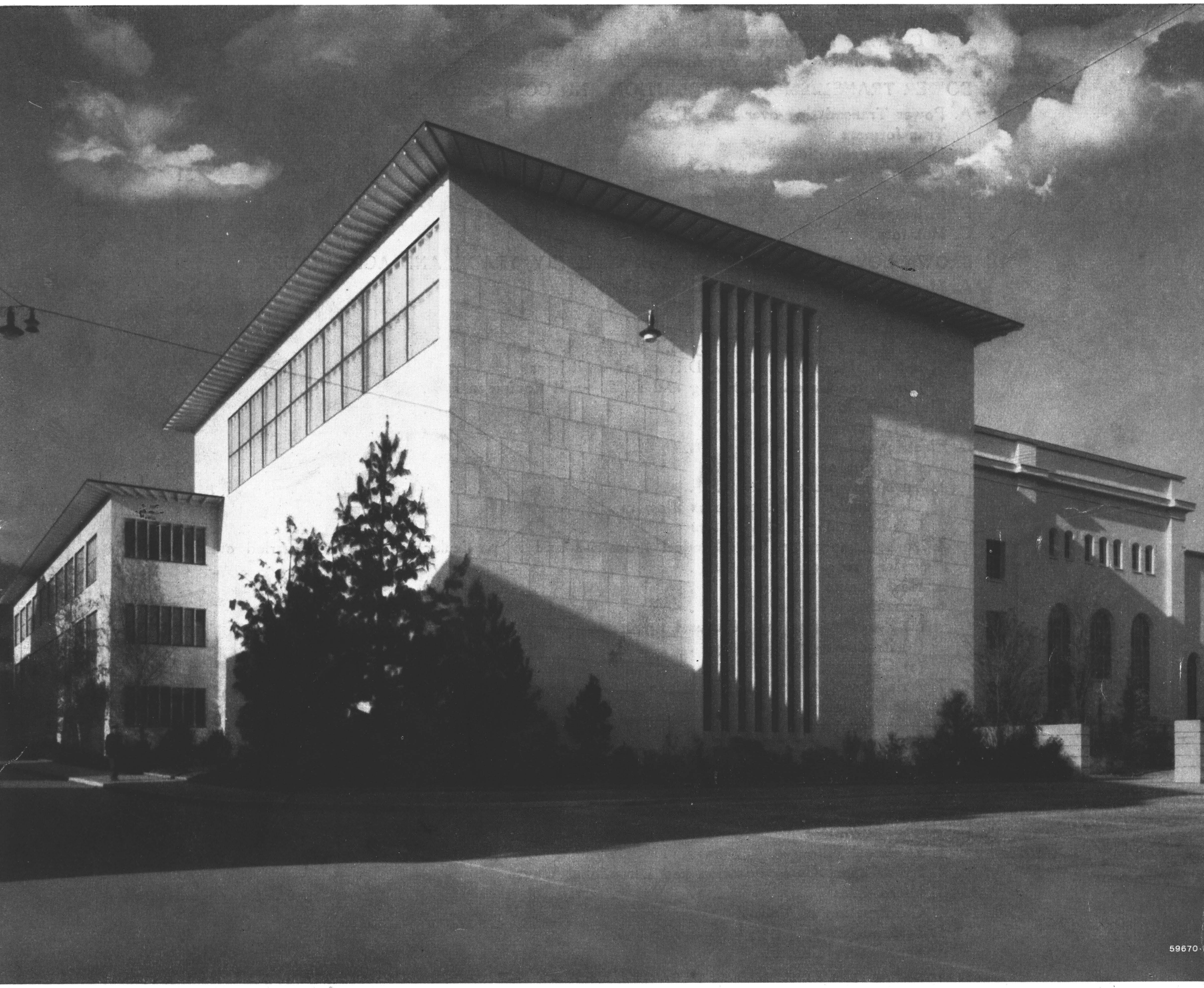
THE BROWN BOVERI REVIEW



The new Brown Boveri high-voltage laboratory

Progress and Work in 1943

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IV. TRACTION.

A. ELECTRIC TRACTION AND TRAIN LIGHTING.

As in the preceding year activity in this field was practically exclusively confined to Switzerland due to the conditions imposed by the war. Within the limits set by the restricted supplies of raw materials, however, electric traction appears to hold out varied and interesting prospects for the next few years. This applies especially to private railways and more particularly to those which are still steam-operated and which electric traction would go a long way to putting on a sounder financial basis. There are also the railways of the same class, however, which have been operated electrically for a long time past, and the rolling stock of which needs modernizing. The scheme outlined above, which is of great financial and economic importance, has been rendered possible by the so-termed Private Railway Assistance Bill, and is being carried out as a work promotion measure with the backing of the Confederation.

In the case of the Swiss Federal Railways where the electrification of the Winterthur-Neuhausen (27·7 km) and Wil-Wattwil (20 km) routes, completed during the past year, has brought the total of the electrified lines up to 2331·871 km, or to exactly 80 % of the entire railway system, traffic on the remaining steam-operated sections, although only comparatively slight, proves so costly with the prevailing coal prices and, what is more, so uncertain in view of the present precarious coal supplies that the Federal Railways are determined to electrify practically all of these remaining sections, immaterial of the density of the traffic which hitherto was the sole criterion for the electrification of a line.

About ten years ago Brown Boveri initiated the era of lightweight designs in the electric traction field with the now familiar "Red Arrow" class of lightweight motor-coach Re $^{2}/_{4}$, series 201, of which seven exist altogether. In the interim development work has been systematically pushed forward in this direction and all components of electric traction equipment considerally reduced in weight. This was effected entirely on the basis of the new knowledge and progress made in dimensioning practice and not by increasing the stressing of the active material, which is moreover limited by the temperature rise specifications. A number of examples will serve to illustrate the progress realized.

For seventeen years shunting locomotives series Ee 3/3 of the same external appearance and general arrangement were supplied to the Swiss Federal Railways. A repeat order for fourteen similar locomotives bearing the serial numbers 16,381 — 16,394 afforded an opportunity of modernizing the electrical equipment. As a result the one-hour rating has been raised by 20 % to 708 H. P., the maximum speed by 25 % to 50 km/h, and the weight reduced from 46 to 41 t; the latter figure includes 3 t of ballast to increase the adhesion properties and to enable the tractive effort corresponding to the increased power to be utilized. The greater proportion of the reduction in overall weight achieved goes to the account of the traction motor, the weight of the entirely new design of which has been reduced to 3700 from 6900 kg, i. e., by nearly 47 %.

It was chiefly in the case of transformers for single-phase traction vehicles, which on account of the low frequency have the greatest specific weight of all of the components of the electrical equipment, that a reduction in weight had to be aimed at in the very first place. By introducing radially-laminated cores, together with a new winding arrangement, it has proved possible to reduce the dimensions and weights of such transformers by 30 — 35 %. Apart from these very desirable advantages which greatly faciliate the development of lightweight locomotives and motor-coaches for single-phase systems the saving in design material, i. e., laminations, copper, and oil, achieved in this manner is particularly welcome under present conditions; in

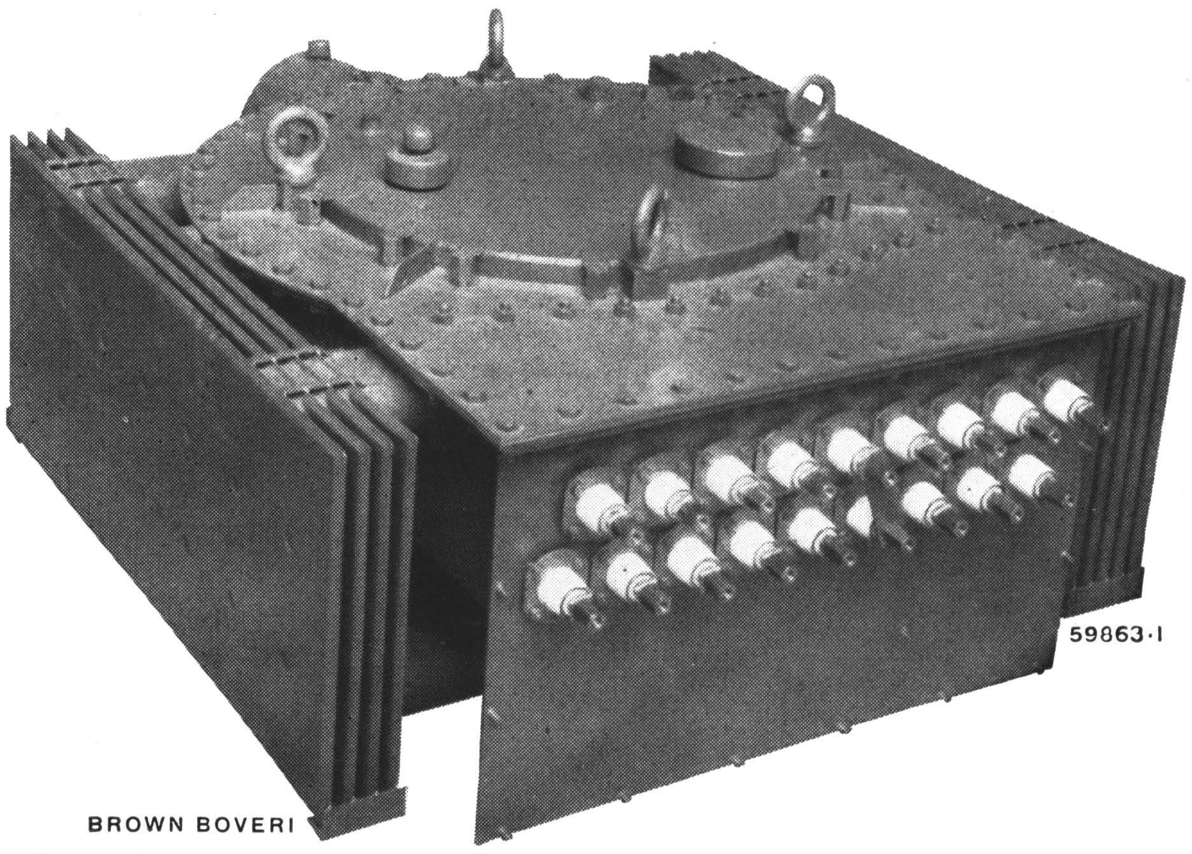

Fig. 138. — Single-phase oil-immersed traction transformer rated 410 (+ 72) kVA, 8000/110 — 624 (230)/110 V, 16 ⅔ cycles, for a motor-coach on the Martigny-Orsières Railway.

Since the transformer was required for lodging under the floor of the coach a particularly lightweight, low model with radially-laminated core was selected.

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Fig. 139. — Motor-coach train on the Chemins de fer fribourgeois (Gruyère).

This railway has a gauge of 1 m and gradients up to 31·5 in 1000. Several new motor-coaches and control cars with Brown Boveri electrical equipment for 850—1100 V d. c. operate over the line. The motor-coaches are equipped with four motors having a one-hour rating of 100 kW each at 36·5 km/h and Brown Boveri spring drive. They attain a maximum speed of 75 km/h. The control gear provided for series-parallel connection and short-circuit braking is characterized by a particularly low weight and permits of multiple-unit or remote control of the motor-coach and control car from the end of the train, as required.

the case of oil only 50 % of the earlier quantity is now required. The new traction transformers are of circular form. As a result lighter supports can be employed and the transformers fitted in or under the vehicle in a much simpler manner. Together with the high-voltage control gear, introduced by Brown Boveri for single-phase traction applications and which is incorporated in, and forms an integral part, of the transformer, very light, multi-step equipments are obtained. Fig. 138 shows such a transformer of the latest type with a continuous rating of 400 kVA according to R. E. B. rules.

Air-blast high-speed circuit-breakers were provided on the Ae 4/6 locomotives of the Swiss Federal Railways series 10,801 for the first time, in lieu of the hitherto conventional round-tank oil-circuit breakers. Experience has been excellent. In particular, it proved possible to discard the blocking device provided to protect oil circuit-breakers in the event of short circuits on the primary side of the locomotive. Nevertheless, the first locomotive-type air-blast high-speed circuit-breaker was still rather bulky. This drawback has now been overcome by a new design with considerably smaller dimensions. Apart from this the simple roof cut-out, arranged within an earthed frame, suffices as primary over-current protection in many cases, even where relatively large vehicles are concerned.

All of these new design features are being incorporated for the first time in two Bo-Bo locomotives, series 251, for which the contract was received, in conjunction with the Swiss Locomotive and Machine Works, Winterthur, from the Berner Alpenbahn Gesellschaft Bern-Lötschberg-Simplon, during the past year. The locomotives in question have four driving, but no pony axles. The total weight of the axles, $4 \times 20 =$ 80 t, is employed entirely to develop the tractive effort.

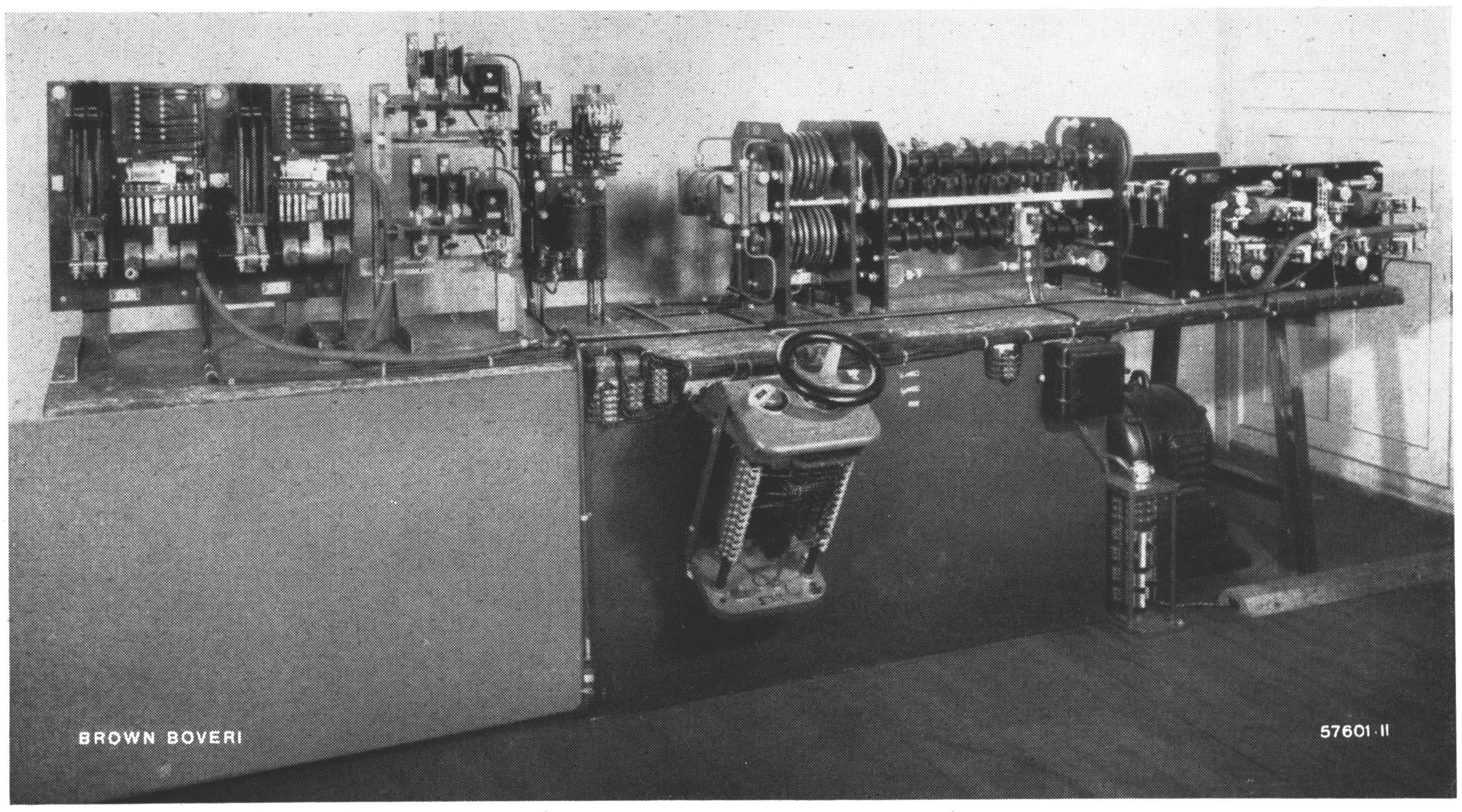


Fig. 140. — Multiple-unit control gear for the Chemins de fer fribourgeois (Gruyère) in the test bay at Baden.

Control current 36 V d.c. This control gear for four traction motors each with a one-hour rating of 100 kW, is designed for 850 V (maximum 1100 V) d.c.

These locomotives with their 4000 H. P. total one-hour rating (at 75 km/h), maximum running speed of 125 km/h, and stable running properties both on straight stretches and in curves, are to be built as bogie engines for reduced wear and maintenance and will incorporate many an outstanding advance.

For the control of a.c. lightweight motor-coaches only requiring a limited number of notches a cam-operated controller actuated by a d. c. servo motor (36—72 volts) has no superior on the score of simplicity, maintenance, and weight alike. Separate arcing switches are provided to take the switching arc so that the individual switch units function without sparking. No blow-out coils are therefore needed, while the interlocking contacts of contactor control gears which never operate absolute reliably, are also dispensed with.

Progress was also made in the development of control gear for *direct-current motor-coaches,* where the trend is likewise towards lightweight designs. During the period under review three metre-gauge motor-coaches (Fig. 139) and four control cars for a maximum running speed of 75 km/h were supplied to the *Chemins de fer fribourgeois* (*Gruyère*) which are operated with 800—1100 V d.c. The mechanical part was manufactured by the Swiss Car & Elevator Corp., Schlieren. The electrical equipment supplied by Brown Boveri comprises four motors with a one-hour rating of 100 kW at 36·5 km/h, driving the wheels through the firm's well-known spring drives, together with very lightweight control gear for series-parallel connection, short-circuit braking, and any desired combination of multiple-unit and remote control of the motor and control cars at the ends of the train. Fig. 140 shows the entire control gear set up for test in the test bay. It is a completely new design of remote and multiple-unit control for power running and electrical resistance braking and permits of automatic starting and braking with a large number of notches and an adjustable maximum current. Moreover, it is characterized by its light weight, low maintenance costs, and small dimensions. Fifteen series, ten parallel, two field reducing, and fifteen braking notches are provided. The control is based on the line switch principle and in the starting and braking zones contact burning is confined to the two line and bridging switches; as a result maintenance should be very slight. Notwithstanding the larger number of starting and braking notches the equipment is much lighter than standard contactor control gear. It is particularly suitable for lightweight motor-coaches of all kinds on city, interurban, and underground railways. Fig. 141 shows the driver's cab of a Gruyère motor-coach.

A platform-type multi-notch controller with twelve series, ten parallel (of which two for field reduction), and twelve braking notches has also been developed for four-motor power cars on interurban railways and tramways (Fig. 142). This is a combined cam-operated controller, with direct-actuated switch-units for a motor

Fig. 141. — View of driver's cab of one of the new motor-coaches for the Chemins de fer fribourgeois (Gruyère).

Note the neat arrangement of the instruments and the unobstructed view all round the cab.

voltage of 650 V, and a control switch with solenoid contacts for the remote control of notch contactors with 24 V. Ease of operation is a noteworthy feature of the controller. The large number of notches makes for smooth starting and braking with best possible utilization of the adhesion weight.

During the year seven further four-axle single-direction lightweight motor-cars of the 401 series with Brown Boveri-Simplex bogies were supplied to the Zurich Tramways. These vehicles, which can well be considered the most modern on the European Continent, have proved eminently satisfactory in service. One of the cars was lent to the Basle Tramways where it operated on different routes for a number of months entirely satisfactorily. This type of tramcar with its high acceleration and deceleration, together with other advantages, is thus suitable for tramways in towns with quite different local conditions.

Four electrical equipments with series-wound motors for large-capacity trolley buses of similar pattern to those at Zurich were supplied to a foreign municipality. The chassis of these vehicles were made by the A.-G. Franz Brozincevic, Wetzikon (Switzerland), while the manufacture of the coachwork and erection of the electrical equipment were carried out in the country in question. Towards the end of the year under review the first of these trolley buses was successfully taken into service. The continual development of the electrical equipment for lightweight vehicles has also involved revision of auxiliary equipment designs to make them satisfy the more exacting requirements. During the year a new *single-phase/direct-current convertor set,* as required in the case of single-phase traction vehicles to generate direct current for the lighting and control circuits, was also evolved. This set is relatively small and of the monobloc type. It comprises a single-phase, 230 V, $16\,^{2}/_{3}$-cycle motor coupled to a d. c. generator continuously rated 1·1 kW at 37—45 V, together with starting and regulating gear to maintain the d. c. voltage constant. In conformity with its small dimensions the new set (Fig. 143) only weighs 135 kg. Starting is effected on the a. c. side and is carried out automatically should the voltage fail and return.

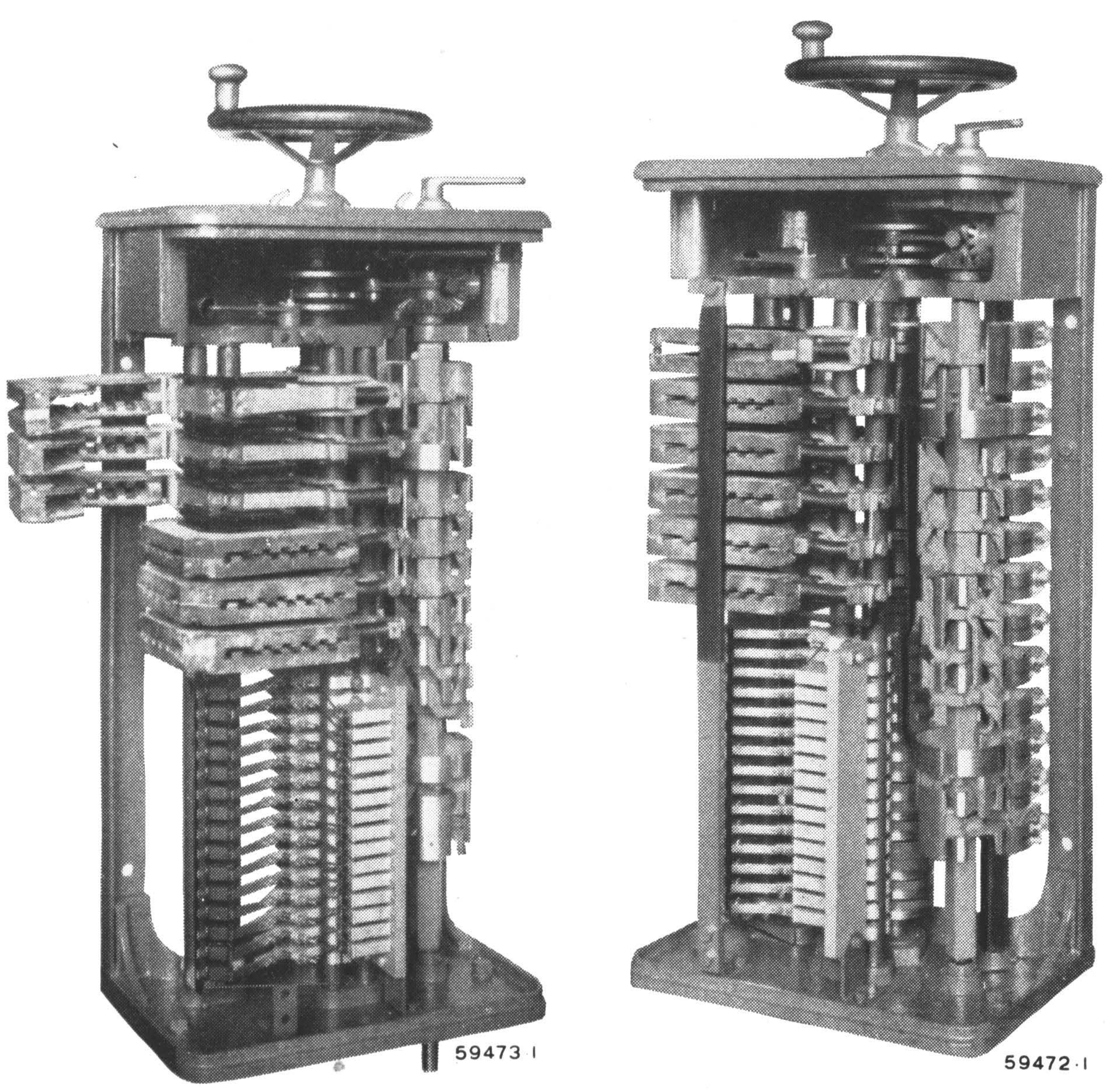


Fig. 142. — Cam-operated controller for the control of four d. c. series-wound motors each with a one-hour rating of 71 kW, 750/2 V, without casing, on right with closed, on left with three opened arc chutes.

The main drum of this new multi-notch platform-type controller has six 750 V cam-operated switch units, which carry the main current, on the top half, and fifteen 24 V control contacts for the control of the step contactors on the lower half. This controller design, combined with a bank of contactors, enables a large number of power and braking notches, i. e., in the present case twenty-two power notches, of which twelve series, eight parallel, and two field-weakening, together with twelve notches for electrical braking, to be lodged in a cam-operated controller of comparatively low height.

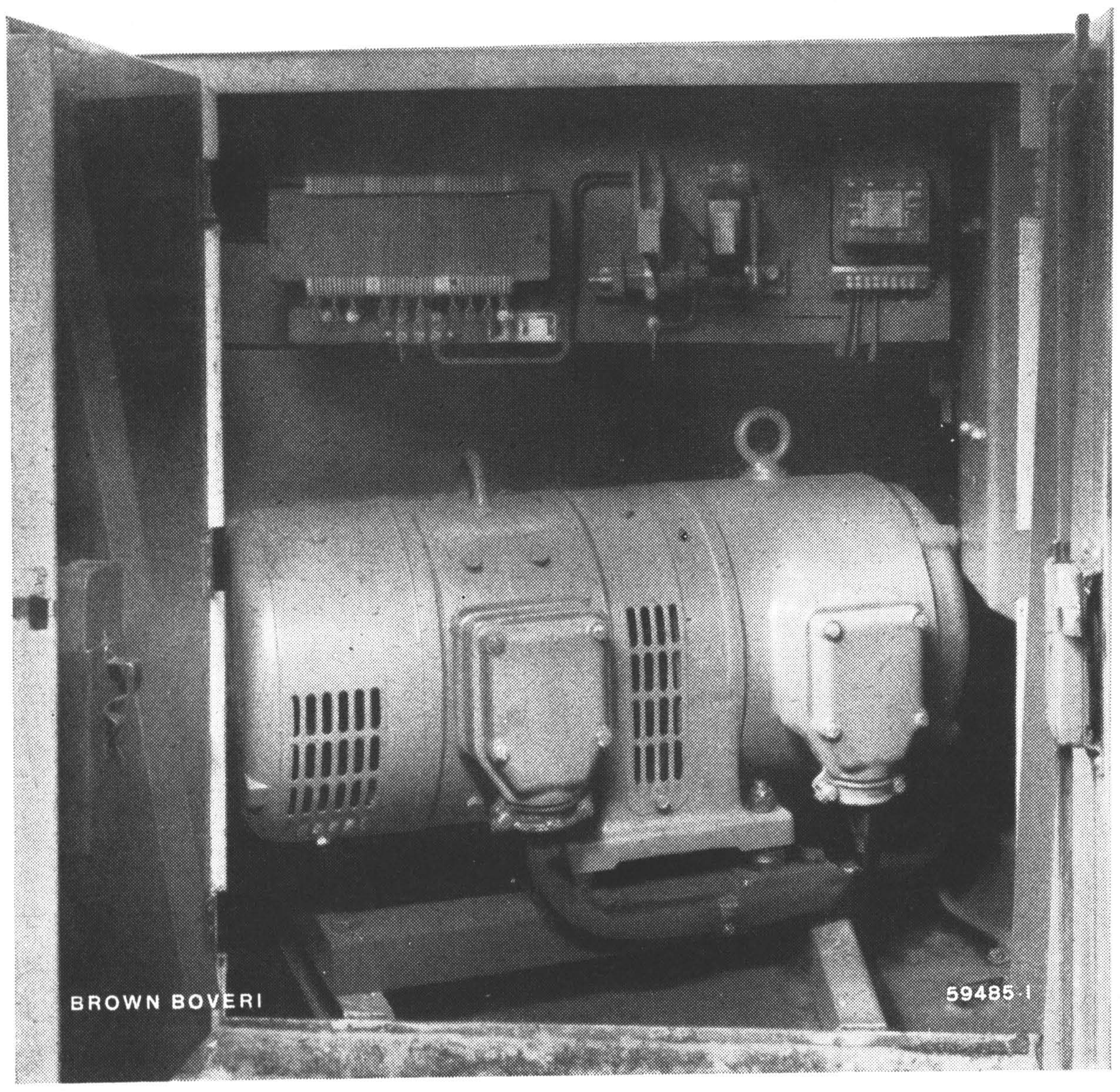


Fig. 143. — Monobloc convertor for lighting and battery charging on the motor-coach for the Swiss South-eastern Railway (S. O. B.)

The whole equipment comprises a single-phase 230 V, 16 2/3-cycle motor coupled to a d. c. 37—45 V generator with a continuous rating of 1·1 kW, together with the starting equipment and train lighting regulator. The new convertor set in the lower part of the ventilated cubicle to the left of the driver's cab is particularly small and light; it weighs only 135 kg. Features of the equipment are starting from the a. c. side, automatic re-starting upon return of supply voltage after failure, and quiet running.

Fig. 144 depicts a single-pole *lighting coupling* for voltages up to 1500 V and currents up to 60 A, devised during the year for connecting the lighting cable between motor and trailing coaches. A feature of the coupling is its very simple and robust design. Positive contact is ensured by the accurate guide between the plug and socket. The coupling is provided with a dust- and rain-proof cover, while the cable is safe-guarded against rupture by means of a special device.

Extensions to the existing Swiss *trolley bus systems* have unfortunately been rendered impossible through

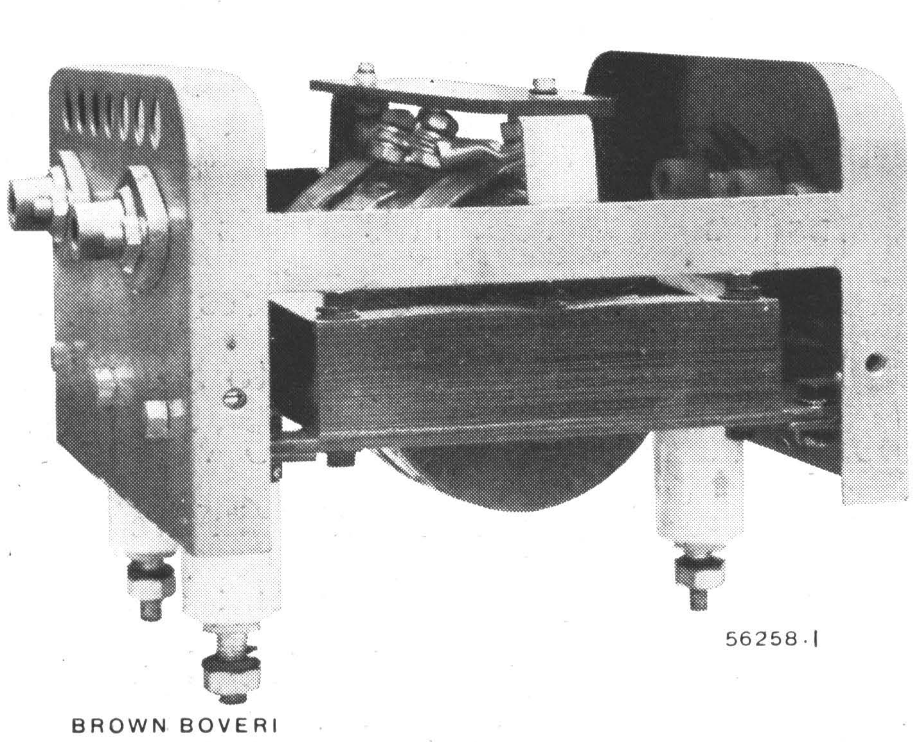


Fig. 145. — Radio interference suppression choke coil for trolley buses.

Service voltage 650 V, one-hour current 150 A, for roof mounting, weight 23 kg, casing removed. These radio interference filters virtually suppress the disturbing influence of high-frequency voltages emanating from switching and commutator sparks on wireless reception.

the tyre shortage, while even where services are already in operation the time-tables have had to be severely restricted to lengthen the life of the tyres. It has therefore only been possible to introduce slight improvements and auxiliary contrivances which have proved necessary from an operating point of view. For instance, a *radio interference suppression filter* for mounting on the roof of trolley buses (Fig. 145) has been devised which virtually suppresses the disturbing influence of high-frequency voltages emanating from switching and commutation sparks on wireless reception. The filter,

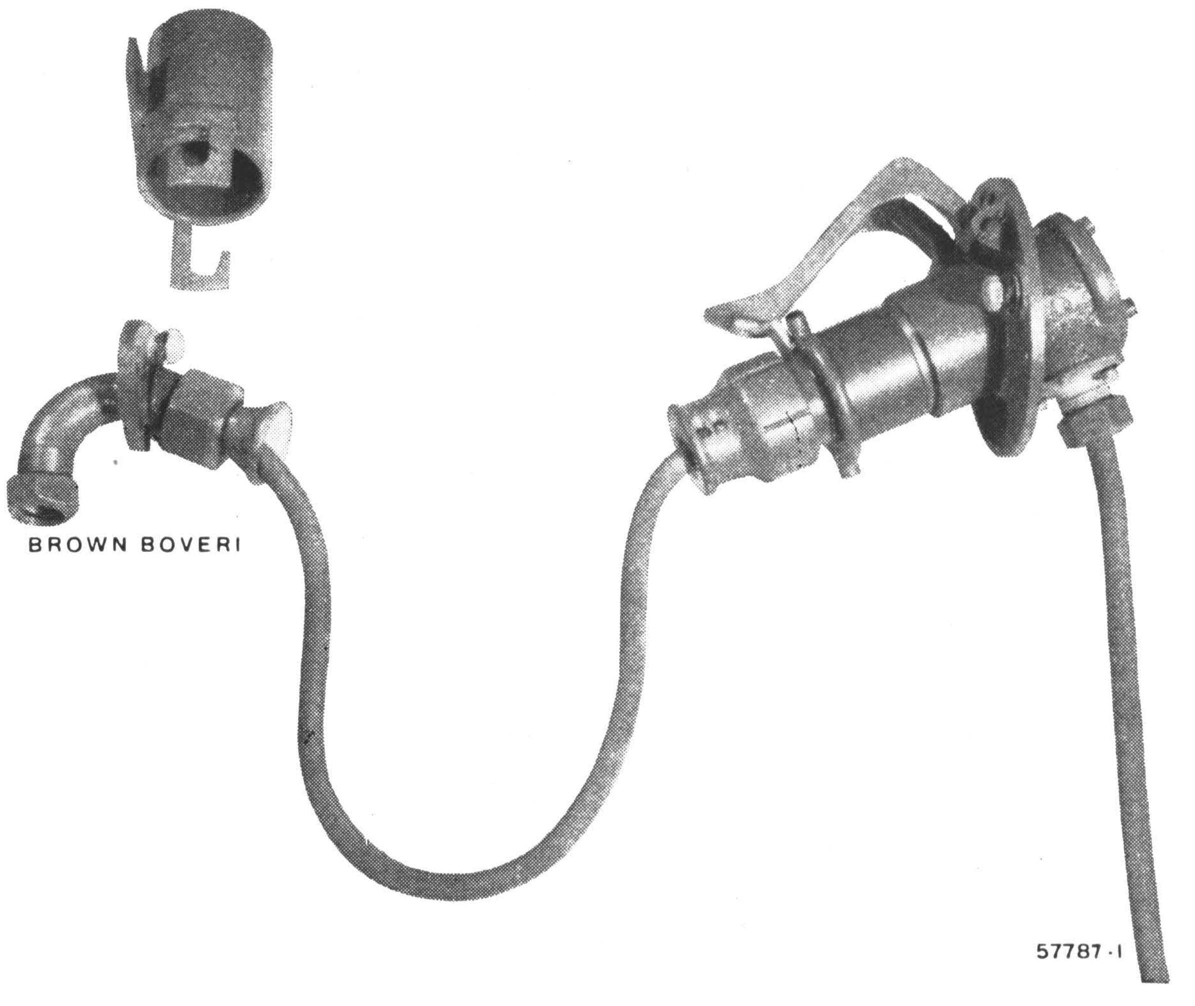


Fig. 144. — Single-pole lighting coupling for voltages up to 1500 V and currents up to 60 A.

A feature of this new coupling is its very simple and robust design. Positive contact is ensured in the control current coupling by the accurate guide between the plug and socket. The individual contacts are sprung to give an ample contact pressure. All couplings have a dust- and rain-proof cover and the cable is protected against rupture by means of a special device.

a combination of choke coils and condensers, is connected between the current collector and lead-in.

Another innovation is *thawing equipment* for *trolley bus contact wires*, where hoar frost and ice are frequently a source of great trouble during the first runs on cold winter mornings. By short-circuiting the wires over adjustable resistances and loading them with a current of 4—5 A/mm^2, they are thawed out and the hoar frost or ice is readily removed by the current collectors of the trolley buses which are simultaneously allowed to run over the route. Fig. 146 shows the equipment neatly arranged in a switch cubicle.

Ever increasing interest is being shown in the *electric trucks* built by the firm with which the driver steers the vehicle and operates the control with exactly the

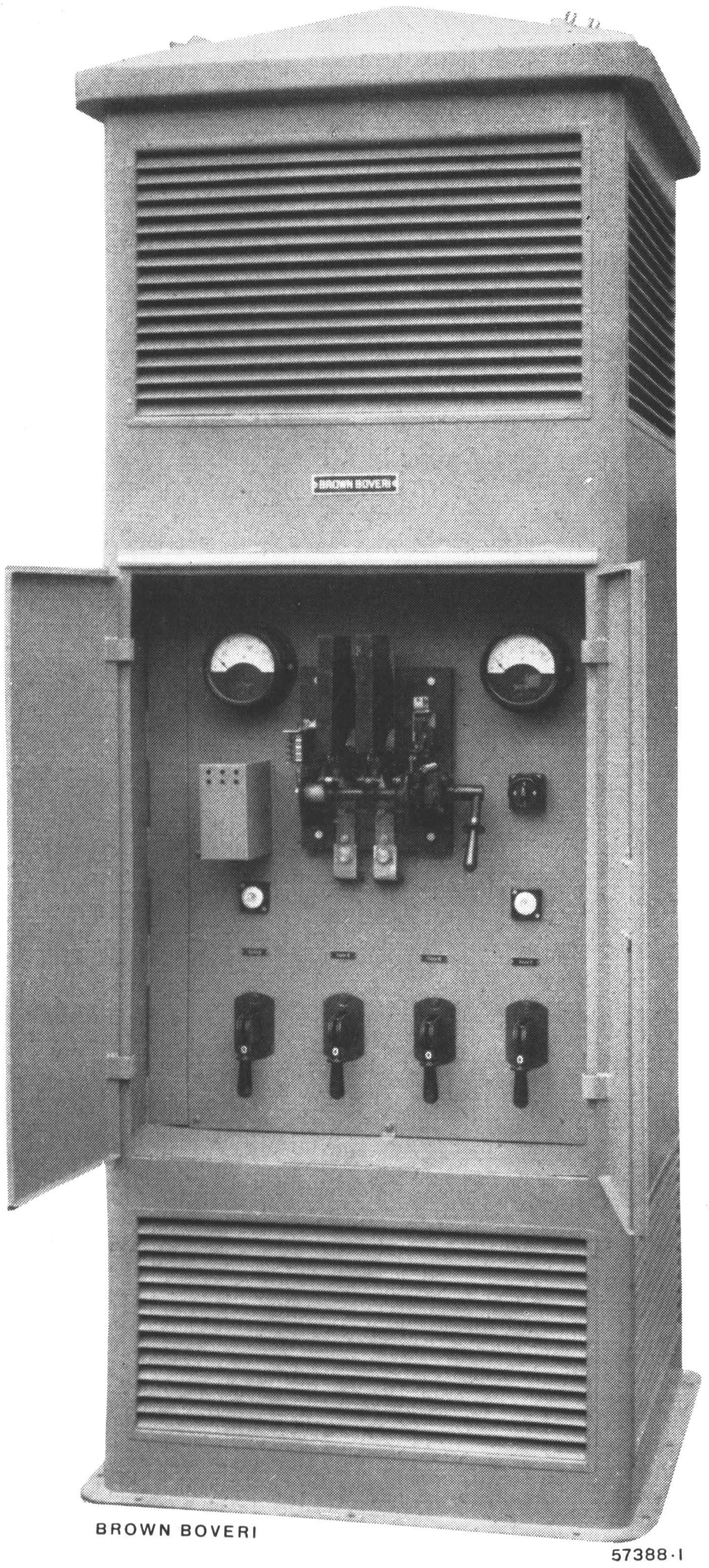


Fig. 146. — Thawing equipment for trolley-bus systems.

This permits the contact wires to be freed of hoar frost and ice which are frequently a source of great trouble during the first runs on cold winter mornings.

same lever and hand movements for both directions of travel. This results in easy and convenient manipulation as well as a high degree of safety in operation. Fig. 147 depicts an electric truck for a net load of 1500 kg which was built during the year. It is equipped with two series-wound motors each with a one-hour rating of 1·9 kW at 10 km/h. The maximum speed is 15 km/h. The practical *three-phase/direct-current charging sets* developed have gone a long way to popularizing our large and small battery-operated vehicles. Fig. 148 illustrates such a set for a charging current of 77—25 A and a charging voltage of 88—104 V with motor for connection to 220, 250, 380, or 500 V as required. After connection of the set to the supply the charging operation is carried out entirely automatically; the same applies to disconnection after the discharge voltage has been attained and the adjustable finishing charging time has elapsed. With this set charging times are short and the life of the battery lengthened. Combined with its control gear the set is also suitable for carrying on the battery-operated vehicle itself, to enable the battery to be re-charged on route, or for erection in garages or workshops.

Considerable progress has also been made in the design of *electric-train lighting equipment parts* on the score of weight, maintenance, and convenience. As proved by the adjacent table this applies in particular to the generator. The type B 36 train lighting

Fig. 147. — Electric trucks with a tare of 1500 kg Two series-wound motors with a one-hour rating of 1·9 kW each give a speed of about 10 km/h (max. 15 km/h).

Brown Boveri electric trucks are becoming more and more popular due to the driver steering the vehicle and operating the control with exactly the same lever and hand movements for both directions of travel. This results in easy and convenient manipulation as well as a high degree of safety in operation.

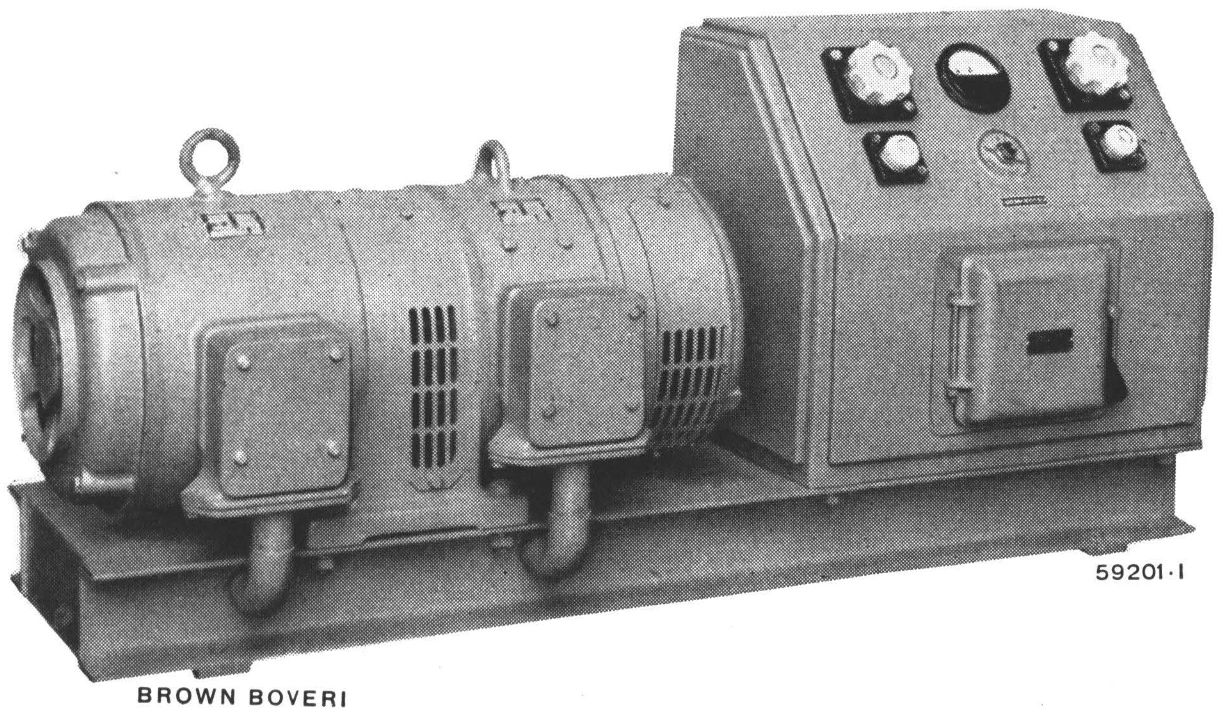


Fig. 148. — A. C.—D. C. charging set particularly suitable for the charging of vehicle batteries.

Charging current 77—25 A, 88—104 V, supply voltage 220—250 V, 50 cycles, or 380 or 500 V by changing over connections at terminals.

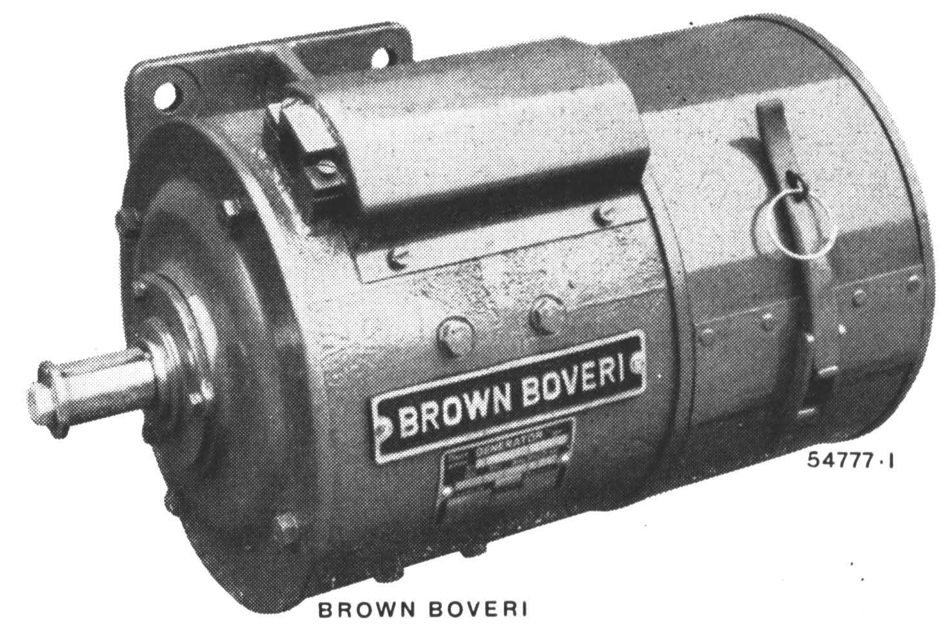


Fig. 149. — Train lighting generator type GZ 94 rated 2·5 kW, 36—45 V, 55 A, 650—2665 r. p. m.

Notwithstanding the increased rating of 22% compared to the earlier model, the weight has been reduced to 93 kg, i. e., by 24 %.

generator belt-driven from one of the axles, which was the most frequently used up to 1931, weighed 200 kg, including the belt driving gear. With the change-over to cardan shaft drive the weight for the 18% more powerful type GZ 104a generator dropped to 122 kg. The recently developed type GZ 94 train lighting generator illustrated in Fig. 149, with its 22% higher rating, weighs only 93 kg. All of the new train lighting sets are designed for the same excitation current, so that given the same voltage the same regulator can invariably be employed.

Year	Model	One-hour current A	Weight kg
1912—31	B 36	45	200 *
1932—41	GZ 104 a	53	122
1942—	GZ 94	55	93
		* including pulley	

The *cardan drive* (Fig. 150) is being exclusively fitted on all new rolling stock in Switzerland. Its advantages are: Absolutely reliable power transmission unaffected by the weather, attendance between normal coach overhauls unnecessary, minimum maintenance costs, simple erection, ready accessibility, freely movable wheel axle, standard wheel sets and axle boxes, and low unsprung weight.

Two recently developed types of regulator can be universally employed for a given lighting voltage: one for a practically constant number of lighted lamps with built-in or separate lighting resistance, the other for a greatly fluctuating number of lighted lamps with constant lamp voltage. The regulators are suitable for all types of batteries (lead, nickel-cadmium, and nickel-iron), various capacities, and the entire new range of train lighting generators. All of the regulators of each type are similar and interchangeable.

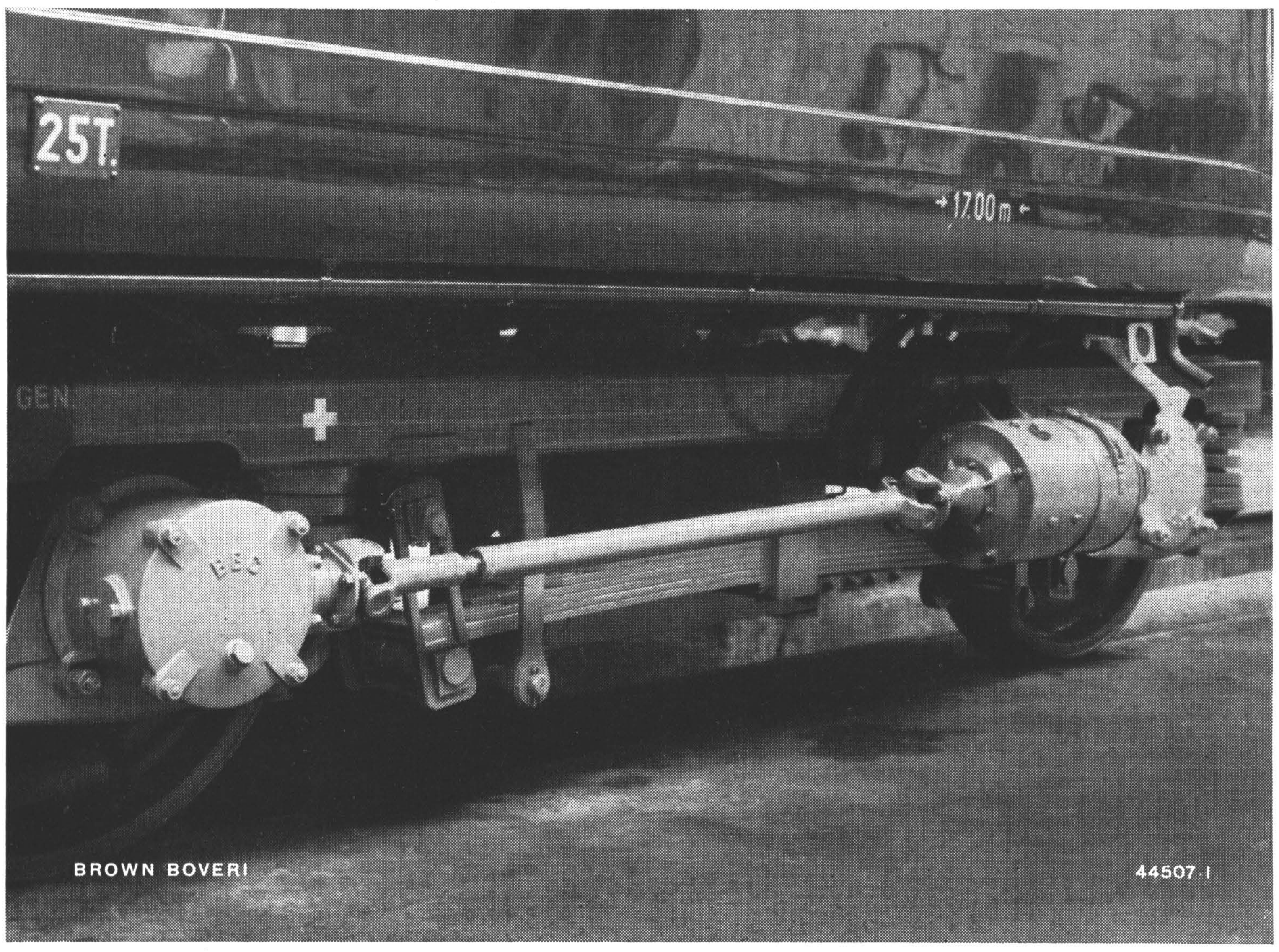


Fig. 150. — Cardan drive for train lighting generator type GZ 54 a comprising axle box gearing with single ratio of 1 : 3·125 and cardan shaft with ball and socket joints and sliding piece.

The cardan drive illustrated is employed exclusively for all new equipment. Its most important advantages are: Absolutely reliable power transmission, unaffected by the weather, attendance between normal coach overhauls unnecessary, minimum maintenance costs, and simple erection.

B. GAS-TURBINE LOCOMOTIVES.

Gratifying news can be given of the first gas-turbine locomotive in the world (Fig. 151). Thanks to the comprehension of the authorities and notwithstanding the fuel shortage the Swiss Federal Railways have succeeded in obtaining sufficient fuel oil to put the locomotive into regular service. In point of fact, it has been hauling scheduled trains with loads of up to 300 t over non-electrified local lines daily since the 25th May, 1943. Since the 3rd June, 1943, it has operated on the Winterthur-Stein-Säckingen line, covering approximately 150 km daily. Mixed passenger and goods traffic is handled which, although not in conformity with the capacity of the locomotive on the score of speed (110 km/h) and power (2200 H. P.), gives an opportunity of collecting valuable operating experience. The frequent halts and starts, the shunting service, waiting periods, etc., involved on this line represent much more arduous conditions than express service over long routes at much higher powers and speeds.

Nevertheless, the gas-turbine locomotive has so far proved entirely satisfactory, no trouble of any importance having been encountered. This fact is all the more remarkable, inasmuch as, from experience, machines which have proved satisfactory in stationary service can frequently only be adapted to the exacting traction conditions with great difficulty and big modifications.

Up to the end of 1943 the locomotive had covered about 32,000 km. It is run on cheap fuel oil, high-grade Diesel oil only being necessary for starting. Immediately after ignition the fuel is changed over to the low-grade oil which in the quality employed has a viscosity of about 16° Engler at 20° C. To assist pulverization the oil is pre-heated to about 100° C by means of the heat inherent in the exhaust gases, being injected at a pressure of about 12 kg/cm². The fuel oil consumption of the gas turbine set is extremely low. In point of fact, practically no oil whatsoever has been consumed to date and its composition has suffered no deterioration, so that renewal should not be necessary for a long time to come.

The drivers have quickly made themselves familiar with the locomotive, like driving it, and praise its properties, which fact may chiefly be put down to the simplicity of its construction and operation.

The fuel available will enable the locomotive to be run for some time longer and thus enable valuable experience to be gathered under winter conditions.

Fig. 151. — The gas-turbine locomotive at a station on the line it is serving.

During short stops the gas turbine is allowed to idle, but when the halt exceeds ten minutes it is shut down. Three to three and a half minutes are required to re-start the absolutely cold turbine; should it still be warm ½ to ¾ minute less is necessary.

V. HIGH-FREQUENCY AND COMMUNICATIONS ENGINEERING.

During the past year research and developmental work in the various branches of high-frequency and communications engineering has been carried on intensively. As the result of thorough investigations, we have succeeded in considerably improving various components of high-frequency apparatus. New components, which possess fundamental advantages in regard to mechanical and electrical properties, were also devised. *Developments* in the sphere of electrical filters and of transmitting and special valve types are particularly worthy of note.

The various specialized branches of high-frequency engineering, especially microwaves, multichannel communication and directional waves, formed the subjects of further investigations. Various novel principles were successfully tested and our endeavours to find original solutions have yielded several interesting and promising results in the past year. Fundamental improvements in regard to size and reliability of newly developed high-frequency apparatus were obtained by the application of new principles and components.

1. *Electrical Filters.*

An important component of most equipment used for communication purposes is the electrical filter. Since the quality and performance of the equipment as a whole is in many cases dependent on the properties of the filters, the development of various types received special attention. To act as a basis for design, tables and curves for the most widely varying basic types of high-pass, band-pass and low-pass filters were drawn up, a work which involved a considerable number of tedious calculations. With the help of these tables and curves it is a simple matter to design a filter with the desired properties in a very short time. As an example of the practical application, the calculated attenuation curve of a low-pass filter is shown in Fig. 152. It will be noted that the attenuation curve measured subsequently for the completed filter, shown dotted, agrees well with the calculations.

Coils with very low losses are indispensable for the construction of filters with a sharp cut-off at the boundary frequencies. We have succeeded in considerably reducing the coil losses by the development of powdered iron cores. Fig. 153 shows a new band-pass filter together with the powdered iron core used. Such filters are employed, for example, in multichannel communication apparatus and in equipment for the "scrambling" of speech. The quality of the filter may be judged by reference to the attenuation curve shown in Fig. 154.

Crystal filters, in which *piezo-electric crystals* are used instead of tank circuits consisting of coils and condensers, were also successfully developed. Up to the present time quartz crystals have been used in

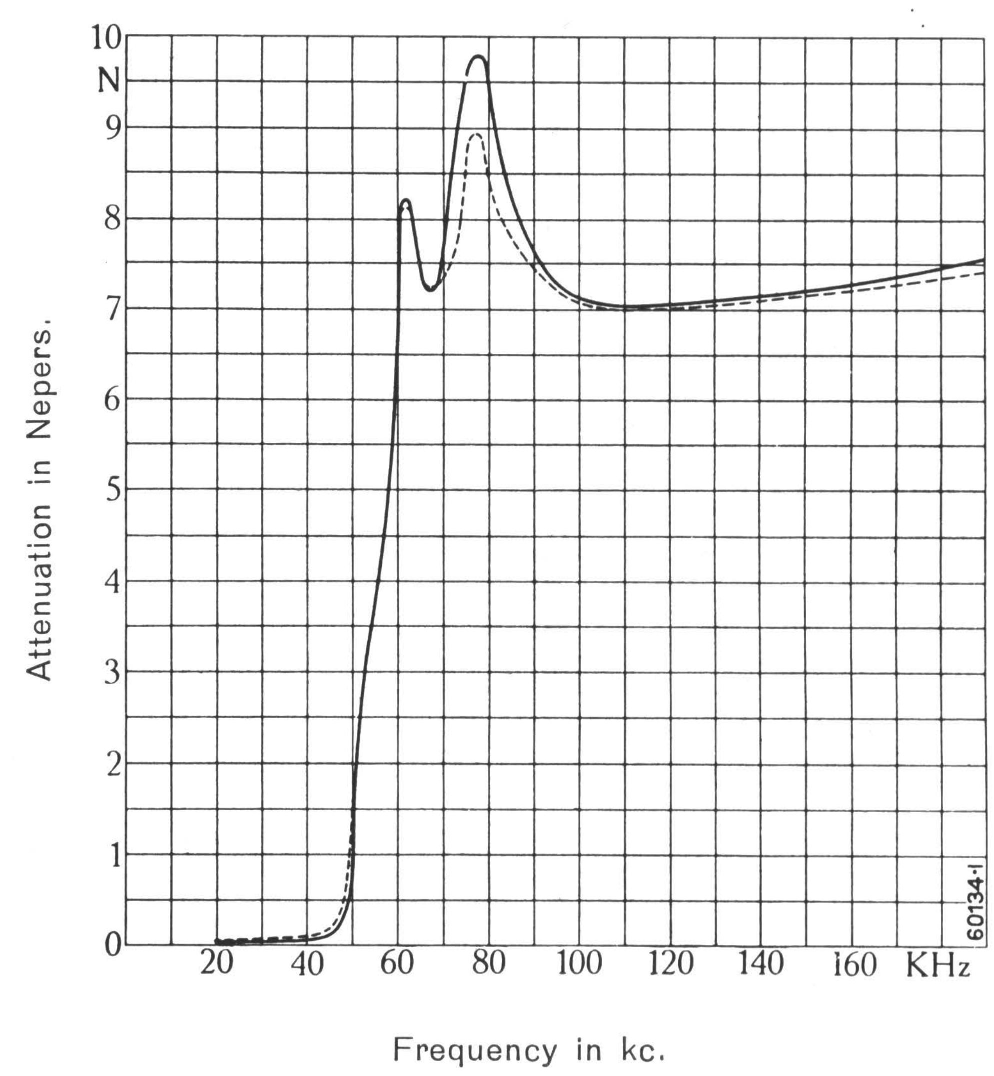


Fig. 152. — Attenuation curve of a low-pass filter.

The relatively good agreement between the calculated and measured values is noteworthy.

Continuous curve: Calculated values.
Dotted curve: Measured values.

the majority of cases for such filters. As these crystals are very difficult to obtain to-day, we are making use of artificially cultivated crystals manufactured by a process developed by Prof. P. Scherrer in the Physics Department of the Swiss Federal Institute of Technology, Zurich. In contrast to the well-known Rochelle salt crystals, their properties differ only slightly from those of the natural quartz used in oscillatory circuits. A fully grown, cultivated crystal is illustrated in Fig. 155.

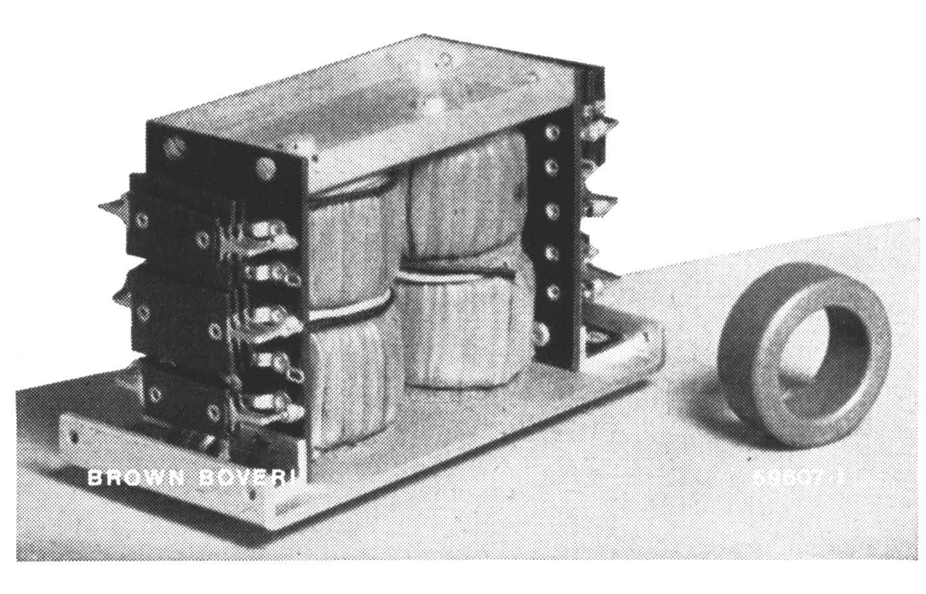


Fig. 153. — Band-pass filter with coils having powdered-iron cores.

The coil cores are made from powdered iron of a definite grain size. The grains are insulated from one another in order to avoid eddy-current losses. In this manner we obtain cores of the highest quality such as are necessary for high-frequency filters.

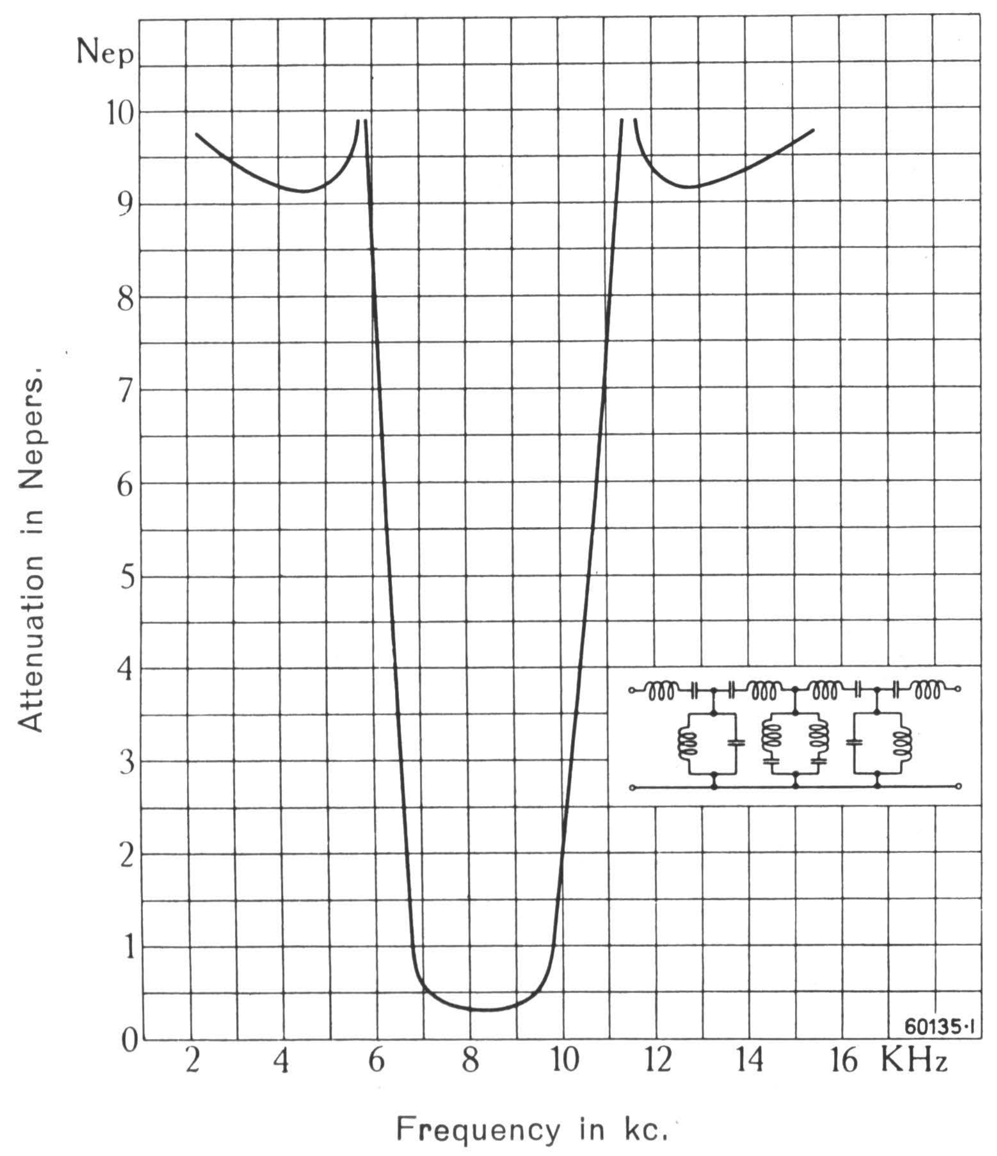


Fig. 154. — Measured attenuation curve of a band-pass filter with Brown Boveri toroidal coils.

The attenuation is plotted in function of the frequency.

The attenuation curve of a two-stage crystal filter is shown in Fig. 156. These filters, made for frequencies above 50 kc., are also particularly suitable for multi-

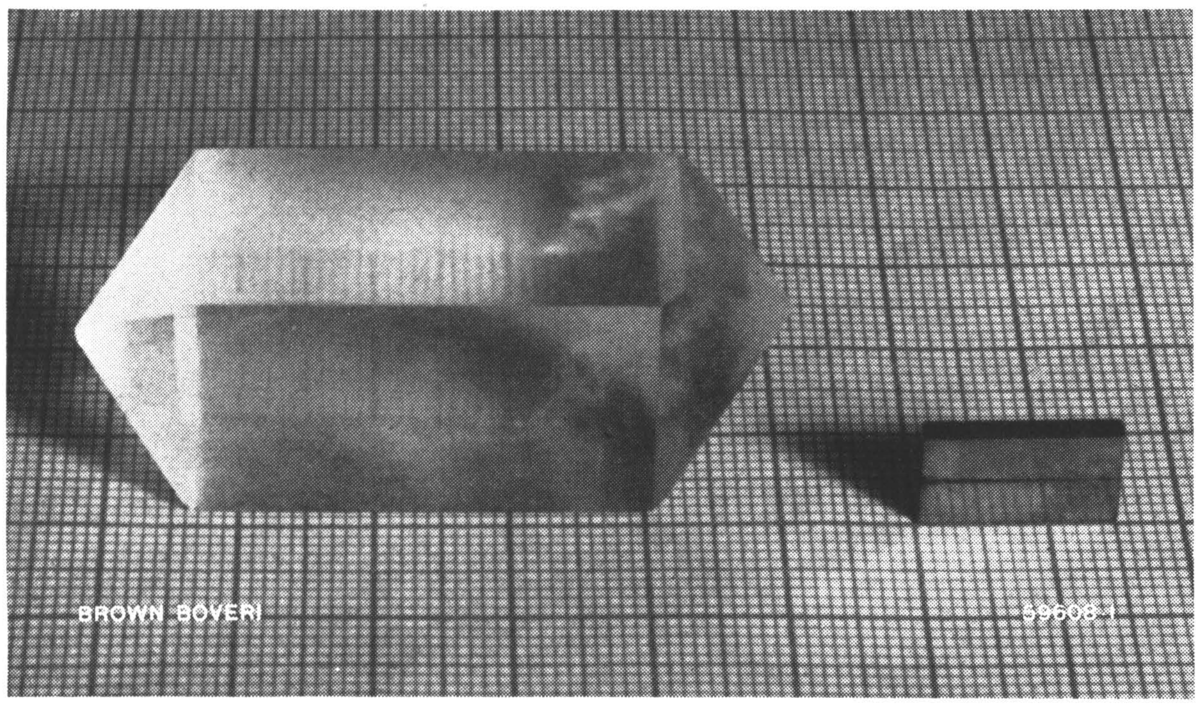


Fig. 155. — Artificially cultivated piezo-crystal.

Crystals such as the one shown on the left are cultivated by a new process for which patents have been applied for. By cutting, grinding and preparing these, it is possible to produce filter or oscillator crystals (see right-hand side of photograph) which can be used to advantage instead of natural quartz crystals which are at present exceedingly difficult to obtain. In high-frequency engineering there are innumerable applications for such crystals.

channel communication apparatus and for "speech-scrambling" equipment. Special advantages are their low weight and comparatively small space requirements.

2. *Multichannel Communication and Directional Waves.*

Our efforts have produced fundamental developments in *multichannel communication.* Filters and modulators, in the form of completely developed units, were used to build test apparatus with which to investigate the fundamental principles of multichannel transmission. Special supplementary multichannel units for use in conjunction with existing wireless equipment are being developed. By adopting a space-saving and light-weight construction, these units may be made portable.

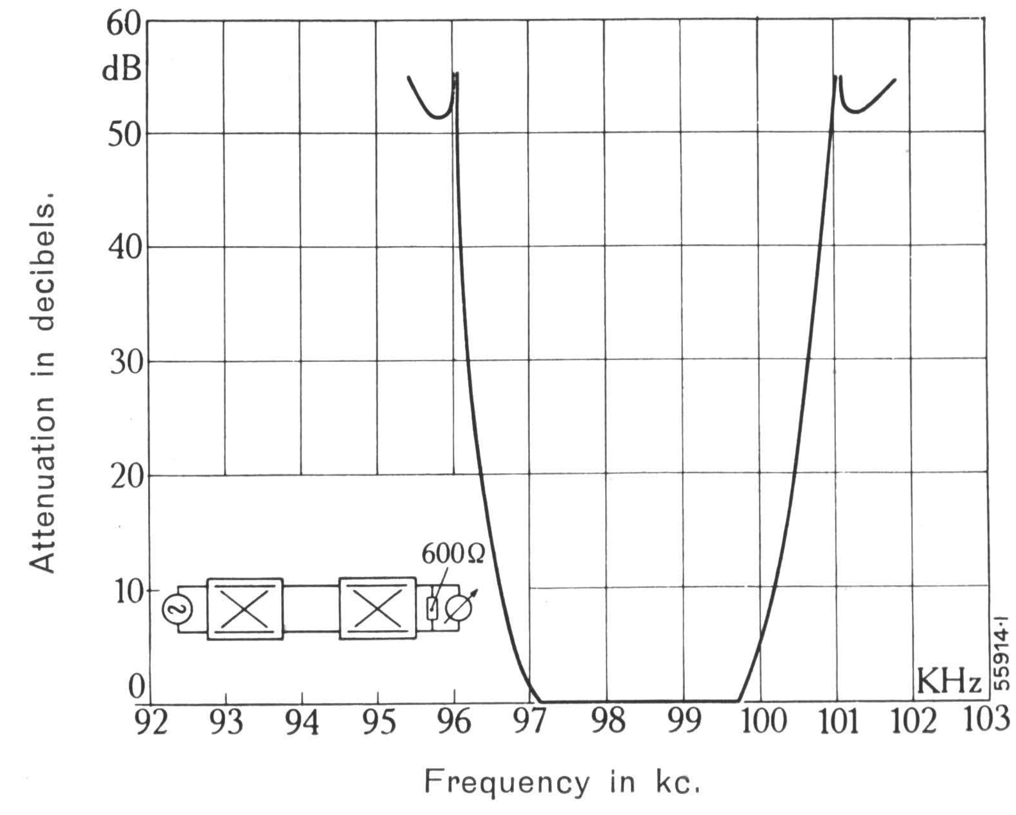


Fig. 156. — Attenuation curve of a two-stage crystal filter with artificially cultivated crystals.

The attenuation is referred to the output level of the frequency band transmitted through the filter.

For *directional wireless transmission* over long distances, we have developed sets which work with wave-lengths of several decimetres and which are used in conjunction with unidirectional aerials. These sets may also be used for relaying. Communication between two stations when obstacles lie in the direct line of sight is made possible by the erection of one or more repeater stations. The repeater stations consist of directional transmitting and receiving units connected together.

Frequency modulation, which ensures a minimum of atmospherical disturbance, is employed in these sets.

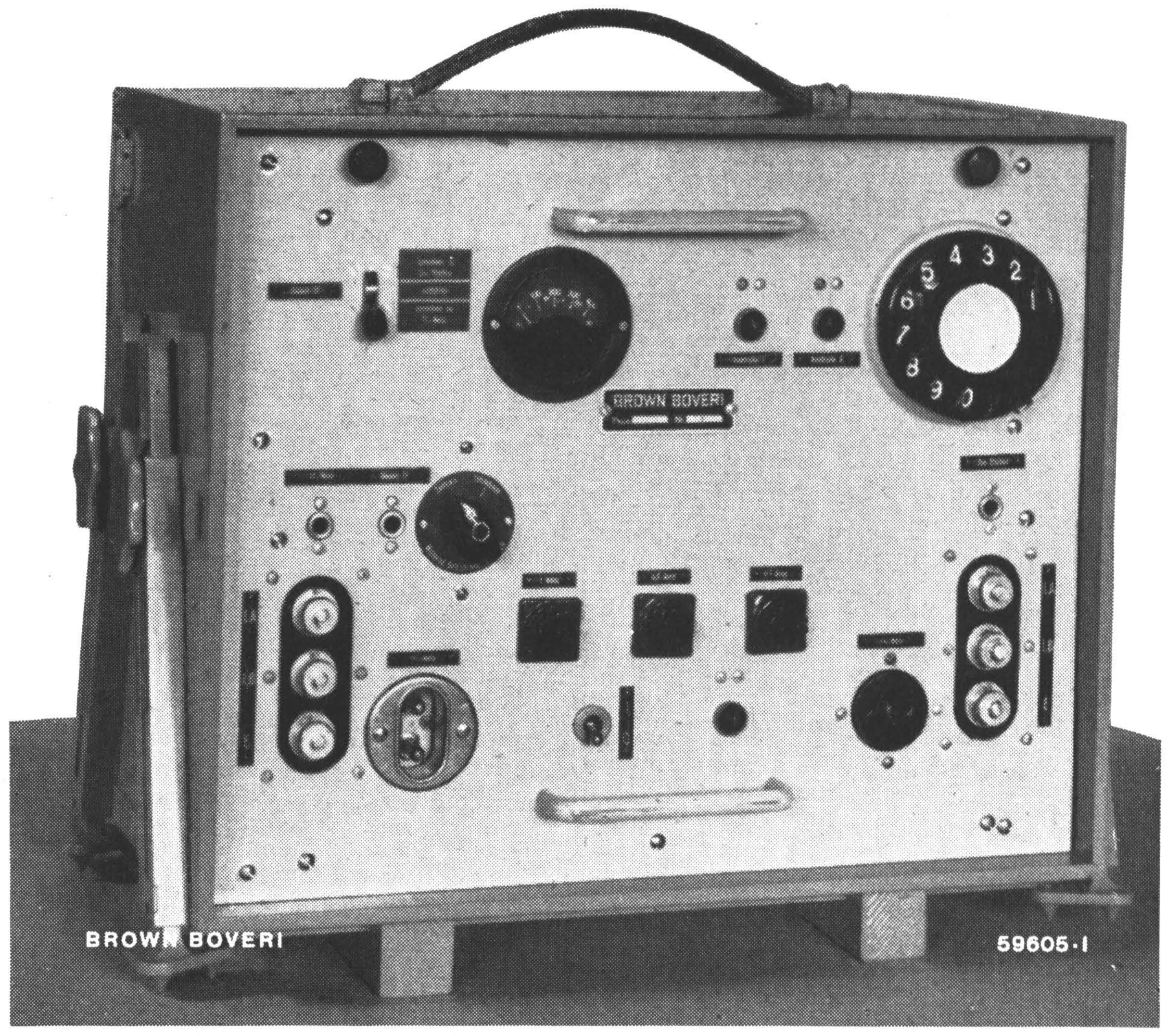


Fig. 157. — Auxiliary dialling unit, used in conjunction with transmitters, for automatic selection of telephone numbers.

Special auxiliary units are necessary for putting through automatic telephone calls when ultra-short-wave sets are used for communication. Dialling and calling impulses are transformed into corresponding audio-frequency impulses.

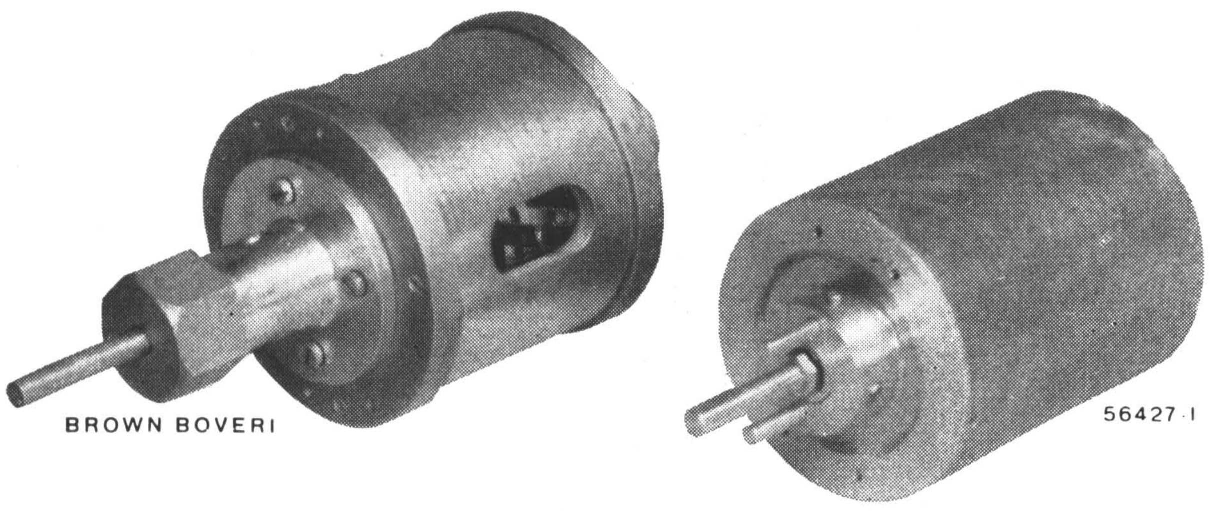


Fig. 158. — Adjustable cavity resonators for decimetre-wave sets.

Such tuning circuits play an important part in ultra-short-wave work. Tuning is effected by rotating the axial shaft. The cavity resonators are made with the greatest precision.

We have already successfully applied this kind of modulation previously, especially for police wireless stations, and it has the special advantage in the present case that non-linear distortion may be reduced to a minimum. By its employment, thoroughly reliable multi-channel communication, even when several *repeater stations* are interposed, is ensured. The small variations of the average frequency of transmission, which cannot be avoided in practice, are compensated by automatic tuning of the receiver. It is thus possible to use a simple, single-knob control and, moreover, the attendance during operation is reduced to a minimum. This is particularly advantageous in the case of repeater stations, which can be operated without continuous attendance. Previous experience with these novel equipments has been in every respect satisfactory, and has confirmed the fact that reliable relay operation is easily obtained with several repeater stations.

For the operation of the directional wireless units in conjunction with an automatic telephone system, an *auxiliary dialling unit* (Fig. 157) was developed. In this unit the dialling impulses are converted into corresponding, modulated audio-frequency impulses, the automatic selection of a given number over several repeater stations thus presenting no difficulties.

The components of these sets are also especially noteworthy, particularly the cavity resonators used for tuning the transmitters and receivers. Fig. 158 shows a cavity resonator, the tuning capacity inside the resonator being controlled from outside by an insulated shaft. The control is so arranged that no current flows in the moving parts, thus avoiding a condition which could otherwise, according to experience, give rise to disturbances.

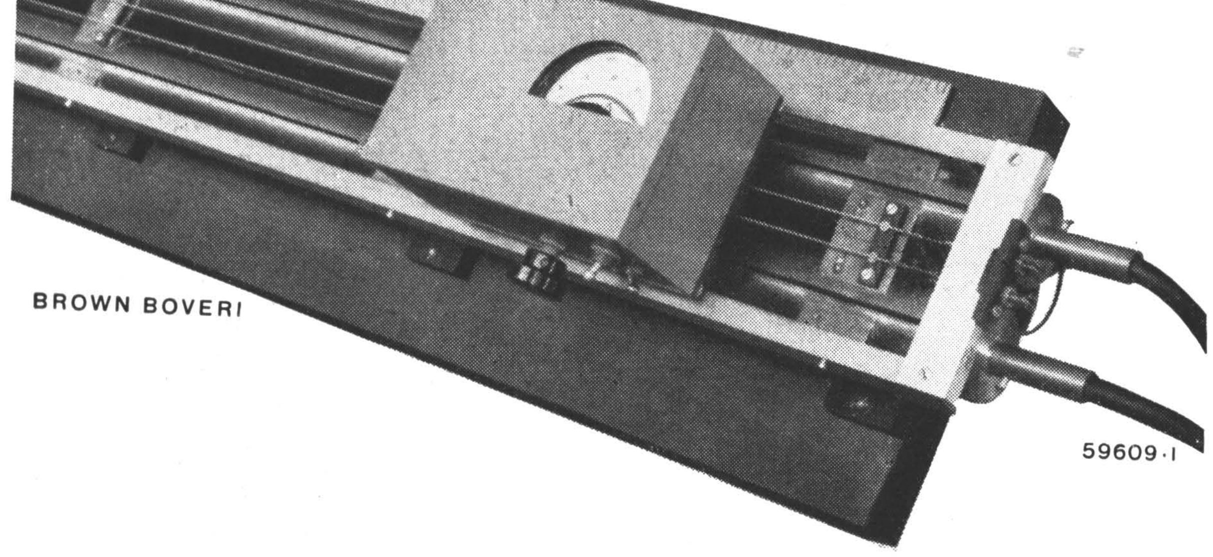


Fig. 159. — Impedance measuring device for ultra-short waves.

The voltage nodes and antinodes between the two shielded Lecher wires are found by means of the movable diode-voltmeter.

Various special measuring instruments for the exact measurement of impedance, power and frequency had to be developed for our investigations of ultra-short waves with wavelengths of several decimetres or a few metres. Fig. 159 shows an impedance measuring device for the measurement of the magnitude and phase angle of impedances. This instrument consists of a Lecher system with shielded conductors, the unknown values being easily ascertained from the position and amplitude of the voltage nodes and antinodes.

3. *Microwaves.*

Reports on the development of our microwave transmitting valves have already appeared in previous numbers of the Brown Boveri Review. These valves are known under the name of *"Turbator"*, and are oscillators which have been derived by systematic development from a magnetron of which the segments are connected to a cavity resonator. With such a valve it is easily possible to obtain wavelengths of about 10 cm. The behaviour of the valves could be exactly analysed mathematically, this leading to the manufacture of valves with oxide cathodes having a large surface which possessed a considerably increased efficiency at lower operating voltages. Specially noteworthy is the simple manner in which frequency and amplitude modulation are accomplished with the turbator. It was

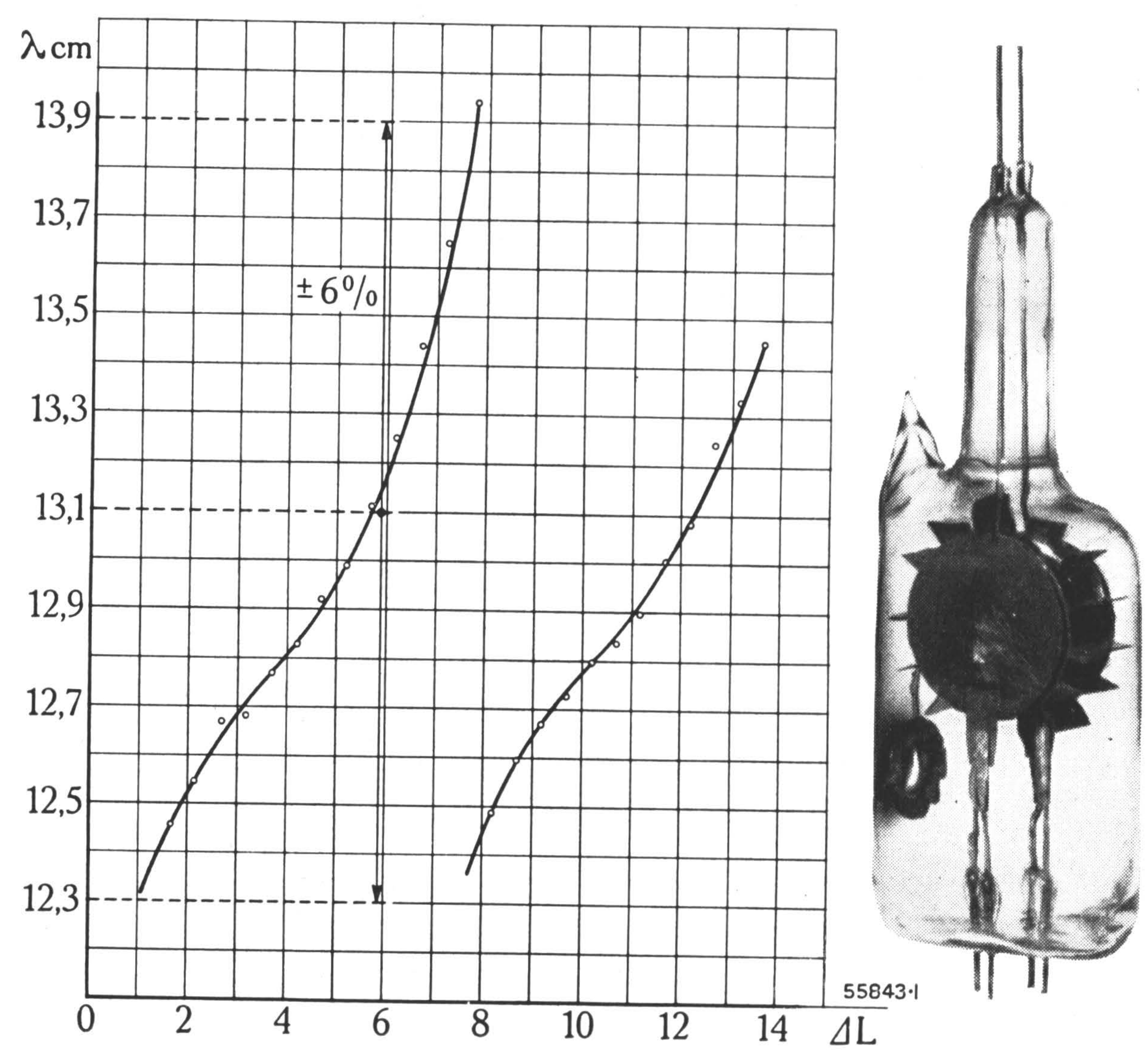


Fig. 160. — Turbator valve with internal and external tuning characteristic.

The frequency of the turbator can be influenced in a very simple manner by tuning an **external**, adjustable Lecher system.

Abscissæ: Tuning length. Ordinates: Wavelength.

possible, for example, to obtain practically linear amplitude modulation with a depth of modulation up to 70 %.

While, in the beginning, a constant wavelength was always used, investigations with the object of obtaining variable frequency tuning for constant operating data have been completed. Tuning may now be realized in practice by means of the transformation of the impedance of an external tuning reactance into the inside of the resonator. In this manner, a frequency variation of ±5 % and more is obtained, which completely satisfies the normal practical demands. Fig. 160 shows such a valve and its tuning curve.

To render the reception of extremely short wireless waves possible, various means of reception were developed and tested, particularly *special diodes* and *receiving magnetrons*. In view of the extremely short electron transit times required, special demands are made with regard to the precision of the electrode construction and the smallness of the electrode spacing. In the case of the diodes, which are made as double rectifiers, a spacing of $^{3}/_{100}$ mm between anode and cathode is maintained. In the case of the magnetron, it was possible, by adaptation of the magnetic field to the wave length to be received, to obtain a considerable increase of sensitivity without sacrificing stability.

The development of *microwave communication sets* was continued. As the turbator can be operated under the simplest conditions, transmitters of extraordinarily small dimensions can be produced with very little material. In the preliminary tests over short distances, the previously mentioned receiving magnetron has proved to provide specially good reception. Various tests on superheterodyne reception with diodes were likewise successful, and the results achieved up to the present justify the assumption that clear superheterodyne reception with simple equipment will also be possible over large distances. Fig. 161 shows an auxiliary unit of a turbator transmitter which contains battery, vibrator and rectifier for power supply, and modulator for direct control by the crystal microphone. The turbator itself with permanent magnet and mirror can be mounted separately on a tripod.

4. *Construction of Valves.*

Various machines for the manufacture of *small, special valves* were designed, with the help of which production could be appreciably increased. A special technique was developed for making the seals between the glass and the electrode leads of our various valve types of low and medium ratings. The development of small valves included a number of types ranging from a small diode up to a pentode with a plate dissipation of 50 W. In addition to these, special valves for measurement and checking purposes were developed. Fig. 162 shows an electronic relay, similar to a magnetron,

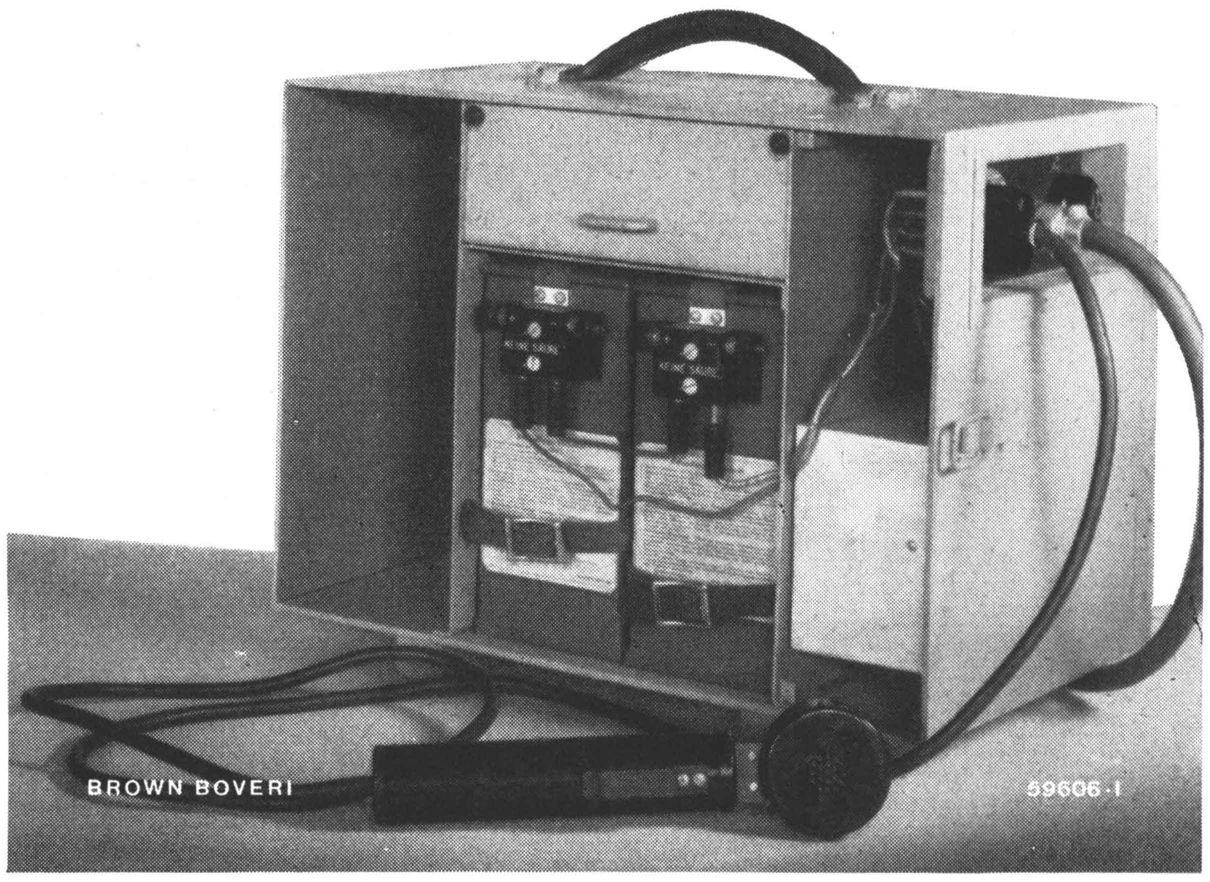


Fig. 161. — Auxiliary equipment of a turbator transmitter.

This equipment is for power supply and contains battery, vibrator and rectifier, modulator and crystal microphone.

which is used commercially for supervising large d. c. currents. In this electronic relay, the flow of electrons is deflected from the normal, radial path by the magnetic field being checked, so that the plate current provides a basis for exact supervision.

Apart from *demountable transmitting valves*, which are intended chiefly for industrial oscillators, *sealed glass valves* for broadcasting transmitters were also included in our programme of development. Some of the new valves are provided with water cooling, others with forced draught cooling. Certain valve types are also provided specially for short-wave operation. The cathodes of all types can be heated by three or six-phase current, so that telephony is possible with a. c. heating. Fig. 163 shows a sealed transmitting valve with forced draught cooling.

5. *Transmitters.*

The following paragraphs contain a brief summary of some interesting reports on transmitters which we have already supplied.

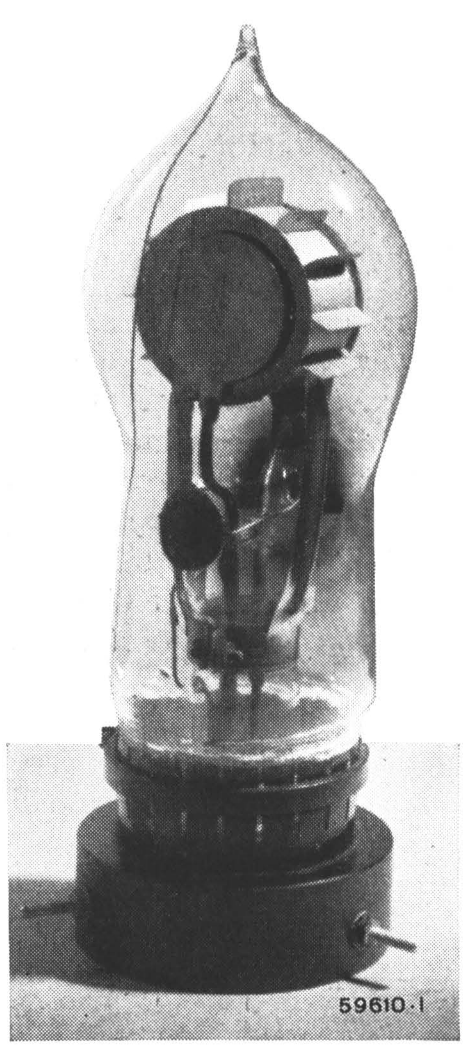


Fig. 162. — Electronic relay for supervising heavy d. c. currents.

The electron stream is deflected from its normal radial path by the magnetic field to be checked, the anode current being used as basis for the supervision of the field.

Medium-wave broadcasting transmitters and short-wave transocean transmitters have been put into service and have proved entirely satisfactory. The subdivision of our transmitters into easily transportable units, which can be quickly assembled on site, results in a considerable reduction of the time required for erection and is therefore very expedient. The auxiliary studio equipment, supplied with the transmitters, also satisfies the demands made on it. Such transmitters are being used more and more under present-day conditions for broadcasting and long-distance telephony. We have therefore laid down a stock of partly completed 10 kW transmitters in order to be able to supply these at comparatively short notice (Figs. 164 and 165).

Fig. 163. — Sealed, glass transmitting valve with forced draught cooling.

The same valve can be used with water cooling when provided with a special cooling jacket.

Police wireless.—As our police wireless equipment for the city of Zurich, consisting of stationary and mobile stations, works exceedingly well and proved to be of indispensable assistance to the police in their efforts to maintain law and order, we decided to further the sales of these equipments. The standardization of our mobile stations has been practically completed in the course of the last few months. The principal aim was the best performance with the minimum of material. The mobile police wireless sets are now made of units which may be easily assembled. By this means the sets are made universal in their application; they may be adapted to all requirements and can be modified or extended at any time. Stationary installations can be supplied, according to the desires of the client, with or without remote control of transmitter and receiver. Frequency modulation is employed, this having the advantage that atmospherical interference is small. They are built for one or two-way communication with ultra-short waves in order to obtain good results in spite of the use of small sets with short aerials. By the use of different wavelengths it is possible to establish duplex communication just as in the case of the normal telephone system. Attendance is simple and

Fig. 164. — 10 kW, medium-wave, broadcasting transmitter.

The h. f. preliminary and final stages on the left, the a. f. preliminary and final stages on the right and the control desk in front show clearly the compact and easily supervised construction of the transmitter. Attendance is extremely simple as the transmitter is semi-automatic. The power supply equipment mounted behind the transmitter can also be controlled and supervised from the control desk.

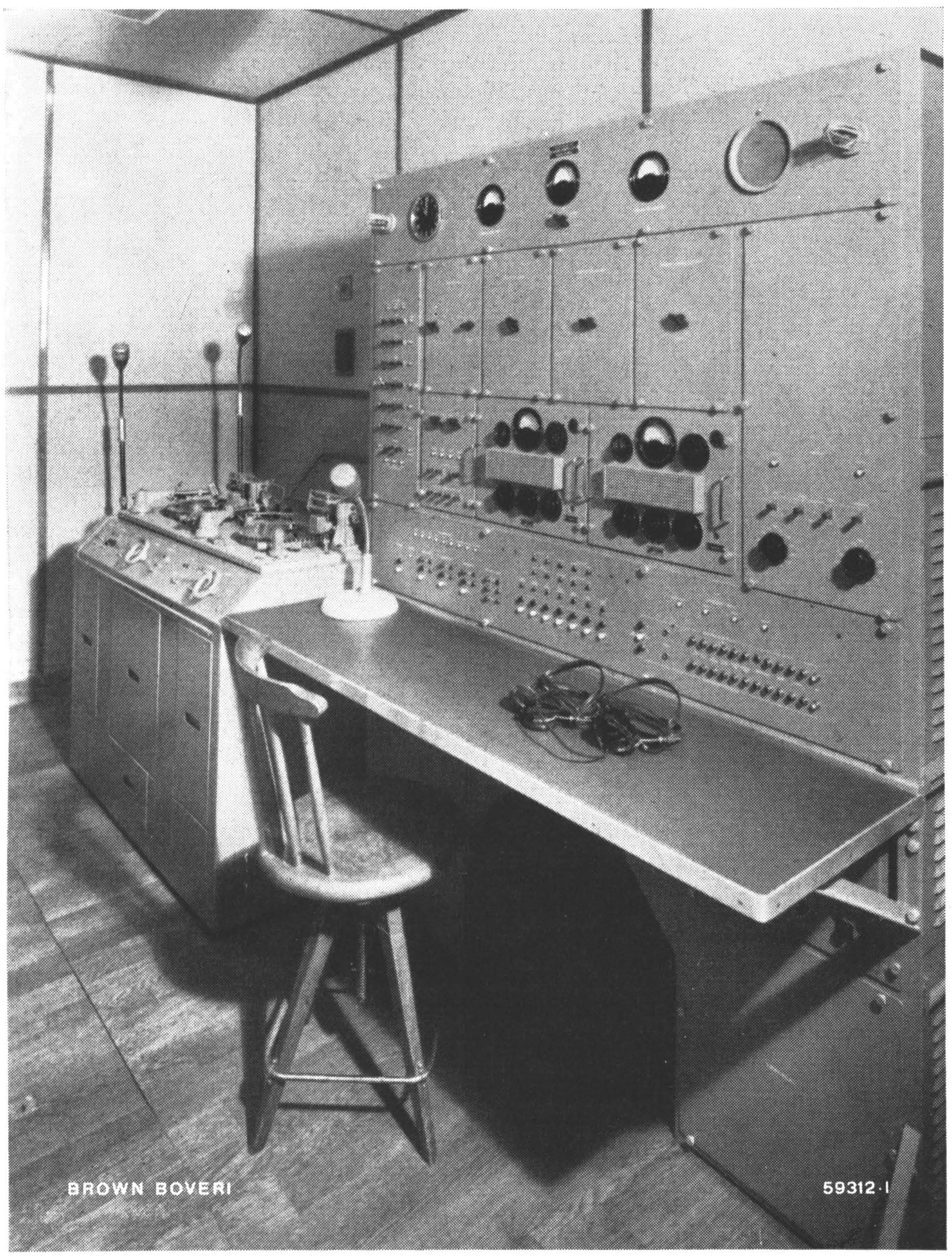


Fig. 165. — Auxiliary studio equipment for a 10 kW transmitter.

Such equipment, with control panels, amplifiers, interval signal unit, a. f. oscillator, turntables for recording and playing records, belongs to the studio of a 10 kW transmitter.

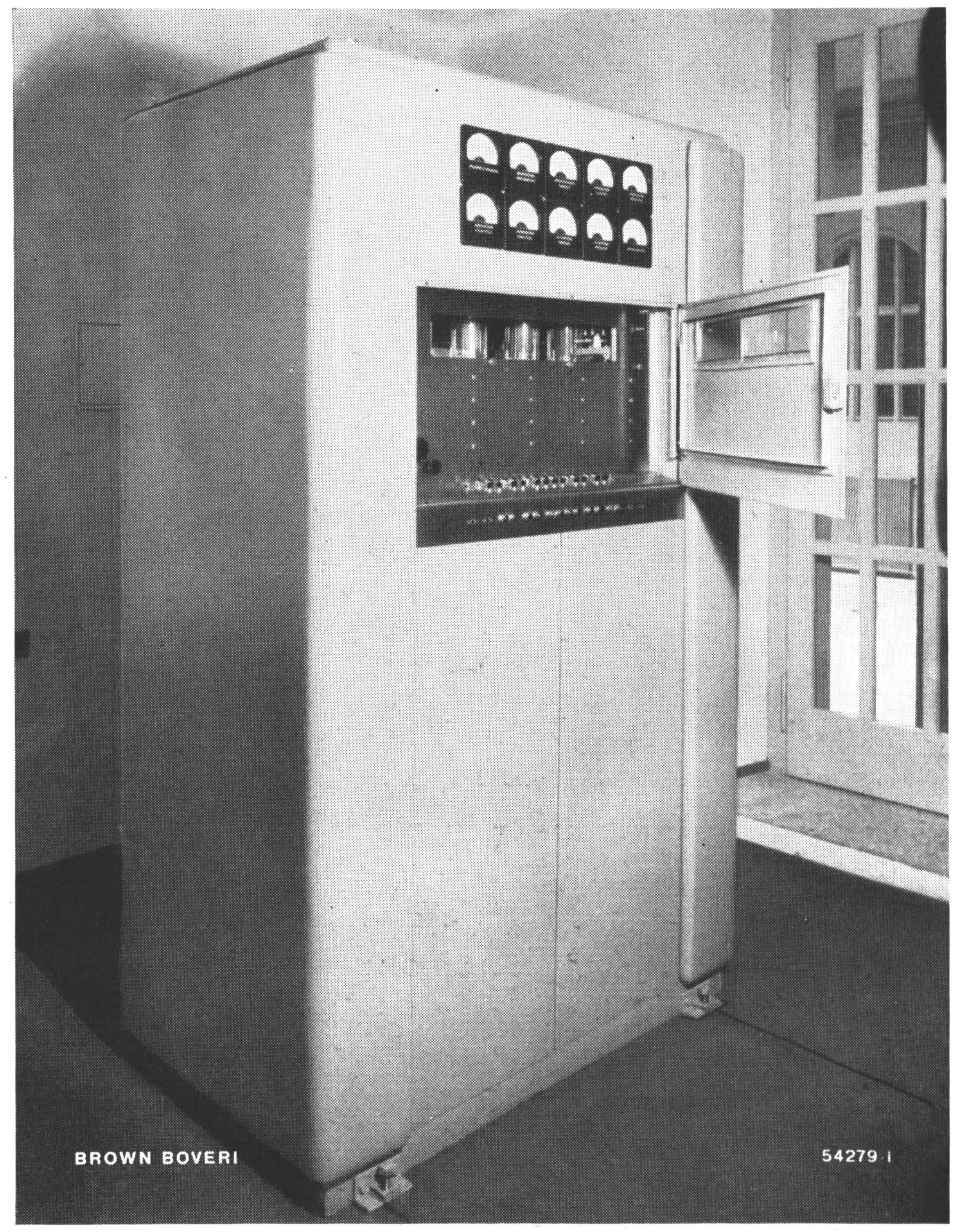


Fig. 166. — Stationary transmitter of the police wireless station in Zurich.

This transmitter, which can work on different wavelengths, is remote-controlled from the central control station, thus allowing a considerable simplification of operation.

requires no specialized knowledge. The Fire Brigade in Basle already operates a wireless installation of this kind and it is to be expected that the police forces and fire brigades of other towns will install wireless equipments of our design in the near future (Figs. 166, 167).

6. *Supervisory Control.*

In this branch of engineering, which is of interest chiefly for power supply concerns, we may mention the following:—

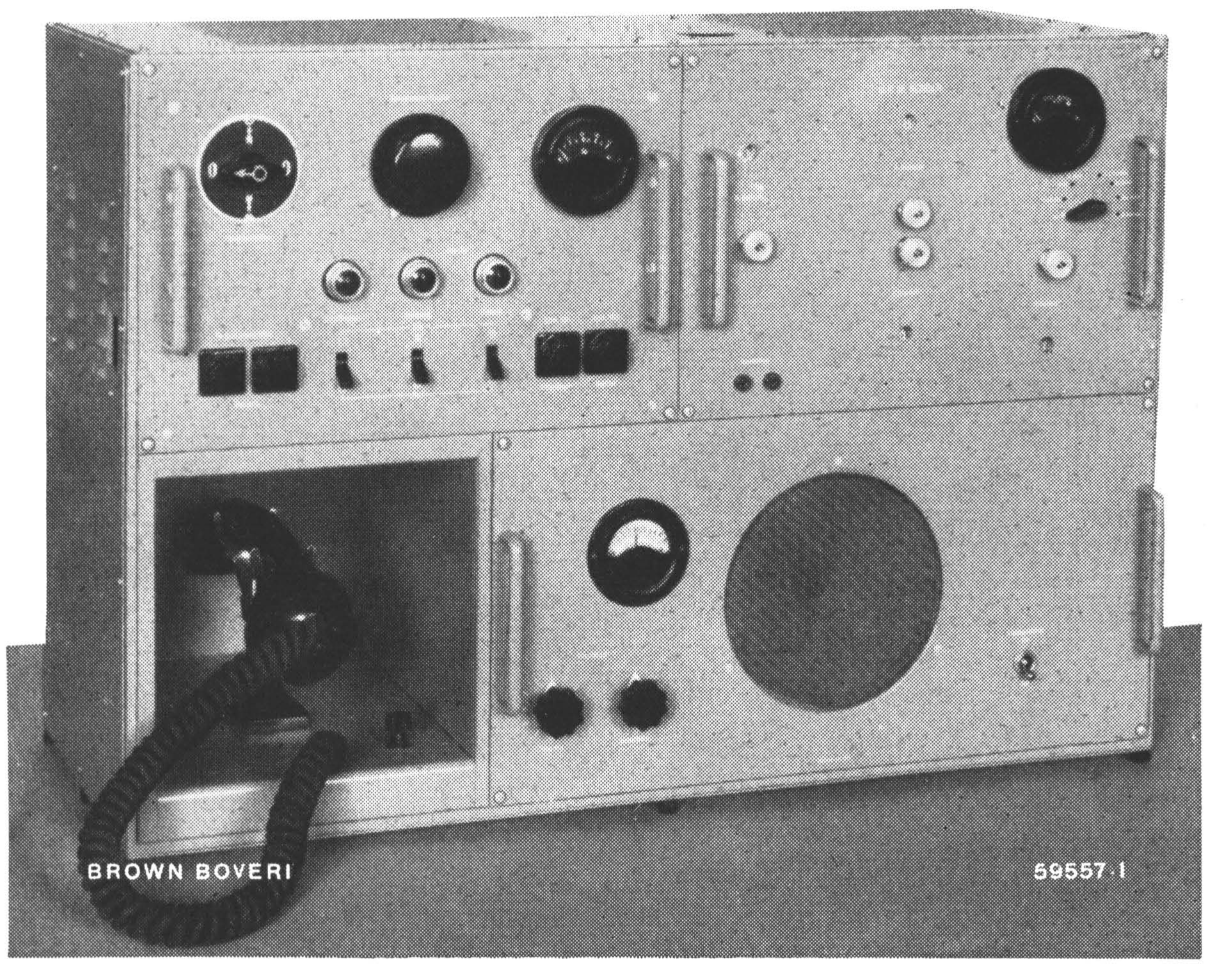
Telemetering.—Our telemetering system has proved satisfactory in all respects. The underlying principle consists in converting the values to be transmitted into audio-frequencies in such a manner that a definite frequency corresponds to each meter reading and a frequency band to each scale of readings. Several meter readings can be transmitted simultaneously over one and the same line by superposing the individual frequency bands on one another, while at the same time it is possible to conduct a conversation. A further advantage is the universal applicability of this telemetering system. Any desired readings (current, voltage, power, reactive power, power factor, frequency, levels, angles, temperature, pressure and vacuum) may be transmitted over any lines and over any distance.

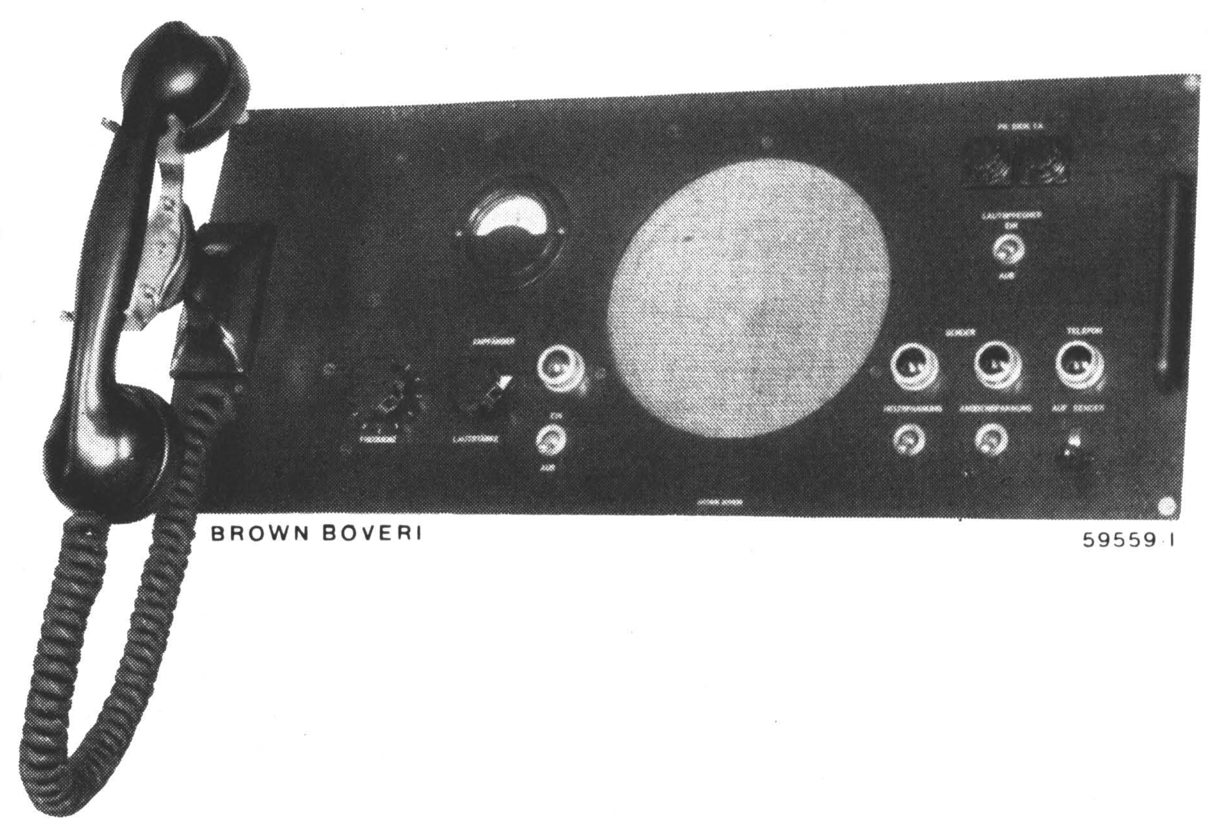
The great accuracy, the instantaneous transmission and the large torque available at the receiving end allow of the connection of automatic regulating devices, so that turbines, for example, can be governed in function of a power or a water level measured at some distant station.

It is possible, moreover, to connect several indicating and recording instruments to the same telemetering receiver (Fig. 168).

High-frequency telephony and supervisory control. Such installations, in which the power transmission lines are utilized for the transmission of the high-frequency currents, serve principally for private telephone communication between the load dispatcher or system-control station, power houses and substations, as well as with neighbouring networks. Besides telephonic communication between the most important points in the network, the same high-frequency equipment is also suitable for the transmission of meter readings and regulating values, of supervisory control signals and of impulses from the line protection relays for simultaneous tripping of the breakers at both ends in conjunction with reclosing equipment.

The high-frequency equipment can be built either for a single application or for a combination of the above-mentioned purposes. The high-frequency cubicle is





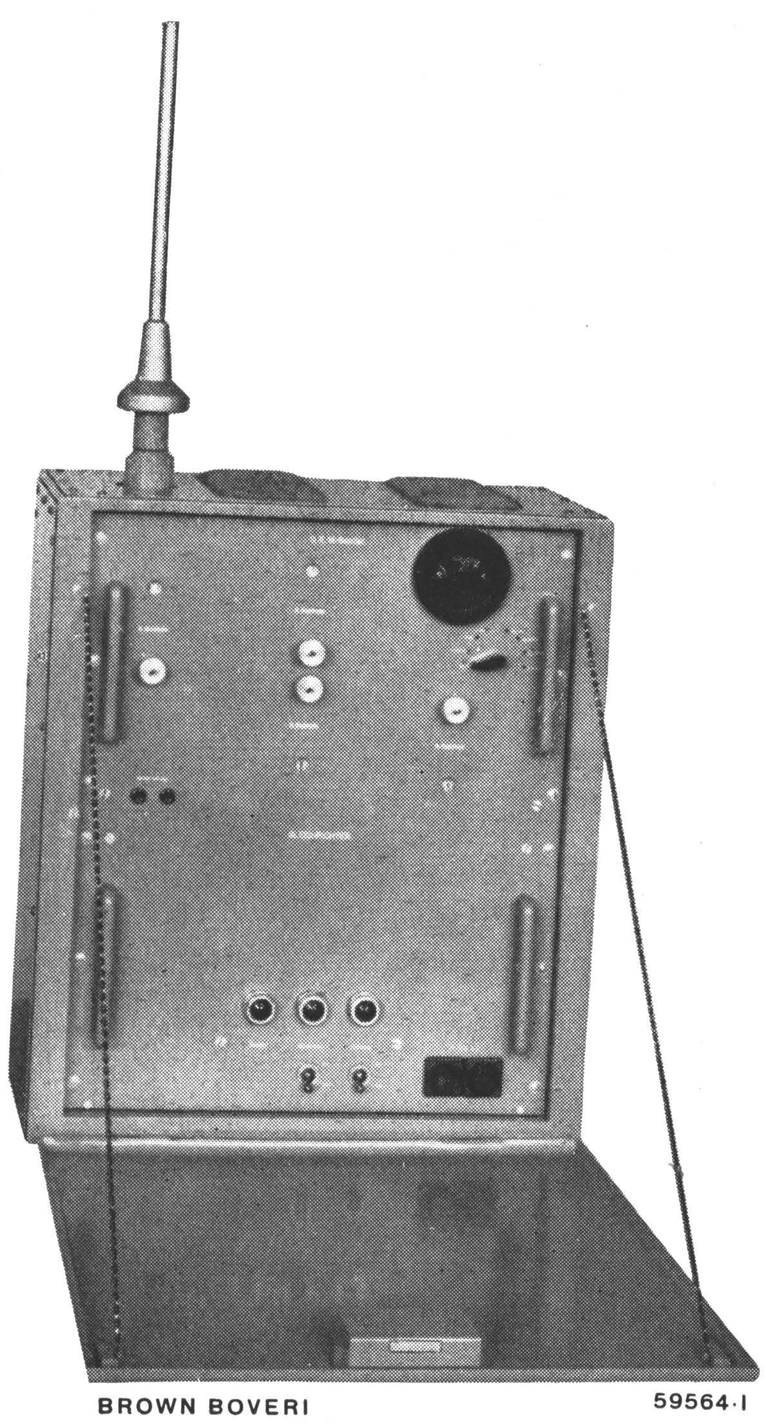


Fig. 167. — Ultra-short-wave transmitting and receiving set with frequency modulation for duplex telephony.

Noteworthy are the advantages of our versatile unit construction.

Upper left. Transmitter, receiver and converter set for feeding the apparatus from an accumulator, combined to form a single unit.

Upper right. Receiver alone with built-in rectifier unit for mounting in a desk, including switch and pilot lamp for the remote control of the transmitter which may be situated at any desired place.

Lower left. Remote controlled transmitter and rectifier built into a casing with lid.

divided into separate, easily interchangeable, standard panels which can be assembled as desired according to the purpose for which the equipment is intended. (Figs. 168, 169 and 170).

In connection with carrier communication over power transmission lines, comprehensive tests on attenuation due to the formation of hoar-frost were carried out at the beginning of 1943 on high-voltage lines in a mountainous district. The results of these tests will be communicated in an article in a subsequent number of this Review.

Low-voltage network telecontrol equipments. Developmental work in the sphere of centralized control by way of the low-voltage distribution networks for lighting and power supply has been brought to a successful conclusion. The apparatus developed may be called low-voltage network telecontrol equipment.

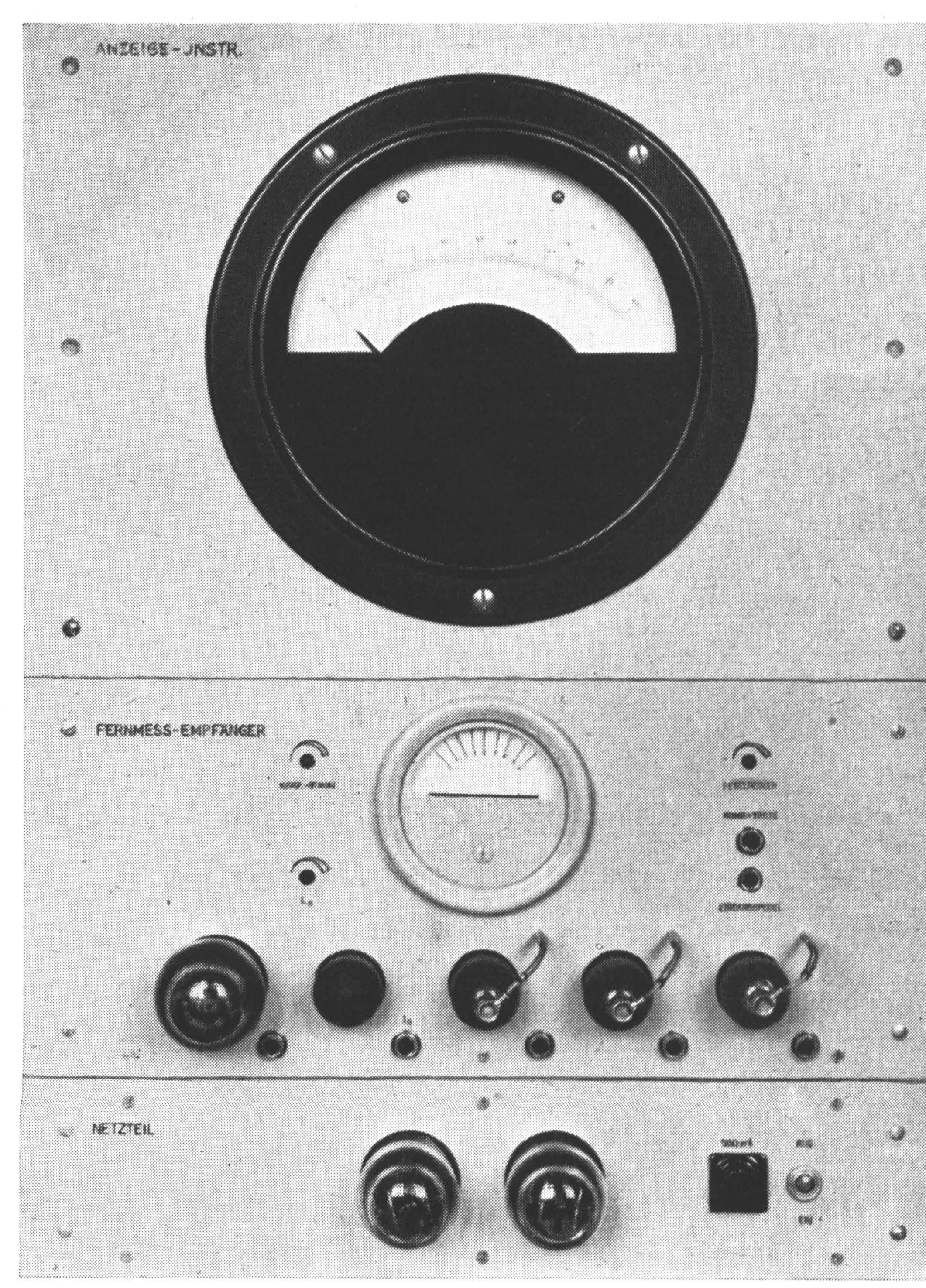


Fig. 168. — Telemetering receiver.

The variable audio-frequency signal transmitted according to the patented Brown Boveri telemetering system is converted in this receiver into a corresponding direct current which can be measured by standard indicating and recording meters with great accuracy.

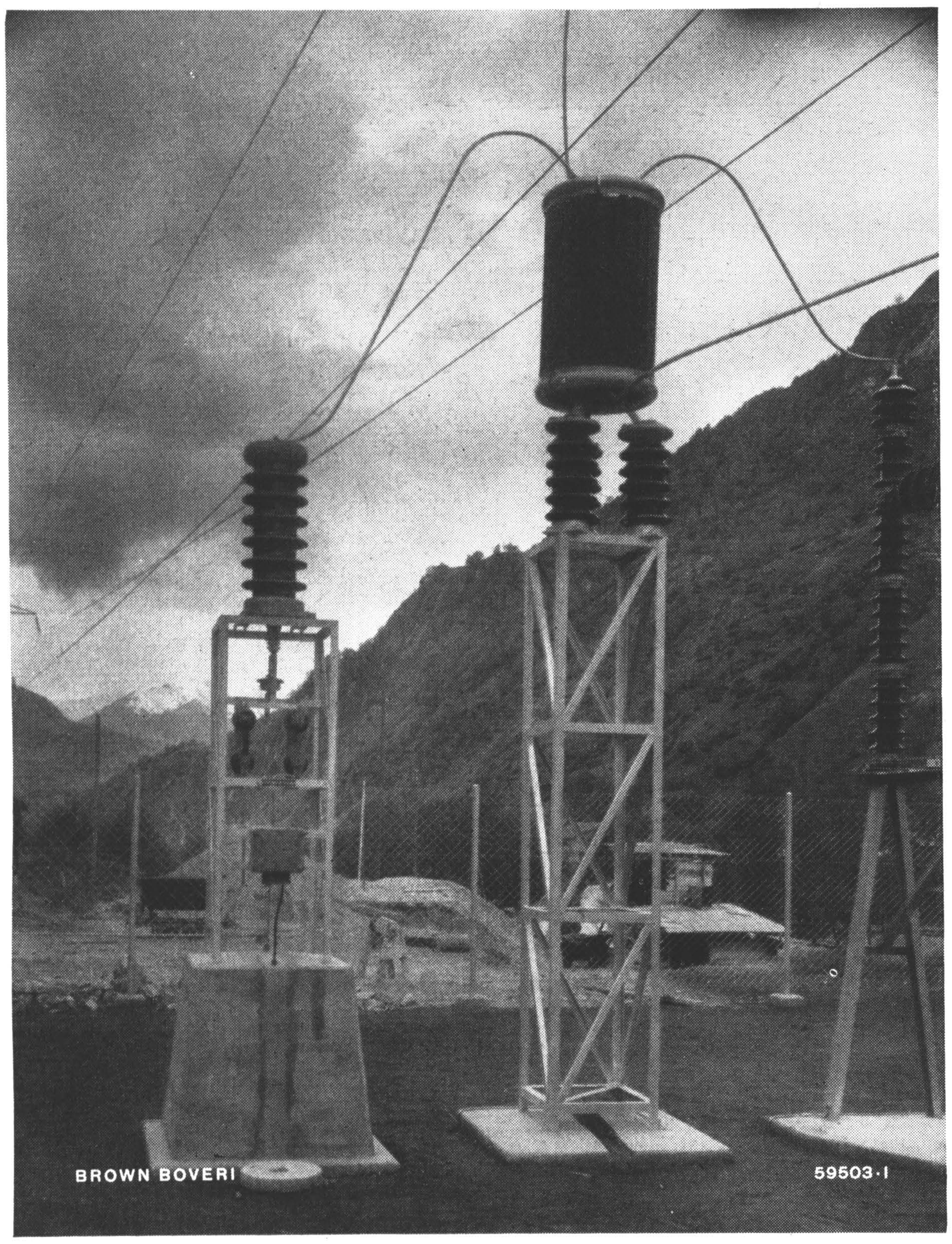


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Fig. 169. — Coupling condenser and two-wave carrier trap unit in the Mörel power station.

The 700 A carrier trap unit and the 75 kV coupling condenser are mounted in an exemplary manner in this open-air station. The Resorbit arrestor visible on the right serves to protect the h. f. telephone equipment from excessive voltages.

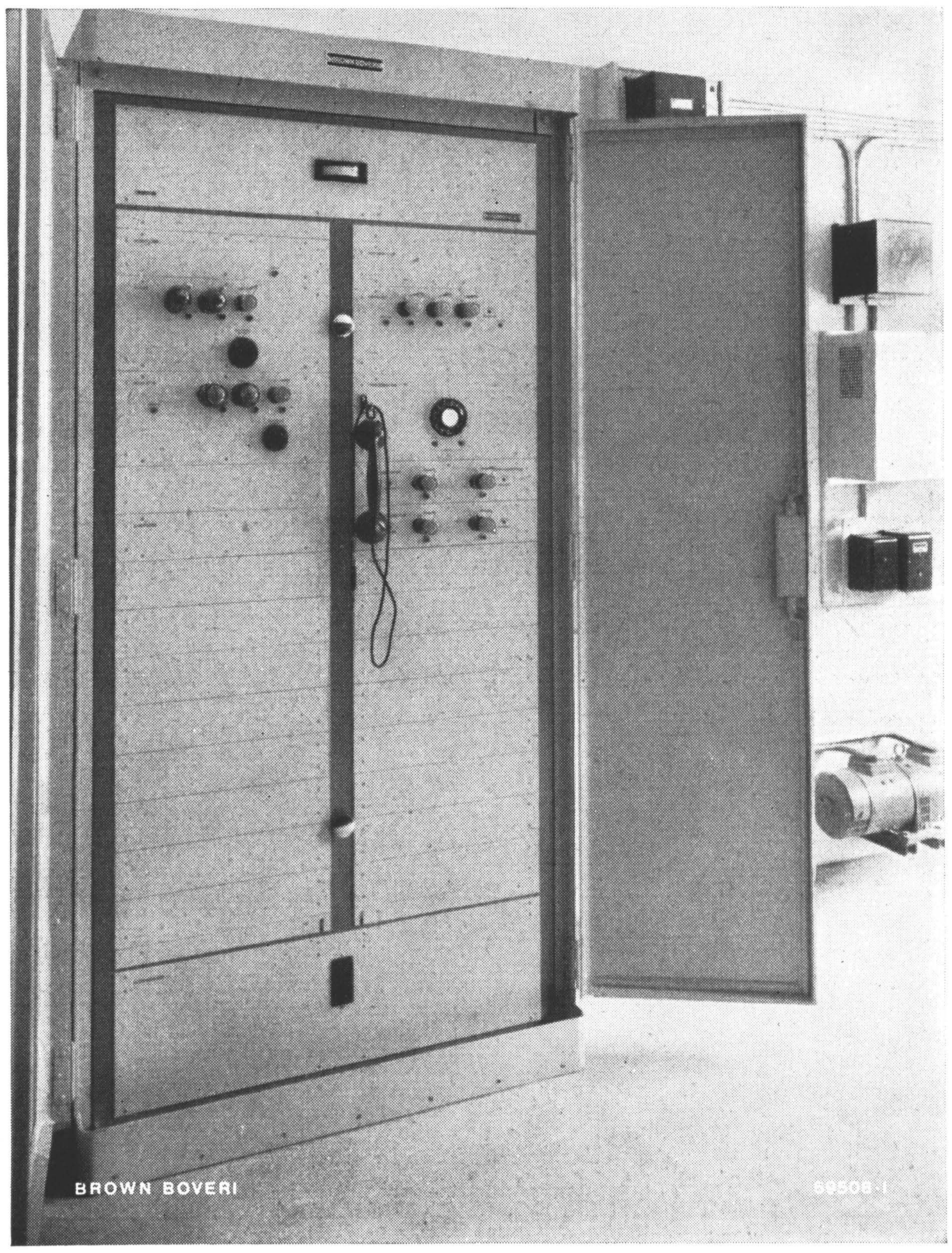


Fig. 170. — H. F. telephone cubicle in the Mörel power station.

The h. f. transmitting and receiving equipment is mounted on standardized, easily accessible panels in such a manner that each individual part can be easily checked. The vacant panels in the lower part of the cubicle are intended for subsequent extensions.

These devices are suitable for controlling street lighting, change-over switches for multi-tariff meters, domestic hot-water systems and motors, for the switching on or off of electric boilers and other consuming devices, all of which have to be remote controlled from one or more central points. These telecontrol equipments thus allow of an arbitrary *control of the power consumption* in the networks of electricity supply concerns.

No separate pilot lines are necessary in this case. The control signals are transmitted directly over the lines of the primary and secondary distribution mains, the erection of a complete telecontrol system consisting merely in the installation of the necessary transmitters, receivers and wave traps, a comparatively simple matter.

Several more supervisory control or related equipments were put into service during the year under review, e. g. the remote water-level indicator for the Laufenburg Power Station, by which the level of the Rhine is telemetered over a distance of about 7 km. For this purpose a telephone line is employed, telephone communication being unaffected by the water-level indication.

A telemetering equipment for power measurements in conjunction with apparatus for remote power consumption metering, which satisfied all demands, was put into service for the "Rhätische Werke für Elektrizität" in Thusis, Switzerland.

The carrier telephone equipment of the "Rhonewerke A.-G.", i. e. the Mörel-Turtmann installation, has been put into service and yielded good results. By way of private telephone exchanges in Mörel, Turtmann and Chippis, conversations may be conducted at will over a 65 kV transmission line between any of the automatic telephones (about 250) connected to these exchanges in the same way as for the normal public telephone system. The installation is capable of being extended for the connection of other power stations to the high-frequency system. Telemetering of one or more values over the same high-frequency equipment is also possible.

A series of special, selective receivers, combined with adjustable, audio-frequency oscillators, were supplied to the Swiss Telephone Department. These equipments are installed in main and terminal exchanges and serve for the remote supervision and limiting of disturbances in a telephone district.

VI. MARINE INSTALLATIONS.

A. VELOX STEAM GENERATORS FOR SHIPS.

In view of the post-war planning now everywhere in progress it appears opportune to refer once again to the fact that the Velox boiler possesses all the properties which are required by a marine boiler. Furthermore the Velox boiler also has a number of other advantages which no other boiler possesses to the same extent. These are its extremely small space requirements, its low weight and high efficiency, the very short time required for putting it into operation, and the ease with which it can be regulated. It can be installed in the same room as the propelling machinery, so that no special boiler room is required and service is simplified. Furthermore, no smoke flues have to be provided, so that there are no restrictions as regards the arrangement of the lower decks. The installation plans already published by us[1] show two different designs of boiler, one being the standard type as used for land installations and also for merchant ships, and a special design intended for such cases where a particularly low weight and small overall height is of special importance. Each particular case can be considered separately so as to decide which type is more favourable. Due to the numerous Velox boilers which we have built and which have now been in service for many years, we possess sufficient experience to be able to supply boiler plants which guarantee an entirely satisfactory service. Moreover, the operation and maintenance of a Velox boiler does not make any greater demands on the staff than any other modern steam boiler or even Diesel engine.

B. MARINE STEAM TURBINES.

It can be assumed that many of the machinery plants installed in the ships which are now being built so hurriedly will be replaced after the war by more economical plants or at least improved. The majority of the existing plants consist of reciprocating engines which will be replaced by geared turbines, whilst for improving existing plants exhaust steam turbines will be added to the installations. During the past year we have been making the necessary preparations for this post-war work, so that the required machines can be supplied without delay. In this connection we wish to remind readers that our exhaust steam turbines possess a special feature, namely the spring ring coupling, by means of which it is possible, despite the flexible connection, to reduce the torque fluctuations of reciprocating engines within a single revolution to such an extent that the increase in power of about 30 % resulting from the turbine does not necessitate a replacement of the propeller shaft. The coupling also prevents the engine and turbine from racing when the propeller comes out of the water during rough seas.

For new plants we recommend the steam turbine for powers down to 1500 H.P. if steam operation is desired. The turbine is more favourable than the reciprocating engine as regards weight and size and is just as economical when steam conditions in accordance with present-day standards are selected.

C. GAS TURBINES FOR MARINE DRIVES.

If for some time now we have repeatedly referred to the gas turbine as the coming machine for ships, this is due to the experience obtained with land installations and from the conviction that these favourable results are also entirely valid when applied to marine service, because they are due to those properties of the gas turbine which in ships are even of still greater importance. These properties are simplicity, safety of operation, and small weight.

We are fully aware that the ratio of cost of the ship and of the cargo to the cost of the propelling machinery is one of the reasons for the proverbial conservatism of the shipbuilder and shipowner. On the other hand in order to improve the efficiency and fuel consumption of existing ships' drives such measures have been adopted in some cases that there is no longer any trace left of that simplicity which is the best guarantee for the safety of operation of the plant.

Thus it is known to provide a reciprocating engine with an exhaust steam turbine and connect both together over gearing and a fluid coupling. When manœuvring it is necessary to disconnect the turbine.

The geared turbine has also not been simplified by the introduction of high pressures and temperatures, and the multiple tapping-off of steam for feed-water preheating purposes. Although these complications concern the boiler and its auxiliaries and the combination condenser—preheater—boiler more than the turbine, the operation of the entire plant requires, however, considerably more careful and conscientious attendance than was the case with former installatious.

[1] The Brown Boveri Review 1940, p. 63/64; p. 232/233; 1943, p. 65.

In an article entitled "Monstrously ingenious" "The Engineer" of October 29, 1937, discusses the presidential address of Sir John E. Thornicroft before the Institute of Mechanical Engineers, in which the head of the world-famed torpedo boat firm referred to the fact that the propelling plants of torpedo boats had become increasingly complicated since the last world war. There it is stated that: "To complicate is easier than to simplify, but perhaps some day there will arise a designer who has the ability and courage to outweigh the disadvantages and even to set the merits of simplicity and resulting trustworthiness against some loss of efficiency or convenience."

This opinion is not an isolated one, because in a discussion concerning a paper read before the Society of Mechanical Engineers [1] about the application of the combustion-gas turbine to the propulsion of ships, Captain Lybrand-Smith, U.S.A. Navy, Head of Research Branch, Navy Department, Washington, D. C. stated:

"Reliability is the great essential for marine machinery. Common sense would indicate that a rotating machine with the only rubbing parts being the two bearings, would be more reliable than a reciprocating machine with its inherent great multiplicity of rubbing and tapping parts. So far as marine practice is concerned, all data which the writer has ever been able to gather confirms common sense.

Marine-turbine machinery is more reliable than reciprocating machinery, whether the latter be steam or internal combustion. As a matter of fact there is very little trouble with marine turbines themselves. There is much more trouble with their necessary adjuncts, such as condensers and boilers. Since the gas turbine would eliminate condensers and boilers, it would eliminate such troubles at the same time.

Gas turbines as power generators are too new in the field to have developed actual data for operating reliability. However, inquiries about gas turbines used by oil companies indicate an extraordinary reliability."

The remarks made here about gas turbines in oil refineries refer to the gas turbines, about 20 in number, supplied by Brown Boveri and their former American licencees, which are used for the Houdry process and of which a large number have been in operation for many years without a reserve, although the entire operation of such oil refineries depends upon the reliability of these machines.

The cited opinions of these two experts from English and American marine circles thus show that simplicity and the reliability connected therewith is a primary requirement of marine plants and that according to their conviction the gas turbine fulfils this requirement.

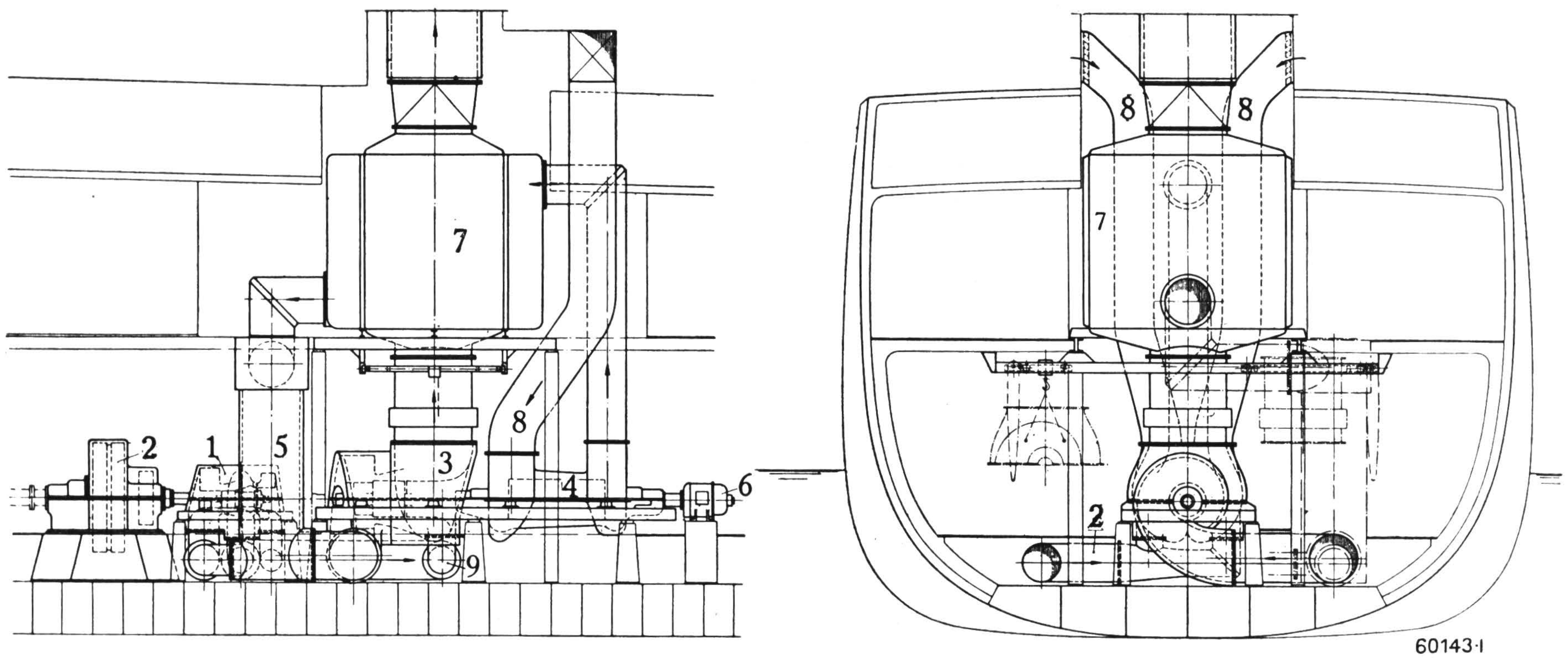
[1] Trans. Amer. Inst. Mech. Engrs., February, 1941.

In fact it is impossible to imagine a simpler machine than the combustion turbine developed by Brown Boveri and now proposed for the propulsion of ships.

A simple combustion chamber, which enables the cheapest fuel oil to be burnt and does not possess any tubes or elements endangered by heat, replaces the boiler with all its accessories, the only auxiliary machine needed being a small fuel pump. The combustion chamber being air-cooled does not require any cooling water. The gas turbine adjoins the combustion chamber. Its blade dimensions correspond to the blading of the intermediate pressure part of a large steam turbine. In accordance with the large quantity of gas the blades are large and very strong, the rotor being short because it only carries six to eight rows of blades. The critical speed lies above all service speeds; in brief the turbine possesses the most favourable conditions which it is possible to imagine as regards safety of operation and efficiency.

The exhaust gases leaving the turbine are employed in a heat exchanger to preheat the air which is compressed in a compressor and after being preheated is passed to the combustion chamber. This preheater consists of ordinary forged iron tubes, because the temperatures which occur there hardly exceed 350° C. By suitably dimensioning the heating surfaces of the preheater in accordance with the requirements of the type of ship or the ship's route it is possible to obtain an overall efficiency of 20—30% for the turbine plant, these being in extreme cases values such as hitherto could only be exceeded by Diesel engines, whereby it must be taken into account that the gas turbine burns a fuel which practically everywhere costs considerably less than Diesel oil.

According to the power and efficiency required, it is possible to employ either the simple combustion turbine or the combined combustion turbine plant. With the latter the compressor is driven by its own gas turbine; the compressor has about twenty stages also with very strong blades and operates within temperature limits of 140—200° depending on the initial temperature of the air which is drawn from the atmosphere and the final pressure after compression. This set can be operated at the speed which is most favourable for compression. The second turbine is that which supplies the useful power and drives the ship's propeller over a gear. This turbine is also very short and of powerful construction, and like the compressor turbine has about five to seven rows of blades which are, however, only half as big as those of the compressor turbine.



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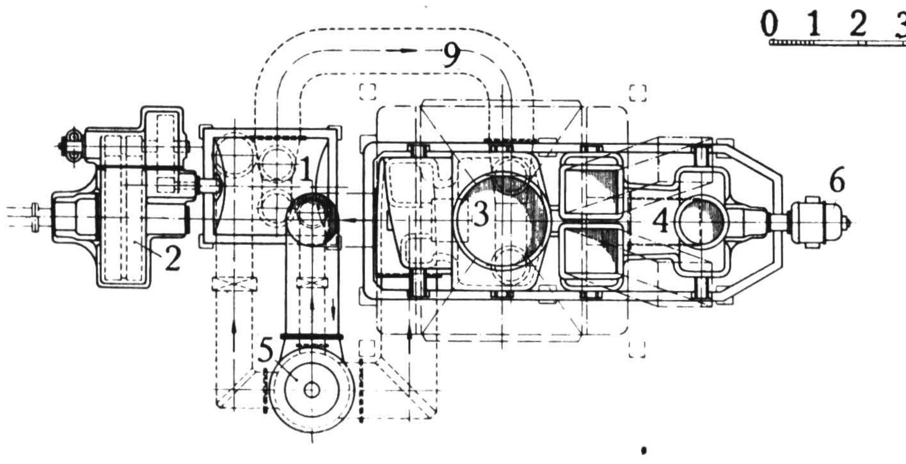

Fig. 171. — Combustion turbine plant of 6000 S.H.P. for a merchant vessel.

1. Useful power turbine 6000 S.H.P., 6000 r. p. m.
   It also contains an astern turbine in the form of an impulse wheel.
2. Double reduction gear, n = 6000/125 r. p. m. with propeller thrust bearing.
3. Driving turbine for compressor, approx. 12,000 H. P., n = 3000 r. p. m.
4. Compressor for the total combustion and cooling air of both turbines.
5. Combustion chamber for both turbines.
6. Starting motor, about 240 H. P. The current is supplied by a Diesel set.
7. Recuperator for preheating the combustion and cooling air, approx. 4000 m² heating surface.
8. Air suction pipe.
9. Exhaust gas pipe from useful power turbine.

Weight of both turbines including compressor and accessories	60 tons
Weight of gear and thrust block	45 tons
Weight of recuperator	50 tons
Total weight of machinery	155 tons
or 26 kg/S.H.P. Fuel consumption 250g/S.H.P.h.	

The combustion turbine is more favourable than the best steam plant both as regards weight and fuel consumption. It requires no cooling water, very little lubricating oil, and can be put into operation just as quickly as a Diesel engine.

The regulation of the plant is very simple. It influences the quantity of oil injected into the combustion chamber and furthermore actuates a two-way valve through which, according to the load, more or less driving gas is passed to the useful power or compressor turbine. This valve need never be fully closed, nor does it require to be a tight fit, so that it can be constructed as a very robust and insensitive element.

Thus when everything is taken into account a machine is available which as regards simplicity cannot be excelled and which up to the present, therefore, has proved to be extremely successful in all stationary plants. For travelling astern, it is necessary either to build a reversing stage (impulse wheel) into the useful power turbine or to employ a variable pitch propeller. The former element is simple and under much more difficult conditions has on innumerable occasions proved to be absolutely reliable in steam turbines. Also the second element, the variable pitch propeller is rapidly coming into general use. Up to the present such propellers have been constructed for powers up to 3500 H. P., some of these having to operate under very difficult conditions, for instance on ice-breakers, where they have proved very reliable.

We are prepared to build plants up to 10,000 S.H.P. with the usual guarantees as regards delivery time and oil consumption.

Fig. 171 shows a combustion turbine plant of 6000 S.H.P. for a merchant vessel. It comprises a useful power turbine which drives the propeller over a double-reduction gear, and a special turbine for driving the compressor. Both turbines receive their driving gases from a common combustion chamber. The recuperator is located above the machine plant and its exhaust gases can pass directly into the chimney.

D. MARINE AUXILIARIES.

Although our opportunities for supplying marine machinery are very restricted under present circumstances, during the past year we have nevertheless received a considerable number of orders for small turbines for driving ship's auxiliaries. Quite a number of the small-turbine type depicted in Fig. 172 have been supplied by us for driving circulating pumps. We should like to emphasize particularly that our small turbines, due to their simple and robust design, are suitable even for the roughest operating conditions aboard ship and are therefore finding increasing application. Their simple attendance and easy operation can readily be undertaken by an untrained staff. The bearings are air-cooled and grease-lubricated, and the grease has generally only to be replenished about once a year.

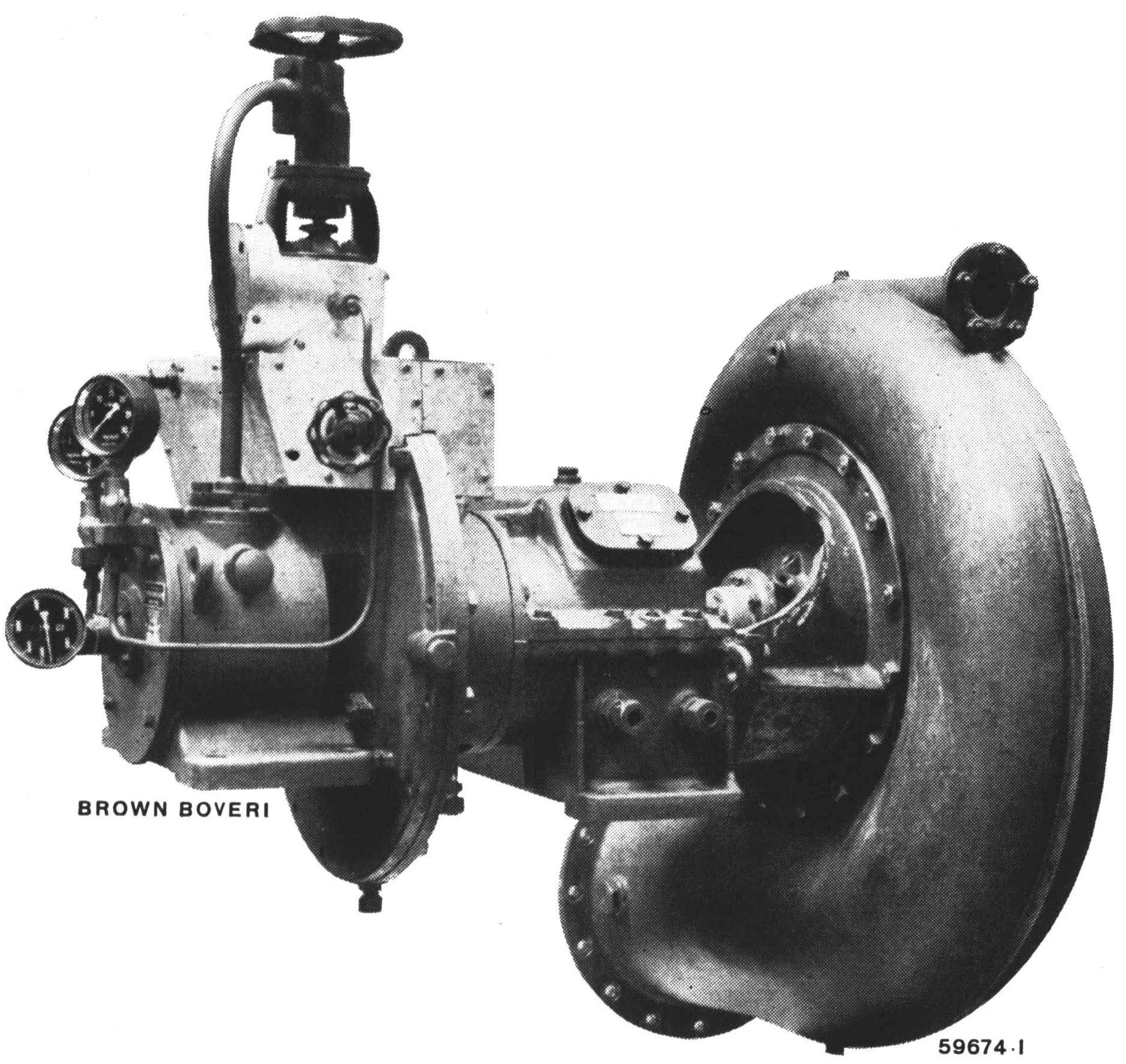

Fig. 172. — Small turbine for driving marine circulating pumps.

This small turbine has a rating of 25—60 H.P. It is of very robust construction, requires very little attendance and is easy to operate. Its roller-type bearings are grease-lubricated and air-cooled. The turbine is coupled over a gear with the machine which it has to drive and connected to it by means of flanges.

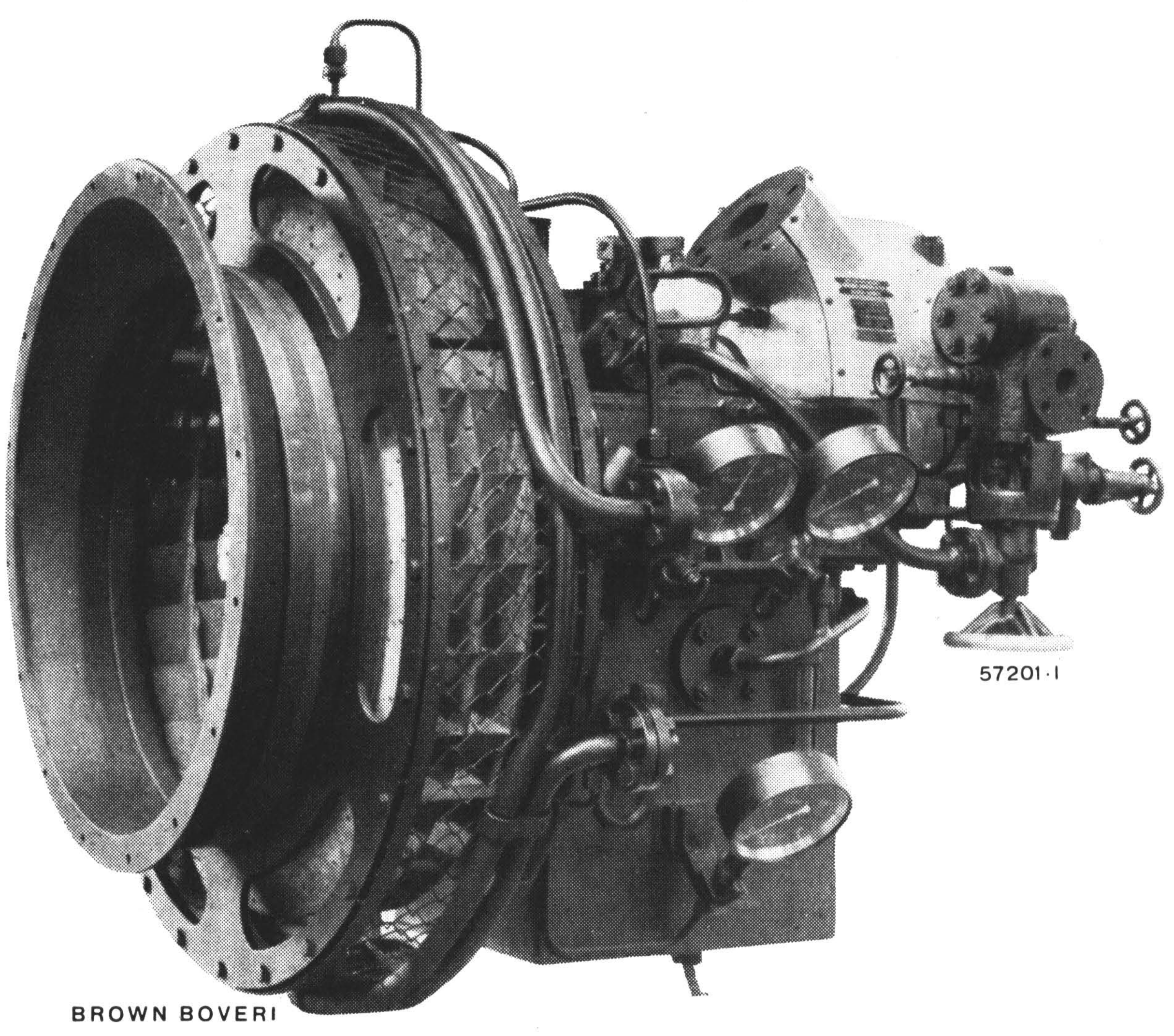

Fig. 173. — Boiler-room fan for torpedo-boats.

Delivery volume approx. 8 m^3/s, driving power approx. 40 H.P. This arrangement with high-speed turbine and spur wheel gear results in a light and reliable set requiring very little space. The oil for the bearings and gear is cooled in a coil subjected to a cooling air stream. The hand-operated control valve also serves as a quick-acting stop valve.

Another constructional example is illustrated in Fig. 173.

We have again supplied complete electrical auxiliary equipments for a number of merchant ships. The splash-proof protection of our marine auxiliaries has been improved to such an extent that machines with this form of protection suffer practically no decrease in power when compared with those having drip-proof protection (Fig. 174). Our designs of electrical marine auxiliaries with drip-proof, splash-proof and hose-proof protection have been still further simplified. Motors with these forms of protection now only differ from each other in so far as the cover over the air ducts is constructed differently in accordance with the protection desired, whilst in all other respects the motors are identical. For some time now we are supplying both d. c. and a. c. machines for marine installations with aluminium windings; only the armatures of d. c. machines are still provided with copper windings. Special measures have been taken with the aluminium windings in order to protect the joints between the aluminium windings and the copper cable against the effects of the damp salt air which causes corrosion. The reliability of our construction was first tested very thoroughly, machines with aluminium windings at a standstill and in operation being placed continuously in a steam bath at 100° C and then left in a saline spray. Machines with aluminium windings supplied by us have therefore proved to be thoroughly reliable in marine service, so that the usual

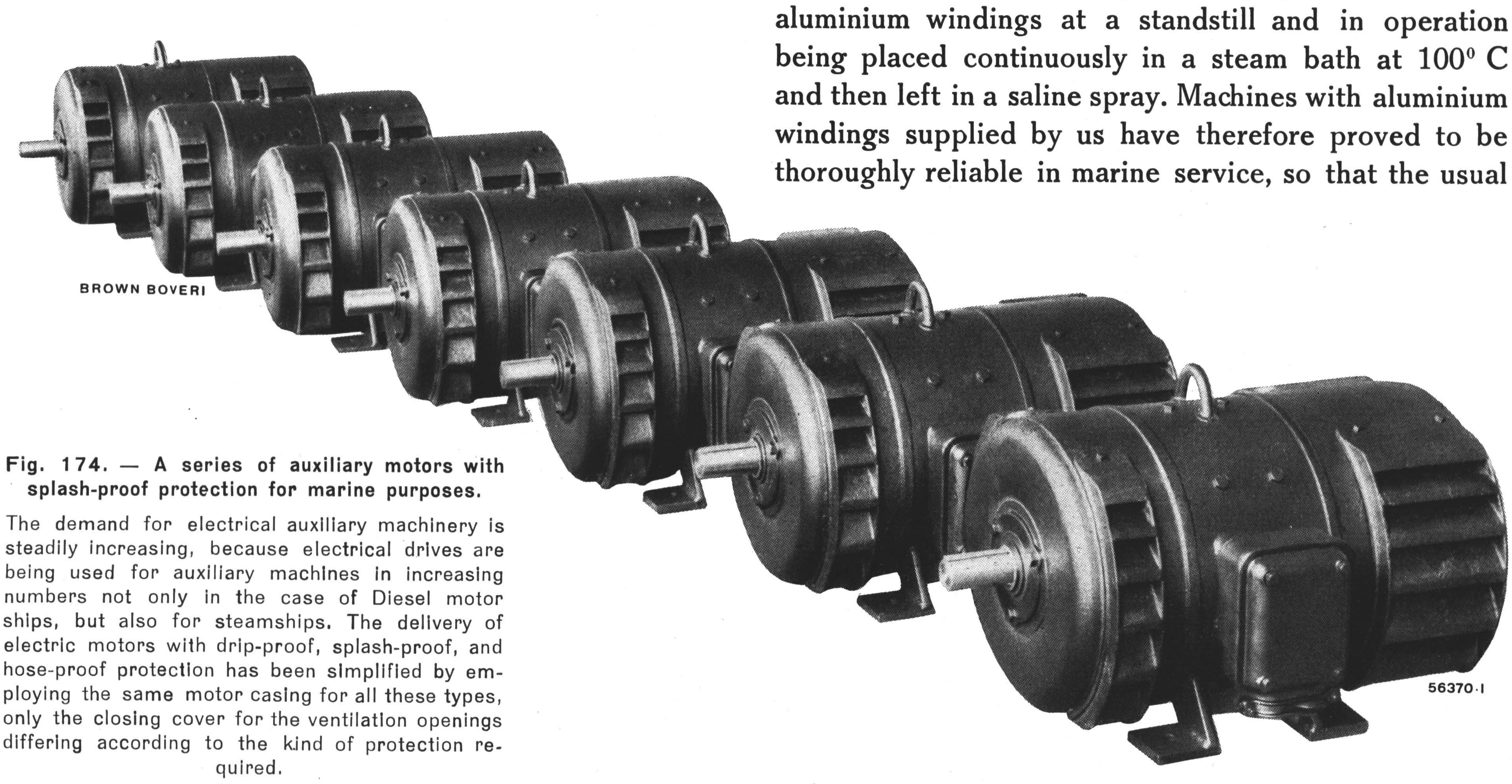

Fig. 174. — A series of auxiliary motors with splash-proof protection for marine purposes.

The demand for electrical auxiliary machinery is steadily increasing, because electrical drives are being used for auxiliary machines in increasing numbers not only in the case of Diesel motor ships, but also for steamships. The delivery of electric motors with drip-proof, splash-proof, and hose-proof protection has been simplified by employing the same motor casing for all these types, only the closing cover for the ventilation openings differing according to the kind of protection required.

objections to the use of aluminium for electrical machinery are absolutely unfounded.

During the past year we have again received a considerable number of orders for "Helux" equipments with automatic voltage and charging regulators. Our "Helux" sets for small powers are now also being used on river boats, because with our small regulator

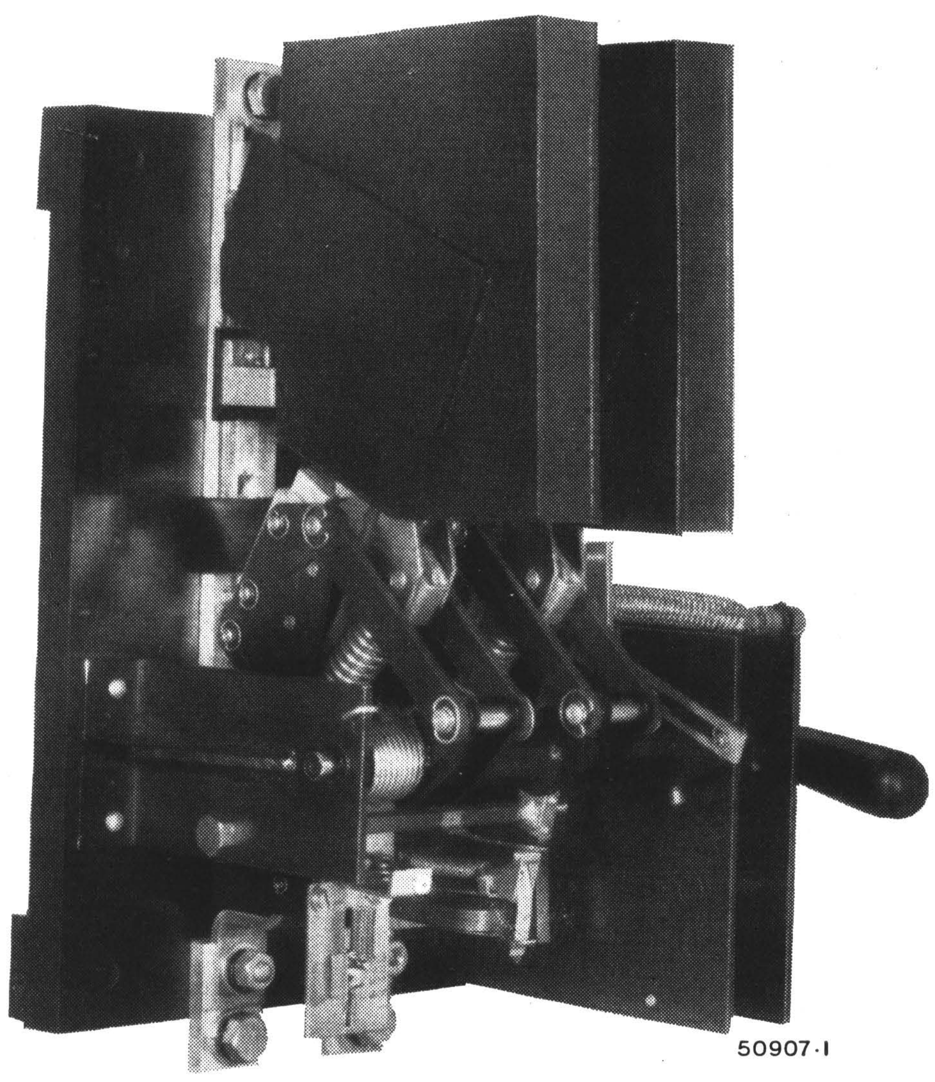

Fig. 175. — Automatic marine-type-circuit breaker for auxiliary power generators, direct current 250 A, 220 V.

Our new automatic circuit-breakers which are built for 100—2500 A, direct and alternating current, and a test voltage of 4000 V, have low weight and moderate space requirements. They are supplied according to requirements with thermal releases or excess-current time relays, reverse current and low-voltage release, and are either fitted with a handwheel or arranged for remote control.

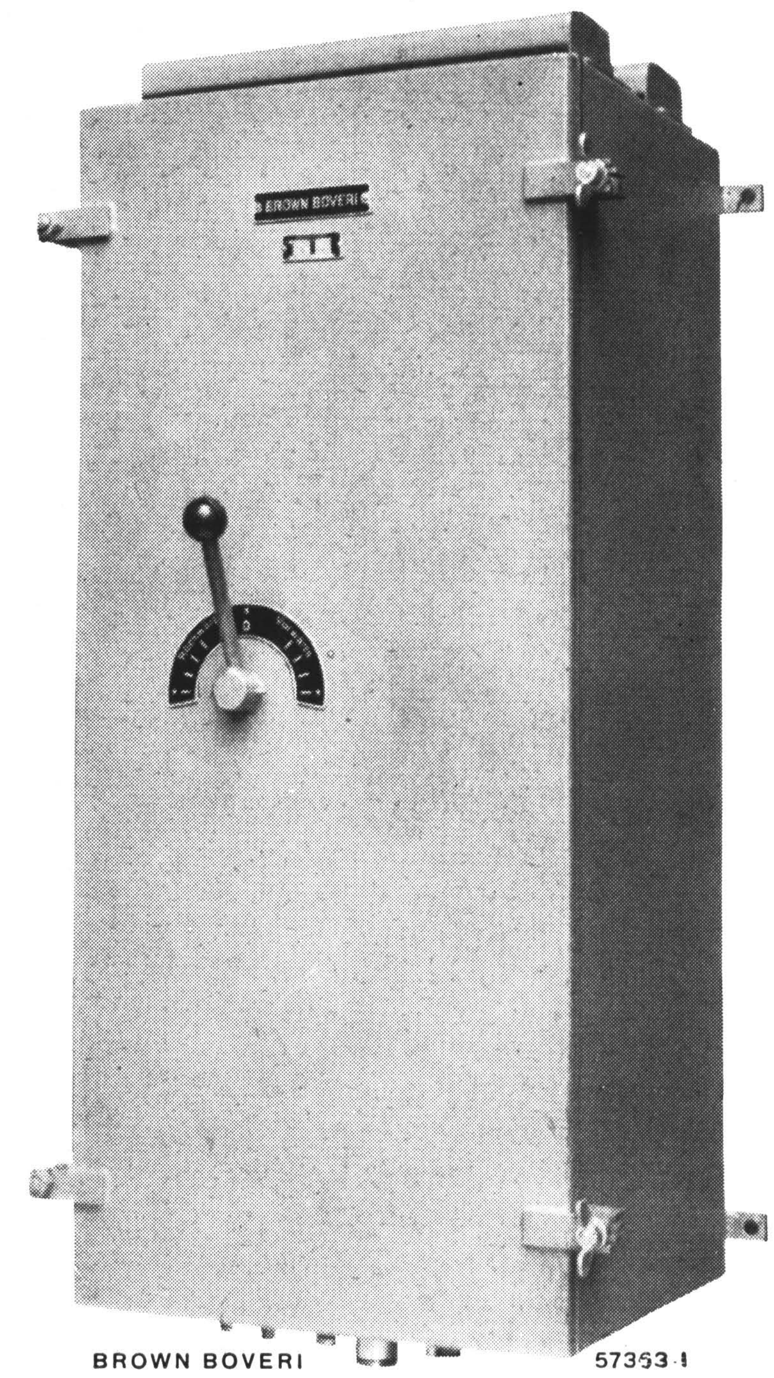

Fig. 176. — Marine-type reversing starter with series regulation for Diesel engine barring gear drives, splash-proof protection with double-pole network interruption, excess-current and low-voltage release, as well as four control positions for each direction of rotation.

The switching operations are performed by means of powerful switch elements operated by a cam shaft. The switch elements are provided with blow-out coils and sparking chambers and operate perfectly reliably with a minimum of contact wear even when operated very frequently.

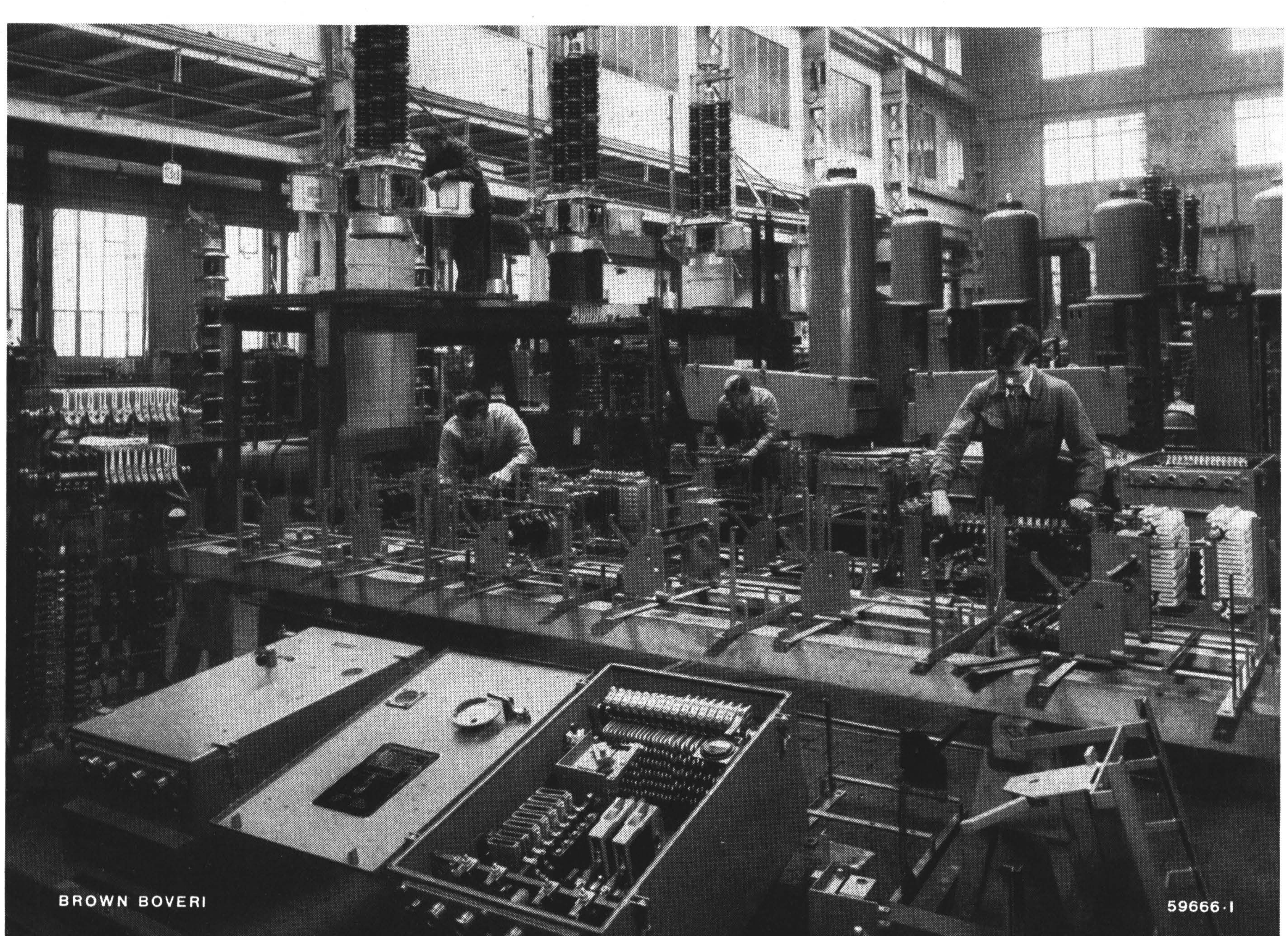

Fig. 177. — View of the workshops where our d.c. marine starters for motors up to 70 H.P. are produced in series and kept in stock without resistance elements and coils, to enable them to be supplied at short notice.

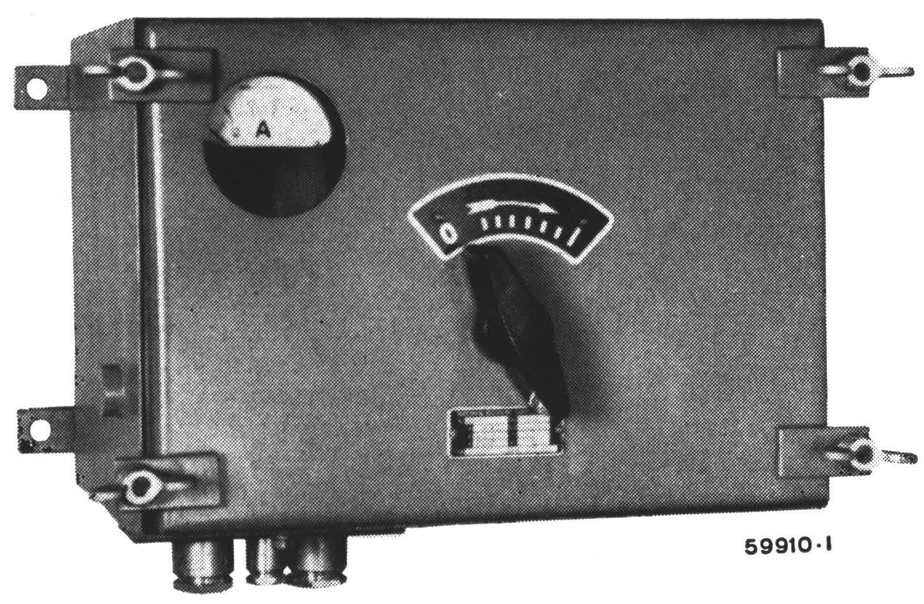

Fig. 178. — Marine face-plate starter for small d. c. auxiliary drives up to 5 H.P.

Compact design with excess-current and low-voltage release in a strong casing for bulkhead mounting.

the costs of the lighting plant are comparatively low. The battery is recharged automatically while the ship is under way, so that the lighting system does not require much attendance. Up to the end of 1943 we supplied up to a thousand automatic voltage regulators, current regulators, or automatic synchronizers for marine auxiliary power stations, this apparatus being in service on naval vessels of all types as well as on every size of merchant vessel, where it is operating to the clients' entire satisfaction.

Amongst apparatus we have supplied for marine installations is the new automatic circuit breaker for d. c. and a. c. generators built for current ratings of

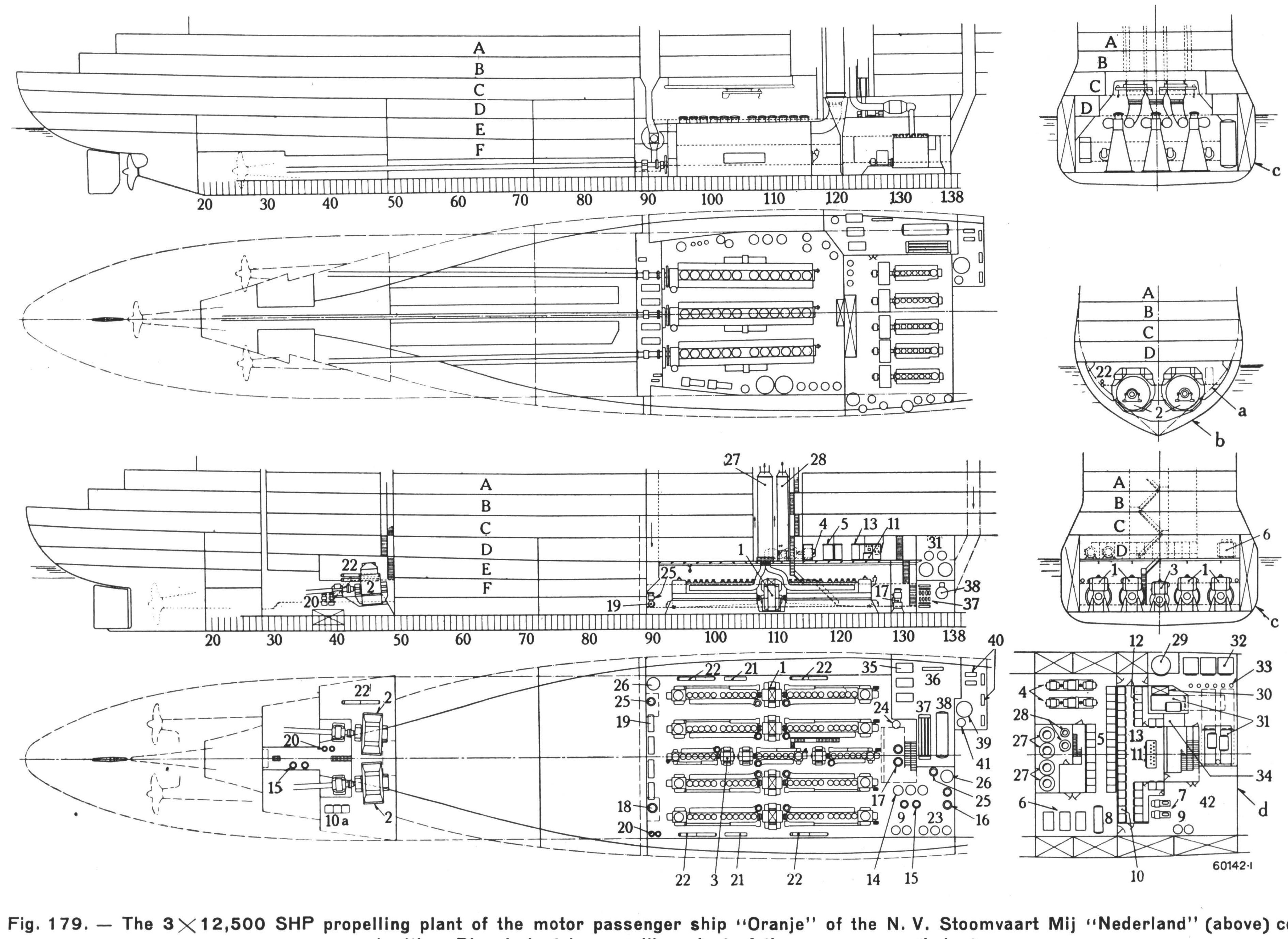

Fig. 179. — The 3×12,500 SHP propelling plant of the motor passenger ship "Oranje" of the N. V. Stoomvaart Mij "Nederland" (above) compared with a Diesel-electric propelling plant of the same power (below).

Normal Diesel engines with 320 r. p. m. and not special high-speed engines have been selected for driving the generators. Despite this the space required for the Diesel-electric drive is smaller than that required by the direct Diesel engine drive, valuable space amidships above the engine room being saved.

1. Main Diesel-generator sets.
2. Propulsion motors.
3. Harbour Diesel-generator sets.
4. Exciter sets.
5. High-voltage switchgear for main generators, propulsion motors, and transformers.
6. Transformers.
7. Compressors.
8. Compressed air tank for switchgear.
9. Starting-air tank for Diesel engines.
10., 10a. Switchgear for main generators, propulsion motors, exciters and transformers.
11. Control panel.
12. Switchgear for harbour Diesel-generators and low-voltage supply plant.
13. Control room.
14. Fresh water cooler for Diesel engines.
15. Sea water cooling pumps.
16. Reciprocating cooling pumps.
17. Fresh water cooling pumps.
18. Bilge pumps.
19. Lubricating pumps for main engines and generators.
20. Oil pumps.
21. Service oil pumps.
22. Oil coolers.
23. Sanitary pumps.
24. Ballast pumps.
25. Drain-water pumps.
26. Drain-water tank.
27. Waste-heat boiler.
28. Exhaust-gas and electric-boiler.
29. Steam separator.
30. Hot water tank.
31. Evaporator for drinking water.
32. Air-mixing tank for drinking water.
33. Norit filter.
34. Deaerating tank for drinking water.
35. Compressors for refrigerating plant.
36. Control panel for refrigerating plant.
37. Ammonia condenser.
38. Fresh water cooler for air-conditioning plant.
39. Cold water tank for air-conditioning plant.
40. Circulating pump.
41. Emergency bilge pump.
42. Space for workshop, auxiliary machinery, stores, etc.

a. Frame 37 b. Frame 49 c. Frame 100 d. Deck D

100—2500 A. These new circuit breakers, although they possess the same technical properties as the former design, are considerably more favourable as regards weight, price, and space requirements (Fig. 175). We have also received a considerable number of orders for our newly developed marine-type starters for d. c. motors, including a number of orders for reversing starters with series regulation for Diesel engine barring-gear drives, these starters being of a similar design to the cam-operated starters mentioned in our last report (Fig. 176). These d. c. starters are now kept in stock for motors up to 70 H.P. without resistance elements and coils, so that they can be supplied at short notice (Fig. 177). We have developed a new marine-type face-plate starter for d. c. drives up to 5 H.P., this starter being of a very compact design and combining the starting elements with over-current and low-voltage release, isolating switch, and ammeter in a single casing for mounting on the bulkhead (Fig. 178). We are, therefore, able to supply marine-type starters for all sizes of d. c. motors used on ships.

E. ELECTRICAL MARINE DRIVES.

The particulars given in numbers 9/10 of the Brown Boveri Review for 1942, concerning the Diesel-electric drive have aroused great interest in shipowners' circles, and have resulted in a number of interesting projects for marine drives which are to be realized after the war. These projects show that the Diesel-electric three-phase a. c. drive with the high-speed Diesel engines now available, results in very favourable conditions as regards weight and space requirements, and that particularly as regards special requirements in connection with main and auxiliary power systems it is more adaptable than any other kind of drive. In the periodical "Motorship", June, 1943, page 70, it is proposed that after the war the "Liberty" ships which are fitted with reciprocating engines and of which there will presumably be several hundred available at the end of the war, should be converted into vessels with a speed of 14—16 knots by means of geared Diesel engine or Diesel-electric drives, because their present maximum speed of 11 knots will no longer be adequate for post-war conditions. Our investigations have shown that such a conversion with a Diesel-electric a. c. plant comprising a propulsion motor and five Diesel-generator sets running at 375 r. p. m. and built for a ship's speed of 15 knots is quite possible; the existing engine room of the ship is not even fully required for this conversion, so that additional cargo space becomes available. Fig. 179 shows a comparison between a direct Diesel drive and an a. c. Diesel-electric drive for a large passenger ship. In this case it is possible to improve the propulsion efficiency of the plant by selecting a twin-screw drive instead of a triple-screw drive, because with electrical drives the power per shaft is not restricted in any way. The illustration shows that the space required for an electrical drive is considerably less than that for a direct drive, and that due to the much smaller overall height of the Diesel-generator sets when compared with the slow-speed Diesel engines much valuable space amidships can be saved for passenger cabins. Since the total propelling power only determines the number but not the power of the parallel connected Diesel-electric generator sets, motor-ships with a. c. Diesel-electric drives can be built for powers hitherto only obtainable with geared turbine or turbo-electric drives.

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(E. G. W., D. S., Op.)

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