BROWN BOVERI REVIEW

The Factory at Birr – 1966

The road through the factory is bounded on the left by the canteen and office blocks and on the right by the factory extension.

1891 *75 Years Brown Boveri* 1966

OVERI REV. VOL. 53 No. 6/7 p. 381–440 BADEN, JUNE/JULY 1966

Printed in Switzerland

View from the north-west showing the factory extension and the new office blocks of the second building stage adjacent to the heavy engineering shop which has been in operation since 1960 and can be seen in the background.

The Brown Boveri Review

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

VOL. 53 JUNE/JULY 1966 No. 6/7

CONTENTS

EXTENDING THE FACTORY AT BIRR FOR THE PRODUCTION OF MEDIUM-SIZE ELECTRICAL MACHINES

The part of the factory erected during the first phase, from 1957 to 1960, was intended for the production of large and very large rotating electrical machines up to 500 MW and above.[1] At that time, after an extensive period of study, a comprehensive architectural layout was drawn up for the newly acquired factory site covering an area of approximately 500000 m². This general plan, which was the basis for exploitation of the site, still maintains its validity today. In the second building phase, which is described in this issue, the factory and service areas are still being constructed to this plan, but the design for the offices, administration block and amenities has been changed in the light of experience gained in the meantime.

After six months of planning, agreement was reached in December 1960 on the extension of the existing plant at Birr. In the new extension it is intended to produce medium-size rotating electrical machines rated between 30 and 4500 kW and weighing between 200 and 10000 kg. Thus, with the exception of the small electric motors, all rotating electrical machines will in future be made in the Birr factory.

Apart from the primary object of rationalizing production of those items transferred to Birr, this also presented an opportunity for partially modernizing the production machinery in Baden and made available urgently needed office space. In particular, more workshops became available for the Turbine Factory, enabling it to cope with the increased demand and larger machines. Further to this there was a certain reduction in the volume of traffic and the demand for housing in the very congested Baden area, as a direct result of the transfer of certain production sections to Birr.

[1] See Brown Boveri Rev. 1960, No. 7: The New Brown Boveri factory in Birr (Aargau).

The second building stage includes the erection of workshops covering a floor area of 34 000 m^2, including the basements. The bays are 18 m wide and 270 m long, the load capacity of the floor being 3 t/m^2. The crane hook height is 6·1 m and the cranes can carry up to 10 t, depending on application, but up to 20 t can be handled using two cranes.

Building work started in 1961 and production departments were successively moved from the end of 1962 onwards. The design of workshop selected for the first phase was retained, though to save time it was found more practicable to prefabricate the roof sections.

From the point of view of factory planning, due consideration was accorded to the progressive developments which are expected to take place in the fields of fabrication techniques and machine tool design, demanding a certain amount of flexibility in the buildings. Provision had to be made at the time for the adoption of unforeseeable methods which may mean that machines have to be regrouped or replaced with a minimum of complication. To ensure this flexibility the workshop floor either consists of a concrete slab with surfacing 25 cm thick, or it is recessed and underslung. Certain machines and ancillaries are mounted on base-plates which have to be exchanged if the machines are replaced or repositioned.

Apart from the production shops the second phase includes various buildings for research laboratories, offices, stores, locker-rooms, a canteen and gate-house. The picture inside the front cover shows the view of the new buildings from the north-west.

The windowless concrete cube standing apart from and at the north end of the main group of buildings contains the acoustic research laboratory. For size and the technical equipment it contains, it is without equal in Europe.

The 7000 m^2 of useful office floor area are divided up between two five-storey office blocks and two storeys of the north wing. As for the first phase, the locker-rooms for the workers are underground and contain facilities for 1500 persons. They are connected by corridor with the workshops and canteen, which allows the users freedom of movement, regardless of the weather.

Across the southern end of the factory building is an area for the reception and inspection of incoming goods. The despatch department was started in the first phase and is situated at the north end, so that there is a flow of material from south to north.

The architect chose a special design for the canteen building with a totally different atmosphere from the rest of the works, so as to give the workers a maximum change of surroundings during their lunch break. The canteen facilities are sufficient to cater for 2600 persons in three shifts.

A closely knit team of architects, engineers, planners and contractors worked hand in hand towards the common goal in drawing up the plans for this large-scale project which is fraught with complexities. After thorough research and many discussions, modern workshops with capacity for expansion were evolved. As with the first phase, the importance of inter-departmental cooperation when a large factory has to be completed in a very short time has once again been clearly demonstrated.

(AH) M. GEISSBÜHLER

PLANNING THE PRODUCTION PLANT FOR BIRR, PHASE TWO

658.23

The second building phase at Birr involved moving the production of medium-sized electrical machines from Baden to Birr, to join the plant for manufacturing large machines which was already there. The layout of the departments and machines provided the basis on which the architect and civil engineer evolved their designs.

The Production Programme

WHILE the first phase of the works at Birr, described in the July 1960 number of the Brown Boveri Review, is concerned with the manufacture of large rotating electrical machines, phase two is intended for one-off and short-series production of medium-size machines. The borderline between these and large machines is a maximum weight of 10 tons and had already been set for the first phase. This resulted in other maximum dimensions, such as 5 tons for rotor weight, roughly 1000 mm for rotor diameters and 4 m for axial length. The range of electrical capacities extends up to about 4500 kW.

The lower limits were imposed less by geometrical dimensions and electrical capacities than by lot sizes in assembly. Thus, production of standard motors and series-produced items with service voltages up to 500 V will remain in Baden.

The production programme covers the following types of machine:

Medium-frequency generators
Asynchronous motors of 30–4500 kW
Synchronous machines (without turbogenerators)
Three-phase, variable-speed commutator motors
Direct-current machines
Exciters for generators
Motors for railway locomotives

In each and every case these machines must be made to suit the customer's specification, which means a great multiplicity of designs. On average, each order contains less than two identical machines (Fig. 1) and so the new plant had to be designed for one-off and short-series production. Consequently, it was not possible to define the production programme exactly in terms of types and numbers. Instead, production capacities for the different groups were determined in collaboration with the sales departments in terms of sale value.

A preliminary study was carried out to determine whether production should be split into parallel lines, a.c.–d.c. for example, but because of possible long-term changes in emphasis in the production programme and the overwhelming proportion of features of production which are held in common, preference was given to a closed production line.

The Basic Planning Programme

The planning of a factory requires specific numerical values for manhours at the different workplaces (Fig. 2), together with their sequence in the

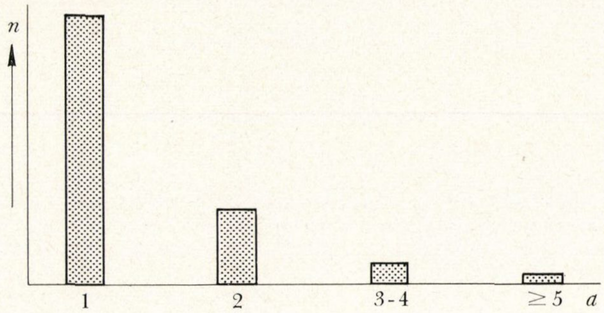

Fig. 1. – Number of orders (n) and number of items (a) per order

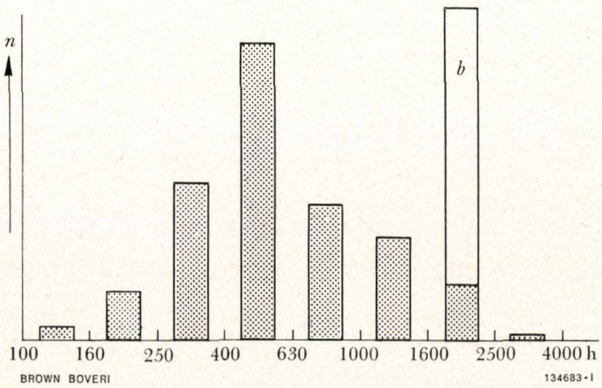

Fig. 2. – Number of motors (n) and the set time per motor (h)

b = Railway locomotive motors

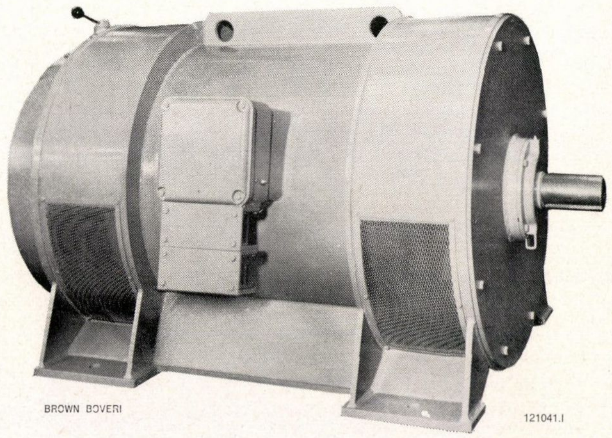

Fig. 4. – Three-phase induction motor type MSn 246 ko

1000 kW 6000 V 116 A
n = 985 rev/min f = 50 c/s

flow of materials. Using computers it would be possible to calculate the required number of hours by extrapolating previous times, but as the data were not available in a form suitable for a computer, and account had to be taken of substantial changes in production techniques, we had to find a different way.

Representative types were selected in the light of practical experience, and the hours required for these at each workplace, together with the sequence of operations, were obtained from workshop records. Summation of the manhours gave the load per machine or department. By varying the numbers and types of motor to correspond with the anticipated changes in the composition of orders it was also possible to find the fluctuation in the hours involved.

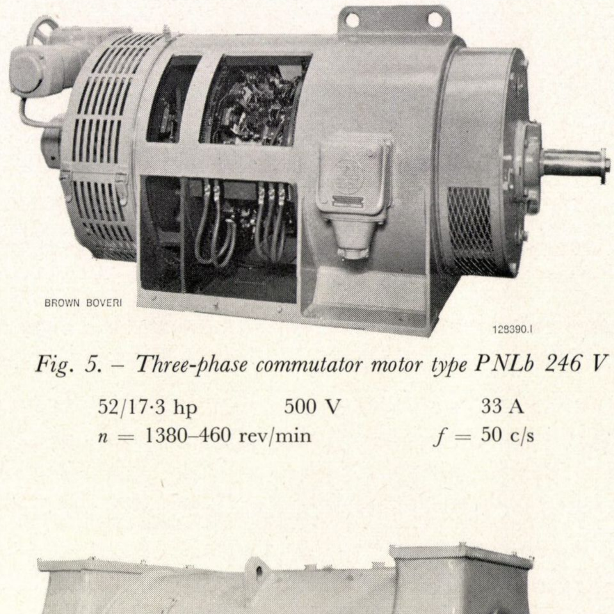

Fig. 5. – Three-phase commutator motor type PNLb 246 V

52/17·3 hp 500 V 33 A
n = 1380–460 rev/min f = 50 c/s

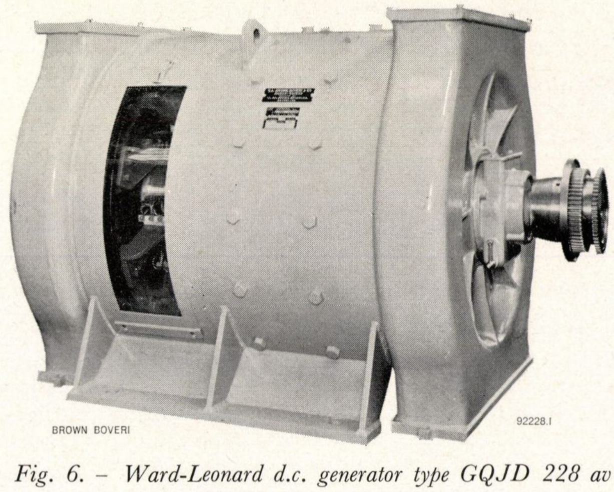

Fig. 6. – Ward-Leonard d.c. generator type GQJD 228 av

1000 kW 450 V 2220 A
n = 1000 rev/min

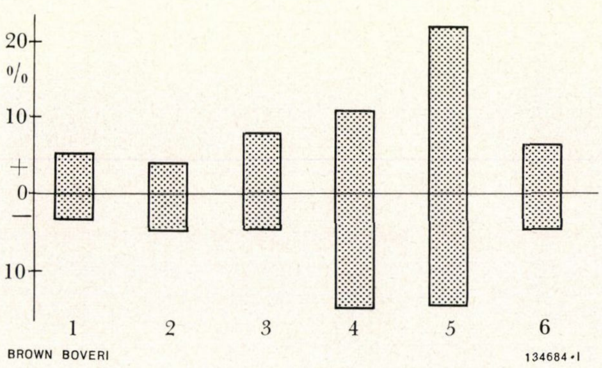

Fig. 3. – Scatter of manhours required per month for constant value of sales and normal variations in range of products

The calculations showed that these numbers of hours differ from the monthly mean by 5 % in the main departments and by more than 20 % in the secondary departments (Fig. 3). Production must therefore necessarily possess a certain amount of flexibility, by moving labour to other workplaces, for instance, by reorganizing the timing of certain production runs (in the case of spare parts, for example), or by balancing the load with other parallel lines of production.

The Transport System

The production of medium-sized machines takes approximately 4000 tons of materials a year. The weights of individual items needing transport vary from the order of grammes to 10 tons for the largest fully assembled motor. A few main lines can, of course, be distinguished from among the many sequences of operations, but the transport system must include allowance for 20 % transverse and backward movements.

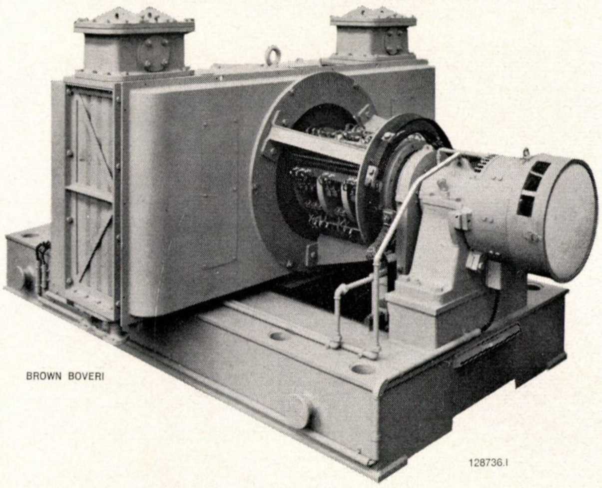

Fig. 7. – Direct-current turbo-exciter type GTD 196a with pilot exciter type GFT 14s

570 kW 380 V 1500 A
n = 3000 rev/min

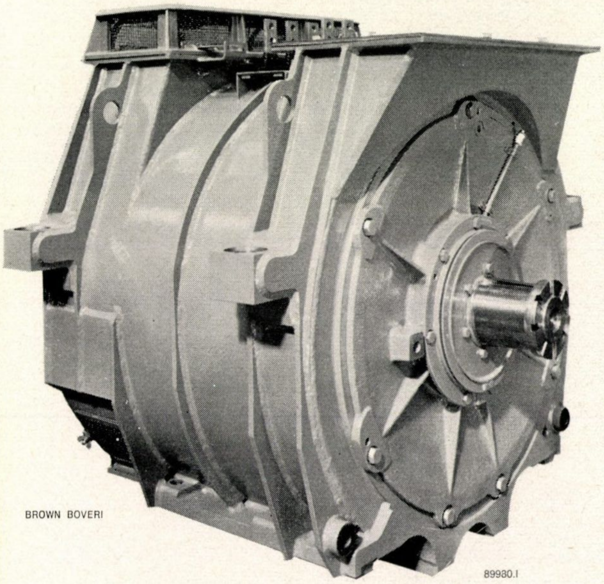

Fig. 8. – Traction motor for Ae 6/6 locomotives of the Swiss Federal Railways with class F insulation

One-hour rating 1150 hp 420 V 2300 A
n = 800 rev/min $f = 16^2/_3$ c/s

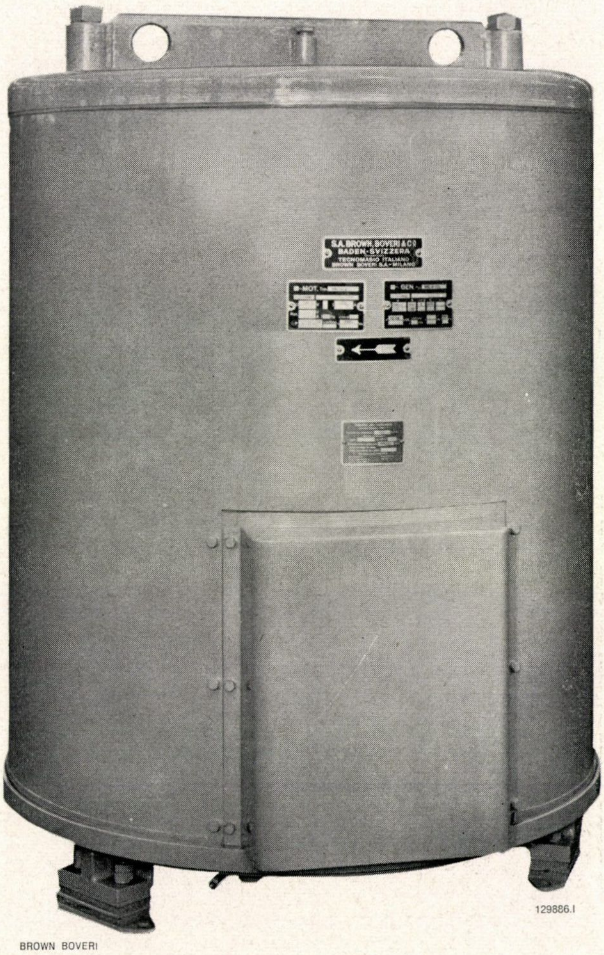

Fig. 9. – Medium-frequency converter type WMUV-10z with cooler and casing

45 kW 540 V 84 A
n = 3000 rev/min f = 9800 c/s

Suitable solutions had to be found for the varied transport requirements and so the existing railway siding was extended by a line for the store. Cabin cranes have been provided for carrying heavy objects in the individual halls and supplying the workplaces with heavy workpieces. So as to be able to transfer heavy material from the store directly into the production bays the crane-track in the transverse bay was set higher, so that the crane-tracks in the production bays extend into the transverse bay. As a result the crane hooks overlap slightly, which has its advantages. Furthermore, trucks and trailers are available on request from the transport department.

Fork-lift trucks with trailers do round trips carrying moderate-sized workpieces on pallets and small items in boxes. A special trip is made in the evening to collect the waste bins, which are then emptied in a refuse store beyond the bays. Liquid waste such as paint or cutting oil is taken to an incinerator.

In the large-bar winding shop a series of workplaces are linked by roller and plate conveyors. The sequence of operations is extremely varied in the case of the small bars, and so special pallets were developed which can be pushed by hand from one workplace to another like trolleys.

Since for structural reasons a basement was to be built under the production area, hydraulic lifts capable of carrying 6 tons were installed to join up with the storage space below.

In general, transport facilities at floor level are much more plentiful than was the case in Baden, and consequently the design included a road 2 metres wide running the length of each bay, which is wide enough to allow a vehicle and a pedestrian to pass.

Arrangement of Departments

The manhours for each type of machine or workplace obtained from the basic programme gave the number of workplaces to be provided, with account taken of possible shift-working. For the sizes of the individual places we were able to take the values determined by experience at Baden and adapt them to the new circumstances. A temporary model of the machines and their appropriate workpieces was used to determine the dispersal areas and storage spaces within departments.

Various arrangements of the departments could be tried out with the individual space requirements obtained in this way. In addition to the medium-sized machines, allowance also had to be made for isolated departments concerned with large-machine production, such as the generator-bar winding shop, which had been only partly moved from Baden to

Bay dimensions

	36-m bay	24-m bay	18-m bay	Transverse bay
Width (axes)	36 m	24 m	18 m	27 m
Length	270 m	270 m	270 m	144 m
Height, roof section lower edge	23·9 m	15·8 m	9·3 m	13 m
Height, roof section top edge	32·5 m	21·4 m	13 m	–
Height of crane hook 150 t	19·6 m	–	–	–
Height of crane hook 60 t	15·5 m	12·3 m	–	–
Height of crane hook 20 t	–	–	–	9·95 m
Height of crane hook 10 t	12·9 m	9·6 m	6·1 m	–
Max. transportable weight	300 t	120 t	20 t	40 t
Floor loading	9 t/m²	9 t/m²	3 t/m²	9 t/m²
Basement	partial	partial	complete	–

Construction of bays:

Foundations, basement and bay floors of in situ concrete.
Columns with crane tracks in steel.
Roof sections of 36-m and 24-m bays of in situ concrete.
Roof sections of the new 18-m bays prefabricated on site.
Weight complete appr. 60 t.

Lighting: Daylight through roof.
Artificial lighting by fluorescent tubes.
Heating: Radiant (160 °C) in roof, radiators under windows on outside wall, air to basement heated to 16 °C in heater batteries.

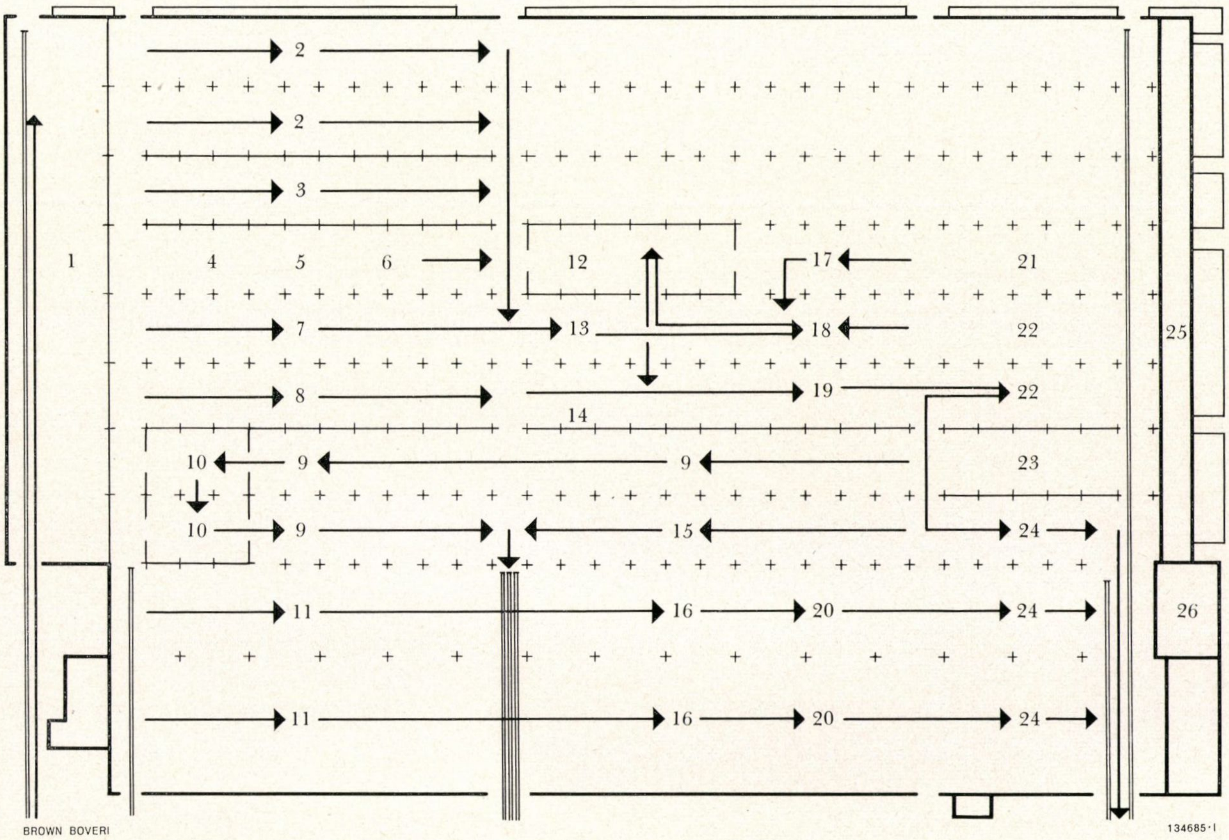

Fig. 10. – Arrangement of departments at Birr factory, as in 1964

1 = Goods-inwards and storage bay
2 = Press shop
3 = Welding shop
4 = Machine maintenance
5 = Machine fittings
6 = Commutators
7 = Casing and shaft lines
8 = General machine shop
9 = Large-bar winding shop
10 = Large-bar impregnating shop
11 = Large machines department
12 = Medium machines impregnating shop
13 = Sheet-metal shop
14 = Tool and drawing store
15 = Coil-winding shop, large machines
16 = Large machine assembly
17 = Small-bar and coil winding shop
18 = Winding assembly, medium machines
19 = Final assembly, medium machines
20 = Assembly and testing, large machines
21 = Training department
22 = Testing bay, medium machines
23 = Power plant
24 = Packing and dispatch
25 = Apprentices' shop
26 = 45-kV substation

Birr in the first phase. The main transverse axes determined during the first phase, and the arrangement of the bays, constituted a layout into which the new departments had to be fitted.

The definitive departmental layout shown in Fig. 10 transpired from discussions with the parties concerned, and served as a basis for further development of the project by the builders on the one hand, and the detail planning department on the other. The departments run from south to north, following the flow of materials, with the exception of the winding shops for bars, which run north-south. Transverse links could not be avoided, but do not upset the flow as they are mostly combined with the storage of finished parts in the basement. Departments having no direct contact with the production line, such as the apprentices' shop, the training department for winders and the development laboratories, are located at the side of the production area, though also to some extent in areas set aside for future extensions to production.

Detailed Layout-Planning

A subsequent planning stage involved determining the exact positions of all the machines and equipment with the aid of a model of the factory to a scale of 1:50. The model machines were arranged in the individual departments in accordance with the sequence of operations. Special fabrication lines were set up for shafts and casings. For the various small components the machines were arranged by type, though in accordance with the general manufacturing sequence. In certain instances, such as the extremely diverse manufacture of coils and bars, the separate sequences of operations were arranged according to their frequency, and the distribution of the workplaces was determined graphically from this.

Models of workpieces and people were also made to complete the miniature layout. It was then used for evolving detailed plans concerning installation of the machines. This required continuous close contact between builders, installation engineers, the suppliers of the machines and the relevant factory staff.

The division of the shop floor into a reinforced load-bearing part and a layer of structural concrete facilitated completion of the detailed plans on schedule, in that, as building progressed, work could be concentrated chiefly on those installations which required openings in the load-bearing part.

Basements

The building structure and the level of the bays of the first phase meant that the new bays, too, could be largely provided with basements. Only the storage bay has none. The basement was designed to contain principally those items which are directly connected with the production plant: certain machine foundations, impregnation plant, furnaces, extraction plant, the balancing machine, transformer stations and technical installations for the testing bay. The main equipment for electricity, air and water are installed under the basement ceiling; subsequent distribution is via conduits in the bay floors. The air-raid shelters are divided into two groups and, by means of removable thresholds, can be used for storing spare parts for the machines, tools and apparatus. The lifts on the main transverse axes are combined with the staircases and sanitary services. Since temperatures in the basement are more uniform than in the bays, it contains an air-conditioned room for calibration.

About half the basement area remained for storage (raw materials, semi-finished articles and machinery materials). As the lot size of each part of the store is generally small, the aim was to allow direct access. The stores are therefore largely fitted with pallet racks for access by fork-lift trucks, and bins for issuing materials by hand. With the civil engineer's approval, the column centres were set at 4·5 and 6 m, which answers the requirements of the building design and of the storage space.

(DJS) P. BERNHARD

PLANNING THE ADMINISTRATION AND DESIGN OFFICES

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The problem of moving the design departments to Birr and of combining and adapting the administration offices was solved by building two free-standing, five-storey office blocks. Since this was in the nature of a first building phase, the room dimensions were carefully defined. The chosen arrangement combines traditional single offices and large open-plan rooms: each floor comprises an office area which can be divided up, a large room of about 300 m^2 and a section at one end containing lifts, staircase, toilet facilities and cloakrooms. On both ground floors there are prestige rooms and rooms containing special installations. The offices associated with the testing bay, the personnel department and the medical centre are in a three-storey block running along the north side of the factory. Design of the office equipment is based on a standardized modular system. Every workplace is provided with a wheeled swivel chair or stool. Notable advantages of the moderately sized offices have been flexibility in furnishing and a comparatively uniform sound level which blankets sudden noises.

AN IMPORTANT aspect of the second phase of the factory at Birr consisted in planning accommodation for all the administrative offices. Owing to the large extra amount of space required, there was no question of extending the small office building erected during the first phase: a new office block had to be built. In this way the previously separate offices of the departments for large and medium-size machines could be planned together. One advantage of this arrangement lay in the possibility of combining all the work groups. In addition, the management decided to move the design departments for medium and large electrical machines from Baden to Birr. There were two reasons for this: on the one hand to create a close link between design and manufacture and, on the other, to gain valuable space in the parent factory. The offices associated with the testing department were to be enlarged and located in the immediate vicinity of the test beds themselves. Also, it was necessary to have offices for the personnel department and suitable rooms for the medical centre near the works entrance. The various works administration sections and auxiliary services were to be kept to a minimum, because a regular postal service to the main factory 14 km away could be counted on. Finally, the design was to include a number of executive offices, a lecture hall and a well-appointed conference room.

Adequate floor space had to be set aside for the construction of small motors which, it is anticipated, will be transferred to Birr later.

Table I summarizes the number and type of workplaces planned, together with the areas occupied.

TABLE I

	Workplaces Number	%	Floor area m²	%
Admin. office	180	33	1 300	21
Design	260	48	2 100	33
Test laboratory	70	13	500	8
Executive, Lecture hall, Personnel, Aux. services	30	6	900	14
Reserve	—	—	1 500	24
	540	100	6 300	100

Basic Considerations

Working on the basis of a total useful floor area of 26 000 m^2, the architects proposed seven free-standing office blocks in a central strip running north-south. A study of traffic and movements revealed no drawbacks in this concept, except that the route from the offices to the factory is for a short distance in the open. Much more significantly, it was possible to avoid the compromises regarding window distribution, room heights and lighting frequently encountered with annexed buildings. In this context it should be mentioned that even halving the factory-building module of 3 m can result in a subdivision which is unsuitable for offices. Therefore, separating the office blocks from the factory building made it easier to achieve a convenient arrangement for the offices (see Fig. 4, p. 396). Furthermore, the offices had to be versatile as regards use, a requirement demonstrated by the fact that even in the first phase two fundamentally different kinds of function had to be taken into account.

To make it easier for the architects to unify the buildings, all special-purpose rooms, particularly those with separate plumbing, wiring and ventilation systems, etc. are on the ground floor. In this way the upper floors, for the offices, could be of uniform design.

Determining the Room Dimensions

The building system to be used had components with standard dimensions of 40, 60, 80, 90, 100, 120, 160, 180, 200 and 240 cm. Since sitting space and traffic areas can be conveniently sized with multiples of 40 cm, it was rational to base the whole design on a module of 40 × 40 cm.

The best width of room was found to be 360 cm. With an extra 15 cm for partition walls and building tolerances this gave a distance between centres of 375 cm and, by halving, the chosen window spacing of 187·5 cm. The depth of the separate offices was taken as 560 cm, as with previous buildings. For the drawing office 680 cm appeared to be a reasonable width (greater widths are perfectly possible, and under certain circumstances, desirable). It then had to be established whether 680 cm was also suitable for furnishing the offices. It was found that an arrangement with three working positions across the width and reference tables at the side provided a convenient solution.

It was also necessary to check whether the combination of these two widths, which would enable the floor space to be used for a variety of purposes, was in fact possible. The design departments presented no problems in this respect. In addition to places for design and detail draughtsmen, who have always worked in fairly large rooms, offices also had to be provided for the departmental manager, design engineers and purchasing department, as well as for the secretaries, for whom a room of normal width is more suitable. However, with the administration offices, too, it was possible to find a solution by dividing them up according to activity: separate offices were allotted only to people with managerial functions, for noisy jobs (typists' offices) and as conference rooms. All the workplaces for production planning, dispatching and scheduling are located in the large office.

The following transverse dimensions were therefore adopted:

40 cm	shelf (with service duct and filing compartment)
520 cm	width of office
40 cm	built-in cupboards with adjustable shelving
10 cm	wall
160 cm	central corridor (open on one side)
680 cm	width of large office
40 cm	shelf
1490 cm	inner width of building from wall to wall

The requirement for at least 500 m² of useful area on each floor led finally to a length for the large office of 26 × 1·875 = 48·75 m. This gave:

Divisible offices	232 m²
Large office	332 m²
Useful area per floor	564 m²

Since the drawing boards are fitted with pantograph drawing machines, and in view of the large floor area, the room height was set at 3·3 m.

The distinguishing features of the design are the corridor which is closed in on only one side and the greater room-width in one half of the building. The result is thus a compromise between traditional single offices and an extreme open-plan layout.

Room Allocation

The upper floors of blocks B and C are occupied by executive staff, the works offices and the design departments (Fig. 1). The ground floor of block B contains a well appointed 120-seat lecture hall and cinema, a 20-seat conference room and an impressive foyer. One wall is decorated with a much enlarged copy of Charles Brown's patent describing the revolutionary idea of the cylindrical turborotor. In front of this stands the first rotor built under this patent. On the ground floor of block C are the auxiliary services, principally a telephone exchange sized for later expansion (with the automatic equipment in the basement), a photocopying department and a drawing store. There is also a central mail-sorting office for the whole works. The block running along the north end of the factory contains offices for the testing bay and personnel department, and also the medical room.

Furnishing

The range of furniture chosen is designed on the modular principle, and offers the following features (Fig. 2):

- A very large number of combinations can be achieved with a very small number of pieces.
- The range covers all types of workplace from the departmental manager and section leaders to clerical staff, design and detail draughtsmen, secretaries and typists.
- Sizes are in accordance with DIN standards.

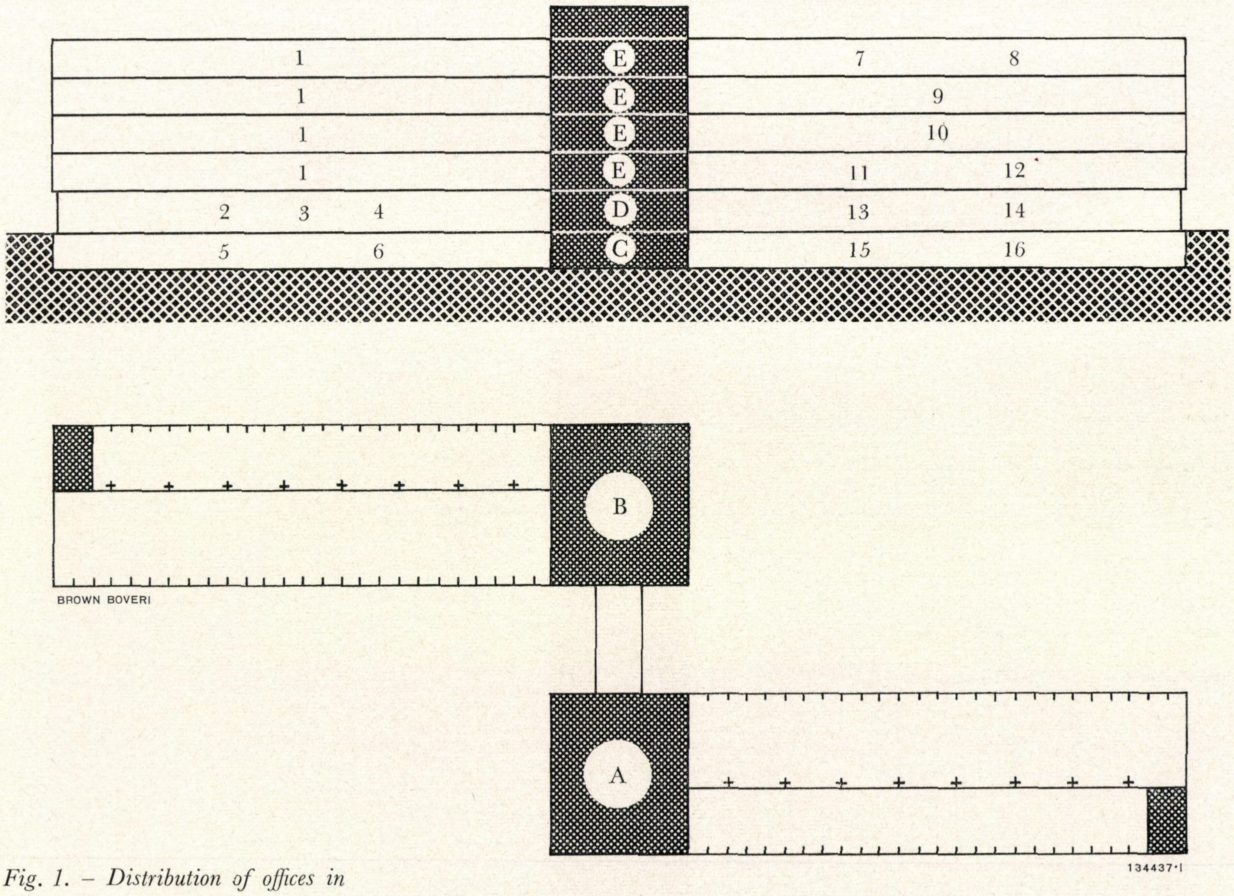


Fig. 1. – Distribution of offices in the blocks

A = Block B (works offices)
B = Block C (design departments)
C = Basement
D = Ground floor
E = Floors 1-4

1 = Design
2 = Photocopying, drawing store
3 = Internal post
4 = Telephone exchange
5 = Document store
6 = Telephone equipment
7 = Directors' offices
8 = Tool design

9 = Spare
10 = Production planning
11 = Works manager
12 = Works office
13 = Conference room
14 = Lecture hall
15 = Air raid shelter
16 = Document store

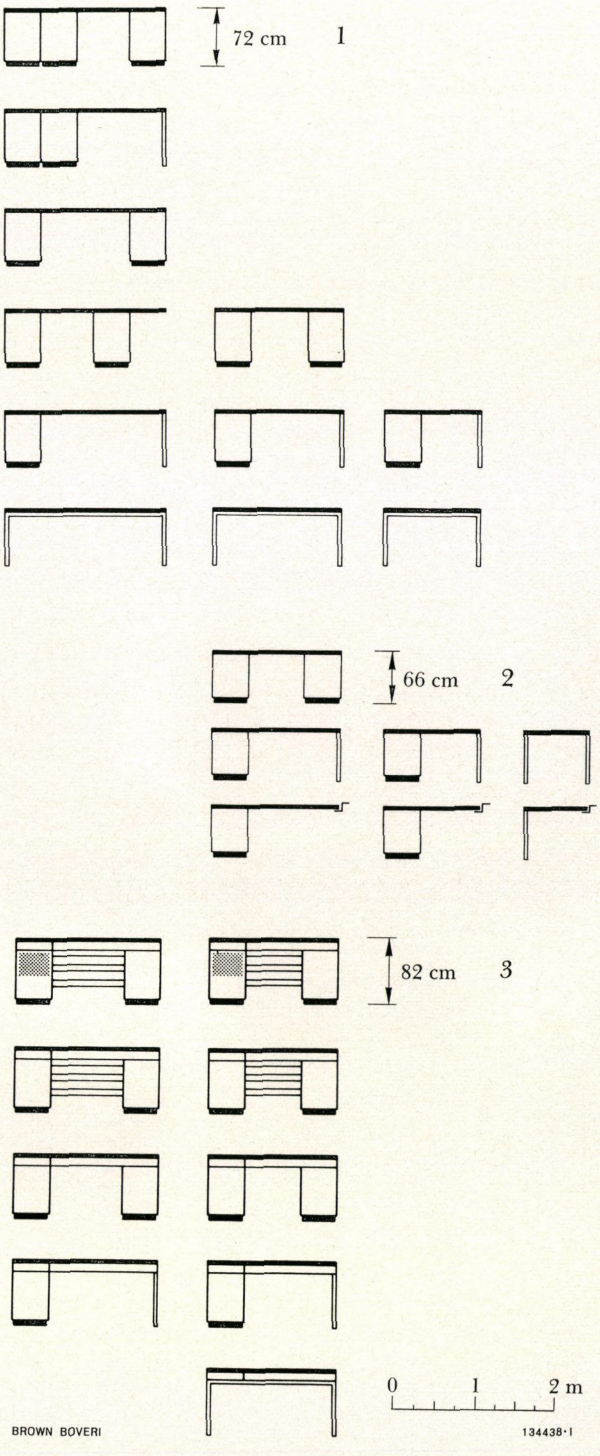


Fig. 2. – Modular office equipment

1 = Desks and tables, 72 cm high
200/80 cm, 160/80 cm, 120/80 cm

2 = Typing desks, 66 cm high
160/60 cm, 120/60 cm, 80/48 cm

3 = Reference and writing tables for the design offices
82 cm high, 180/90 cm, 160/90 cm

– The drawers and cupboards are in different sizes, but matched and interchangeable.

– The design is rugged, simple and functional.

The system includes desks of three heights:

82 cm for sedentary/standing work
72 cm for sedentary work
66 cm for typewriter desks

Every workplace is provided with a swivel chair or stool on castors.

The drawing units have hydraulically adjustable stands, plastic-covered boards and pantograph drawing machines with protractors. Card indexes, vertical files and drawing cupboards away from the workplaces are of steel.

Fig. 3 illustrates two different arrangements: an administration office and a design department. Table II shows how the space is utilized.

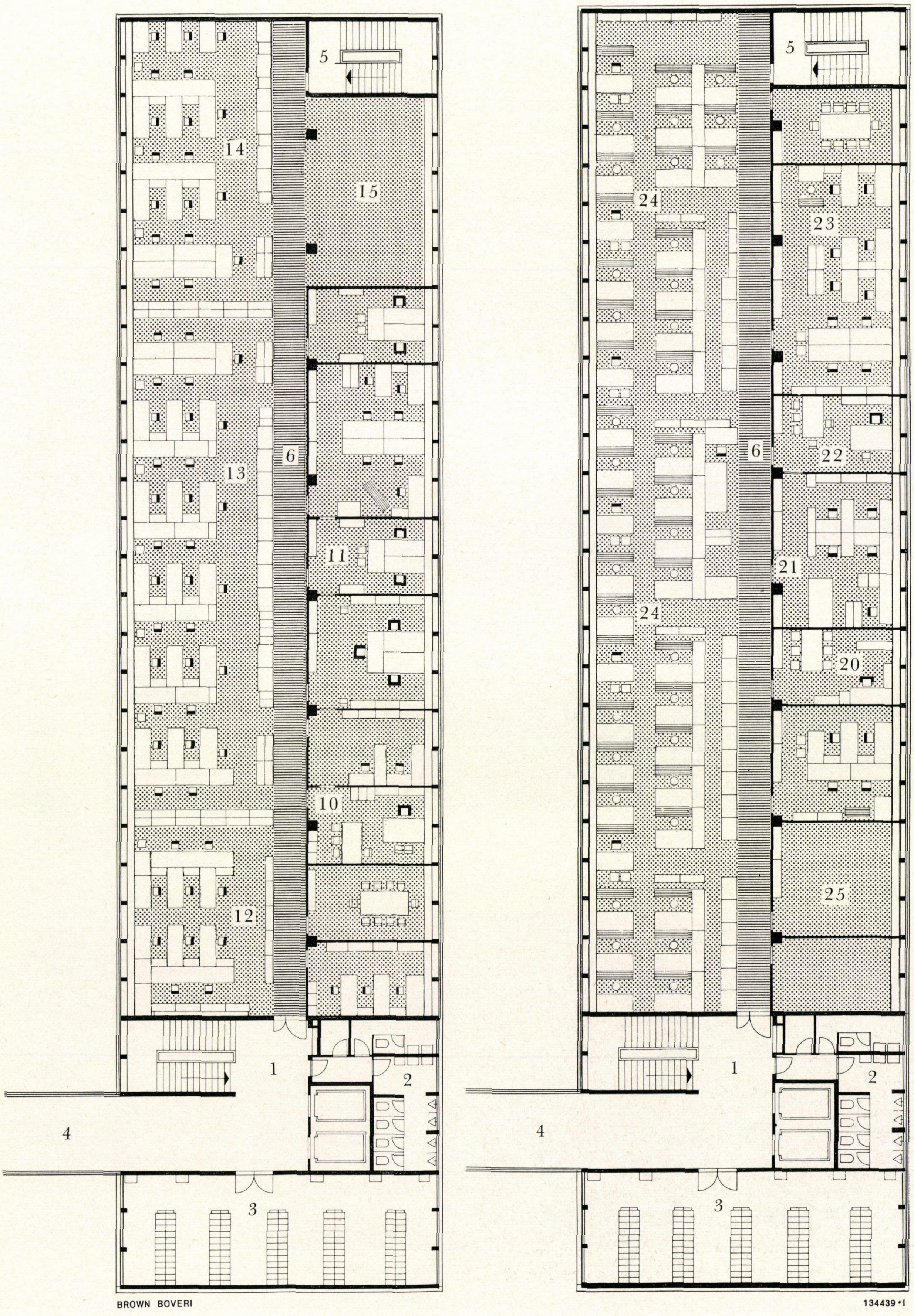
TABLE II

		Admin. office	Design
Right-hand side	Area	184 m²	184 m²
	Positions	19	21
	Area/Position	9·7 m²	8·8 m²
Left-hand side	Area	332 m²	332 m²
	Positions	58	43
	Area/Position	5·7 m²	7·7 m²
Total	Area	516 m²	516 m²
	Positions	77	64
	Area/Position	6·7 m²	8·1 m²
Reserve space		48 m²	48 m²

Fig. 3. – Plan of the administration office (left) and of a design department (right) ▶

Illustrating the flexibility of layout.

1 = Staircase with lift shaft
2 = Toilets
3 = Cloakroom
4 = Interconnecting passage
5 = Second staircase
6 = Central gangway
10 = Works manager
11 = Assitant works managers
12 = Scheduling
13 = Clerical staff
14 = Dispatching
15 = Spare
20 = Chief designer
21 = Purchasing
22 = Departmental manager
23 = Design engineers
24 = Design office
25 = Spare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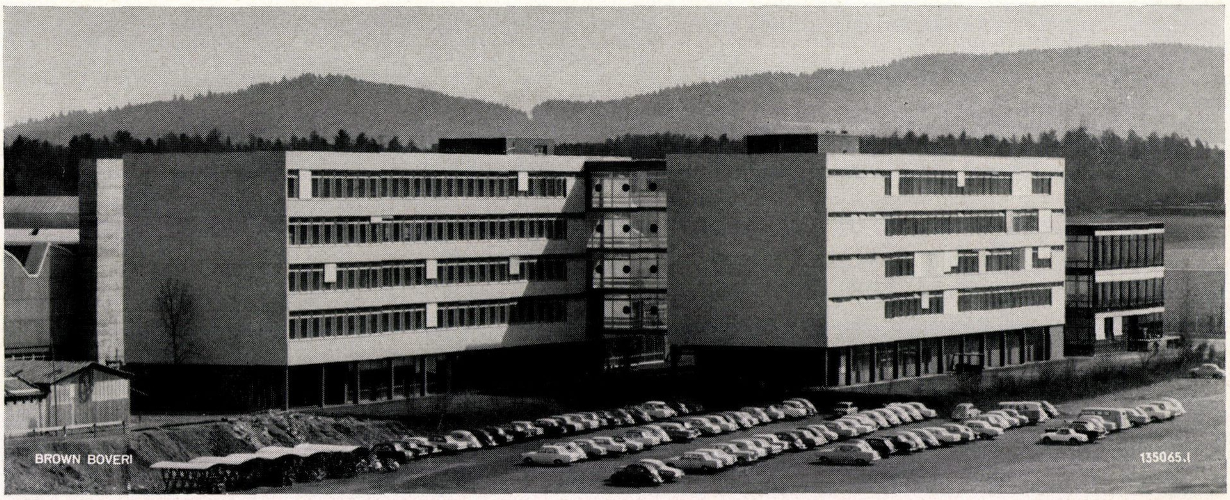


Fig. 4. – The offices from the north-west The factory can be seen on the left, and the canteen on the right

Fig. 5. – Administration office Separate offices to the right, seen from the gangway

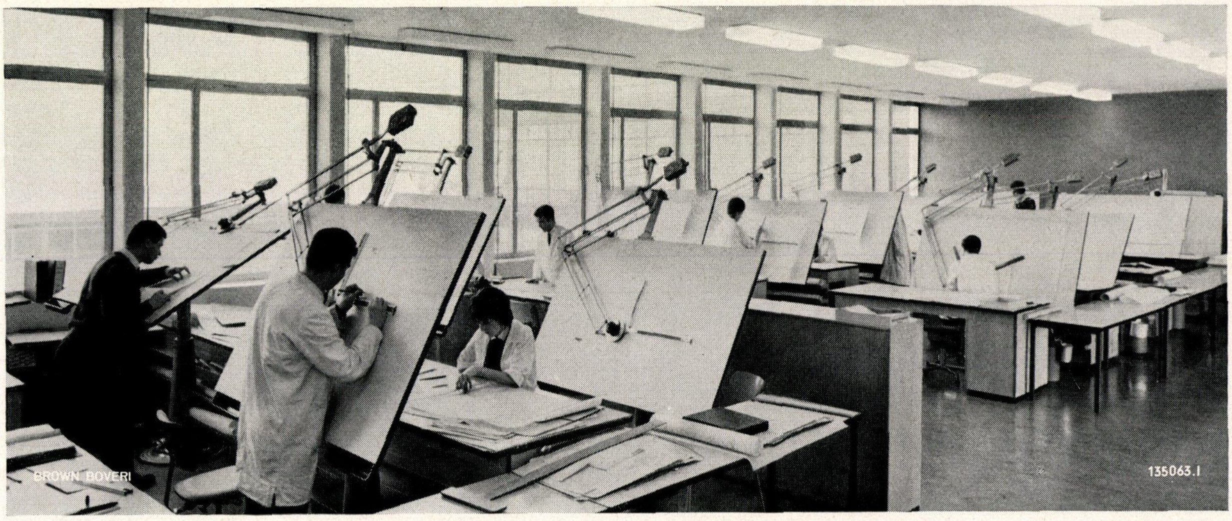


Fig. 6. – Design department

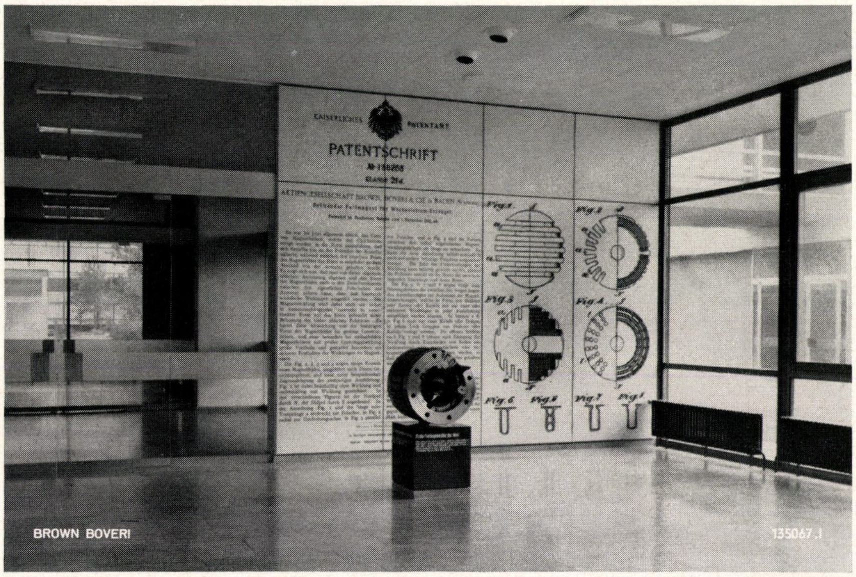


Fig. 7. – The entrance hall of block B with the first turborotor in the world

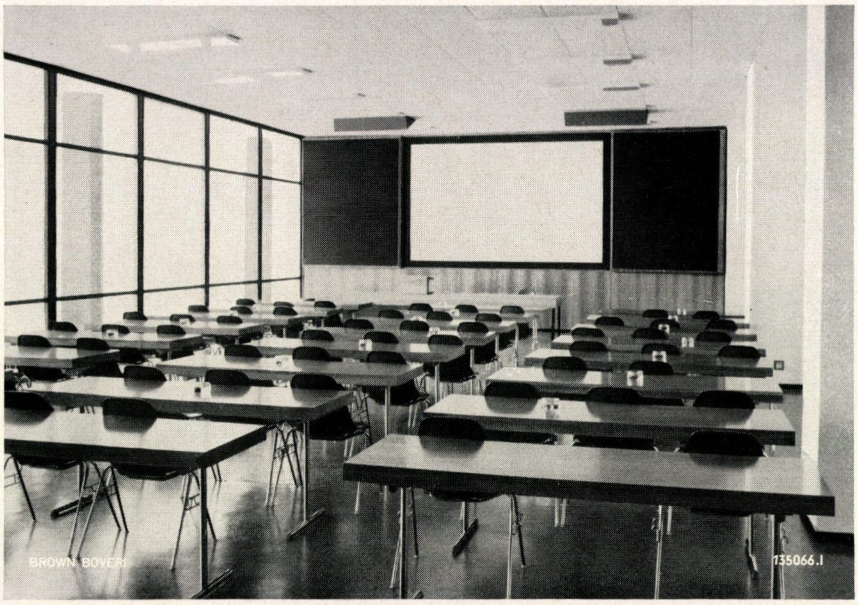


Fig. 8. – Lecture hall and cinema in block B

Observations

Putting about 50 office workers into a single room of more than 300 m² has so far produced no complaints. This is remarkable since there is no air-conditioning system and no carpet, as is often used in large offices. Certain difficulties have been experienced with natural ventilation, however, owing to the occasional high winds.

The unusually pronounced noise-blanketing effect is of great benefit: the isolated noises occurring from time to time are scarcely perceptible above the comparatively uniform sound level.

The E-shaped desk arrangement adopted in part in the large office is convenient as regards space and movement. Indirect glare can occur under certain lighting conditions, but this can be remedied by adjusting the venetian blinds.

(DJS) R. SCHMID

ARCHITECTURAL ASPECTS OF THE SECOND PHASE

658.2

The original overall plan was revised. The central north-south axis has been set aside for offices and amenities and at the same time separates the eastern area (for heavy machines) from the western area (light engineering). The resulting buildings combine aesthetic considerations with a modern and economical method of construction.

Overall Planning

THE ORIGINAL overall plan for building the first phase of the factory at Birr also served as a basis for the projected extension. However, in the light of new discoveries and experience, including the figures for areas and staff estimated by the planning group, the plan had to be largely revised and modified.

In this reappraisal the building axes, the locations of the paths of communication and the power distribution arrangements were taken over without alteration. This was also true of the effective room heights, crane track heights, etc. On the other hand, substantial changes had to be considered for the following reasons.

Passenger Transport

The original plan was based on the assumption that the great majority of employees would come to work by train. This is still true of a considerable number of people, but at the same time road traffic is rapidly increasing in importance (Fig. 1). The number of workers and staff who come to work either singly in cars or collectively by bus is growing constantly. Consequently, the need for parking space is becoming greater every day. There is already an obvious need for a large-scale bus stop. The new flats in Birr have also played a part in changing the traffic pattern.

As goods traffic increases, the inconvenience of the level-crossing at the north-west corner of the factory is becoming more and more apparent and the road planned for the west side of the site is becoming increasingly urgent.

The Offices

Originally it was intended that at Birr there should be only those offices which are directly connected with production. It was planned to leave all the design departments in Baden. However, this idea has changed radically in the meantime. In the light of experience gained since then, it seemed rational to bring the design departments near to the production departments in order to ensure close and continuous collaboration. This alteration meant that the overall plan had to be revised as it precluded any possibility of using the original concept.

Allocating the Areas of the Site

While considering the site as a whole, the idea gradually crystallized that the entire site should be clearly divided into separate areas corresponding to the various types of product and function, and that the different zones should be easily accessible to traffic (Fig. 2).

This led to a radically new layout for the space not yet built on. In order to cope with only the most urgent requirements as regards parking space, the whole area on the north side of the factory, which had originally been intended partly for office buildings,

Fig. 1. – Motorways (double lines) and roads planned for the Baden–Turgi–Birr area

had to be set aside as a car park. In the long term even this will not be enough. In the future, additional parking space is to be provided along the new road on the west side of the factory.

The acoustic laboratory is located in the area set aside for parking because it was found from detailed investigation into the vibration to be expected from the production plant on the one hand, and from road and rail traffic on the other, that the most favourable conditions are to be found on the north side of the factory.

The concentration of offices originally planned at the north end of the factory was reasonable only so long as they were administrative offices and lengthwise development of the factory was restricted on the south side. Any further extension would have incurred serious disadvantages. Moreover, this arrangement was at variance with the desire for close collaboration between design and production. A layout with decentralized offices along the whole length of the factory was therefore suggested. Accordingly, it was decided to allocate an area for offices and amenities such as locker-rooms, canteen, etc., along the west side of the existing factory buildings. In this way the required direct contact can be achieved should the heavy-machine depart-

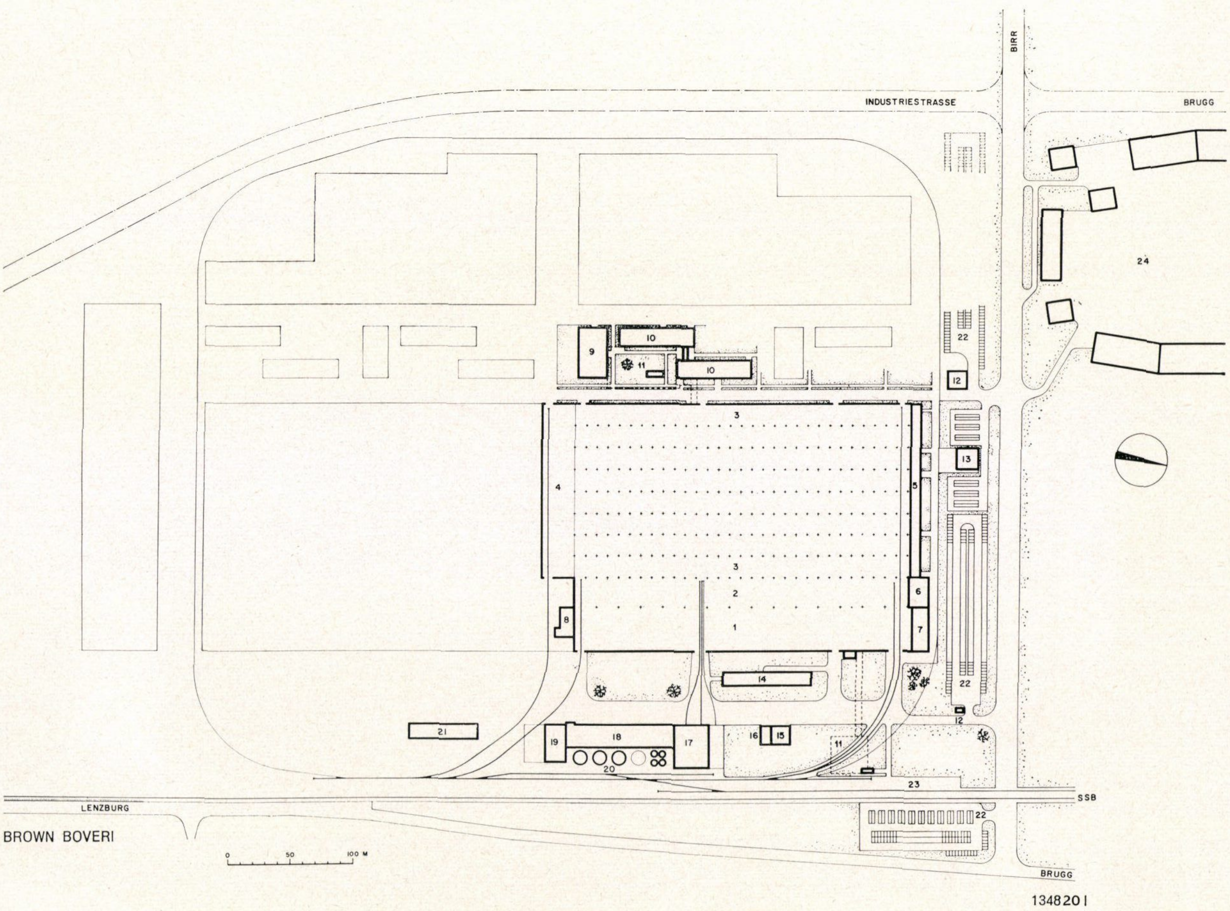


Fig. 2. – Plan of the complete site at Birr

1 = 36-m bay
2 = 24-m bay
3 = 18-m bay
4 = Transverse bay
5 = Offices
6 = Main 45-kV station
7 = Ventilation laboratory
8 = Sand blasting and paint dipping
9 = Canteen
10 = Office buildings
11 = Locker-rooms
12 = Gatehouse
13 = Acoustic laboratory
14 = Temporary office building
15 = Cooling plant
16 = Solvent store
17 = Overspeed testing bay
18 = Services
19 = Boiler house
20 = Fuel store
21 = Refuse dump
22 = Parking
23 = Railway station
24 = Blocks of flats

ments be extended or one or more departments for smaller machines be added. In the future this area, which includes large expanses of grass and vegetation, will form the backbone of the whole works. Extensions can be made in accordance with development of the manufacturing departments. The area is bounded on east and west by two main access roads, and forms a geographical division between the areas for large and small products. In consequence, the new main entrance has been built at the northern end, in the middle of the parking space. In future the present main entrance will be used chiefly for goods coming in and going out, and as access for those employees who come to work by train.

Constructional Planning

Planning of the building work was governed principally by architectural requirements, but also by the contractor's wishes as regards building times. Since only two and a half years were available for both design and execution, solutions had to be found which would keep the time needed to a minimum and allow prefabrication off the site itself and independent of the rest of the building work. This resulted in the use of prefabricated components, finished to a greater or lesser extent.

The problem of timing was of very great importance right from the beginning. It was quite evident that there would have to be sufficient time for careful planning of details. Prefabricated elements can be quickly produced and erected in large numbers only if absolutely clear and unequivocal data are available. Almost all the building components above ground were very well suited to a building method of this kind.

Circumstances as regards the basement of the factory building were unusual and the ceiling over the basements was not suitable for prefabrication methods.

Construction

It was decided to build all the basement floors of reinforced concrete. Excavation for the foundations began early in 1961. Concreting commenced in the spring of the same year, and by the end of the year the essential parts were so far advanced that erection of the superstructure started at the beginning of 1962. Fabrication of the whole of the structure above ground, comprising columns, steel crane tracks and the concrete roof bays, also began in the spring of 1961, in parallel with work on the foundations, and was ready in advance so that smooth continuous erection could begin when the work below ground level was finished. The unusually large bays for the saw-tooth roof were cast flat at ground level and then fitted and finished in a special temporary building on the site; a technique used for the first time in Switzerland. The first departments began working in the new buildings at the end of 1962.

Building Layout

The architectural arrangement of the various structures had to be related to functional requirements. In the case of the factory building itself—the large saw-tooth roof structure—natural lighting was the determining factor, and this in turn governed its orientation in the whole building complex. In the newly created central area the widely differing functions of the buildings permitted a freer arrangement, though still related to use.

The office blocks are of uniform shape with prefabricated facades and are linked by a glass-walled covered way which also serves to break up the building mass. A single building here would not

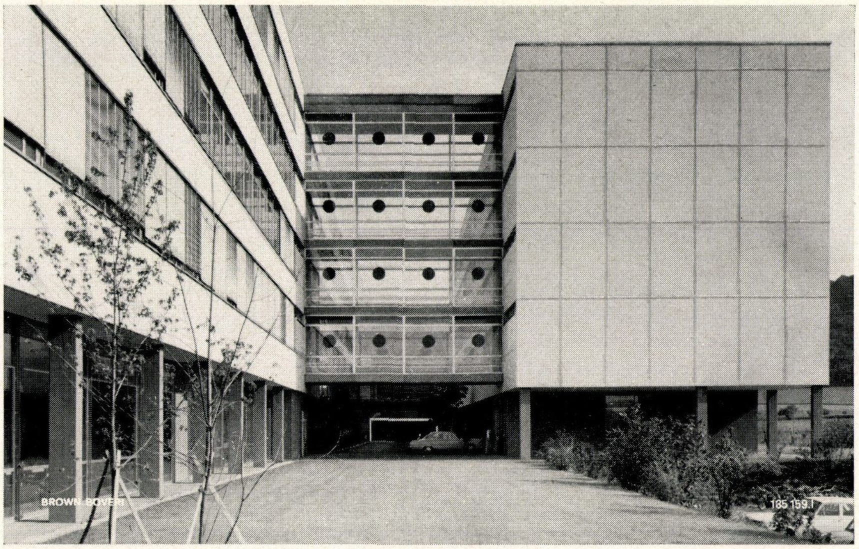


Fig. 3. – Office blocks with glass-walled connecting passages

Fig. 4. – View from the canteen and office block towards the new factory buildings

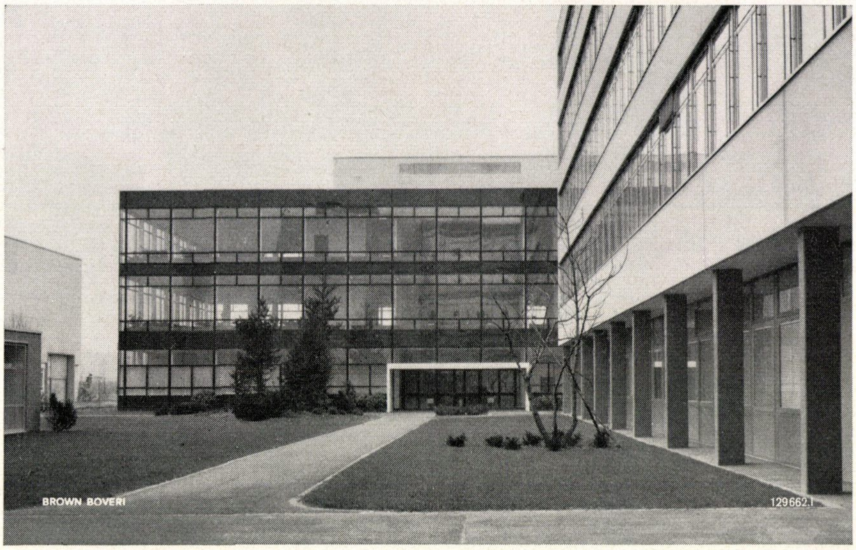


Fig. 5. – The canteen exit looks out onto lawns

only have been impractical, it would also have clashed with the intentionally widely spaced layout of the area.

The canteen is designed not merely as an eating place. Naturally, it complies as rationally as possible with practical requirements (self service, limited choice, etc.), but particular attention was paid to the external and internal design, the intention being that during his breaks from work a person should not only feed but also feel at ease. Broad windows look out on to the attractive countryside.

(DJS) H. R. SUTER

ROOF SECTIONS FOR THE FACTORY

624.074.5

Prefabricating the roof sections simultaneously reduced the construction time and the cost. Due to their dimensions the prestressed roofing sections were cast on site in a shed constructed for that purpose. Between three and seven spans were fitted daily, which represents a covered area of 500 to 1100 m².

Constructional Engineering Requirements

THE SPAN WIDTH of the workshop was fixed at 18 m according to the overall layout and was the same as for the first phase (1957–1959). As a result of the rapid developments in the building industry and the resultant changes in construction methods and relative costs, the roof construction system was thoroughly revised. Versions in steel, in situ concrete and precast construction were studied. The results of the study showed clearly that the prefabricated roof section shown in Fig. 1 was by far the most suitable. It permits the greatest possible degree of prefabrication and the minimum of finishing operations, and thus results in the shortest erection time. The large number of identical units (202) led to favourable production costs and made the sections the most economical construction because the cost of finishing work (insulation, asbestos cement, etc.) was greatly reduced at the same time. Finally this method provided uniformity of construction with the existing buildings.

The roof sections with their supports constitute a strong, deflection-resistant frame capable of withstanding the horizontal forces due to wind and crane loadings. Owing to the high moment of inertia of the roof sections there is practically a "total clamping", which led to the use of favourable support profiles.

The cross-sectional forces were calculated for the various stages of construction. Fabrication, fitting-out and transport on site were carried out in the horizontal position, supports being placed at intervals under the rigid girders. It was impossible to use the workshop floor for transporting the finished sections into place due to the various foundation recesses and the great weight involved, so the overhead workshop cranes were used to cope with the

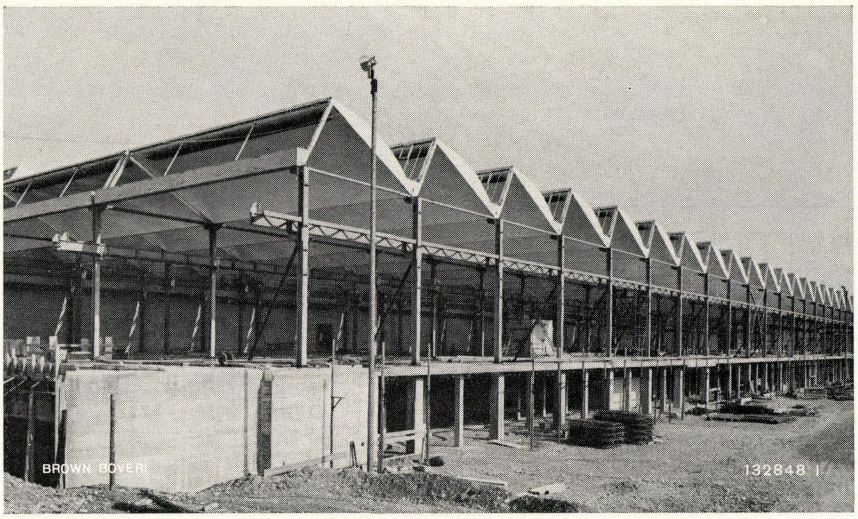


Fig. 1. – 202 prefabricated roof sections constitute the roof of the new workshops

horizontal rigging. Because of this the shells could not be rested on the rigid girders and therefore had to be rested on the upper and lower prestressed edge, which caused additional stresses.

The steel supports, which after connection to the roof sections work as rigid frame columns, have a cantilever effect at the assembly stage and were unfavourably stressed due to the great weight of the sections and wind buffeting. For these reasons the crane tracks were provided with temporary supplementary supports.

Construction Problems

Prestressing the sections in the stressing jig was essential for reasons of economy. Progressive introduction of the prestress loadings was achieved by covering various individual cables with plastic sleeves. In this way stressing was reduced to a minimum and with a standard quality concrete (HB P 300) a curing period of six days was achieved.

The rigid concrete shells had to be supplemented with elastic parts at the ends which cater for the compression of the shells due to the preloading. This distortion due to preloading releases the shell from its mould so that there is no vacuum formation on removal. Rigid connection between sections and supports is achieved with the aid of tie bolts.

With on-site construction, tolerances are of particular importance, especially where large areas are involved. Calibrated measuring tapes were supplied to the building contractors, steel suppliers, crane manufacturers and roof erectors. In addition to this the axes of the 270 m long shops were accurately measured by a surveyor.

On-Site Plant

Prefabrication in a factory remote from the site was obviously out of the question due to the complication of transporting the finished sections (size 9 × 18 m, weight 55 t) by road. The obvious solution was prefabrication on site, involving only short distances

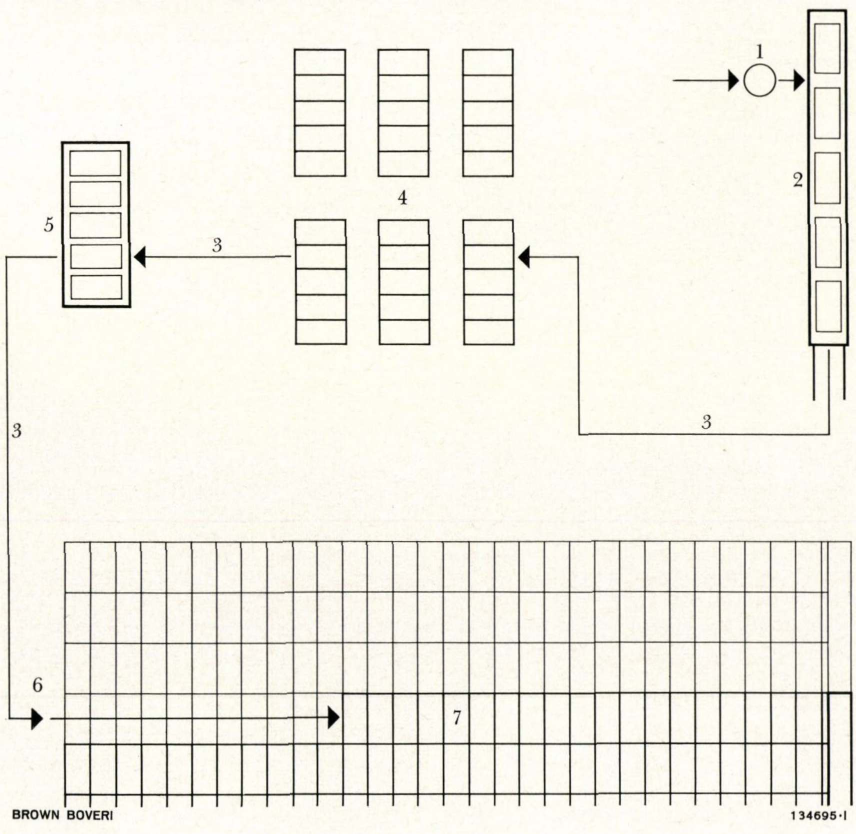


Fig. 2. – Roof section fabrication cycle

1 = Concrete preparation
2 = Moulding shed
3 = Transport by special vehicle
4 = Storage area
5 = Fitting-out shed
6 = 60-t mobile crane
7 = Factory workshops

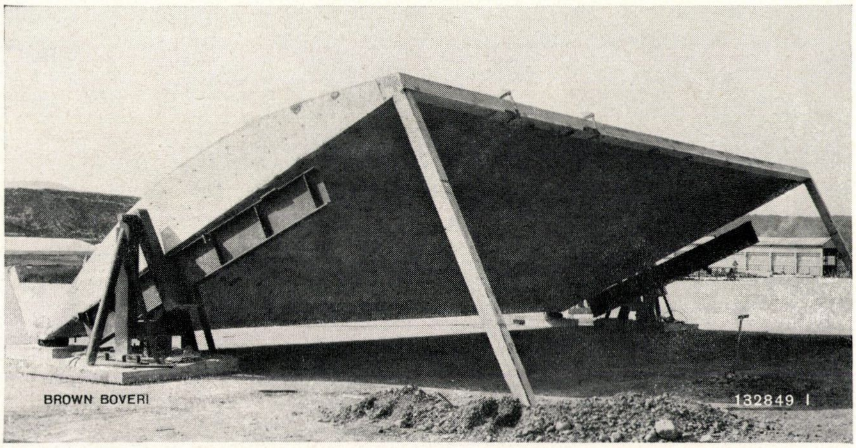


Fig. 3. – Storage of roof sections, showing tilting apparatus

The moulding shed can be seen in the background.

(Fig. 2). These considerations led to the construction of a dismountable fabricating shed. This consisted of a shed which was easily and quickly assembled or dismantled and which contained the moulds and prestressing equipment. This temporary building was 120 m long by 11 m wide and was equipped with an overhead crane which could travel approximately 20 m beyond one end of the structure. Two 30 t mobile cranes were used to transport the completed sections and perform other lifting jobs on site. The building had the capacity for constructing five sections in series. The concrete was brought from the mixing plant by conveyor belt and distributed by the cranes.

Fabricating the Roof Sections

The individual sections were cast in a continuous process. The concrete was compacted with the aid of high-frequency immersion vibrators and surface vibrators. At the thinnest point the sections are 6 cm thick. In every instance a strength of 300 kg/cm^2 was reached before unclamping. Five sections per week were produced by this method.

The finished sections were picked up at four points by two 30-t mobile cranes, lowered on to a 60-t vehicle specially constructed for the purpose and transported to the storage area. Whereas the front bogie of the transporter was drawn by a tug unit, the

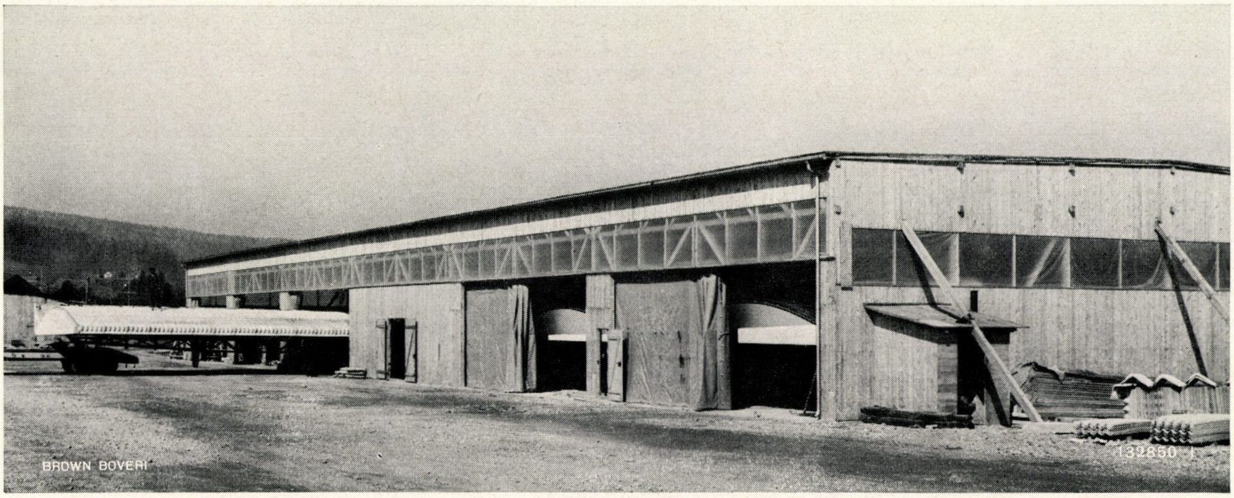


Fig. 4. – Fitting-out shed with finished section ready for transportation

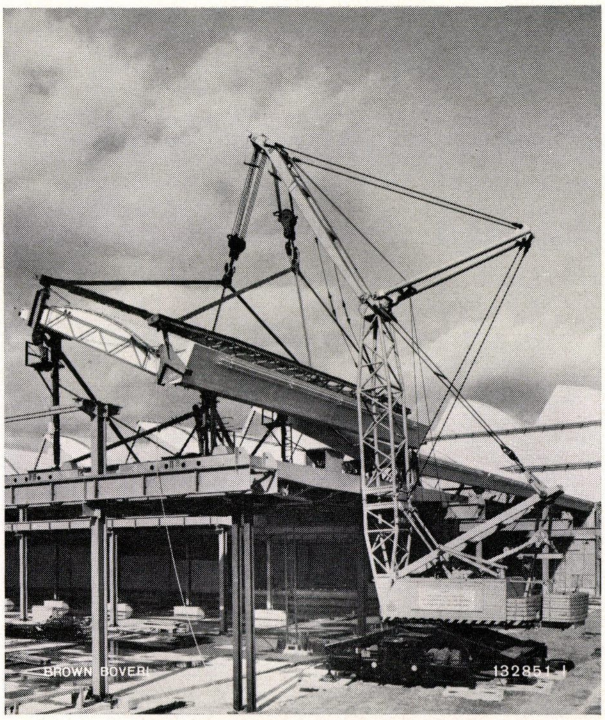


Fig. 5. – Placing the sections on the crane cross-beams with 60-t mobile crane

trailing bogie was steered by the driver's mate (hydraulic steering with cable controls). The sections were supported at two points on each bogie to reduce twisting to a minimum. On arrival at the storage area the sections were swivelled into their normal position with the aid of a tilting mechanism (Fig. 3).

Equipping the Roof Sections

The sections were transported from the storage area to the fitting-out bay (Fig. 4) with the special vehicle. This temporary sectionalized building with its sliding canvas doors enabled work to proceed even in inclement weather conditions. The outer surfaces of the sections were insulated with corrugated asbestos sheeting and the inner surfaces were painted. The radiant heating panels and the pipes for the supplementary heating system were fixed to anchor brackets cast into the concrete.

Fitting the Sections

From the fitting-out shed the finished sections were then transported to the southern end of the workshop structure. A mobile crane fitted with outriggers and a special cradle was used to lift them to a height of 10 m where they were rested on the cross-beams of two workshop cranes (Fig. 5). The four supporting

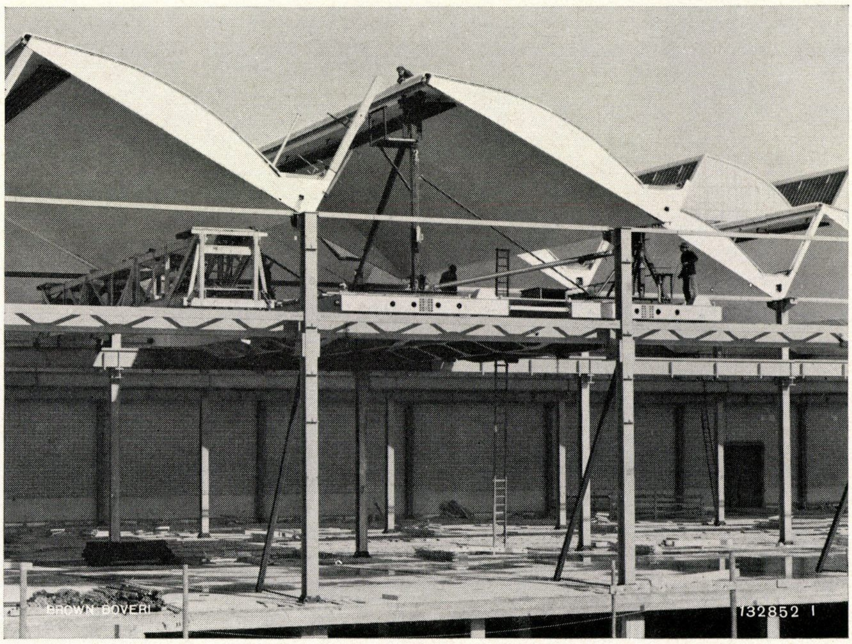


Fig. 6. – Moving a roof section into position

On the left of the coupled cross-beams can be seen the movable cradle for the final operations.

positions were fitted with hydraulic presses with diagonal struts for vertical and lateral adjustment. The crane cross-beams were used for moving the sections into position on the prepared steel supports (Fig. 6).

After bolting into position there was relatively little work to be done on the roof, i.e. sealing the gaps between the sections, glazing, fitting the cat-walks, water spouting and lighting and connecting up the heating system. A movable cradle on the crane cross-beam simplified these operations considerably. Depending on weather conditions three to seven sections were fitted per day, which represents 500 to 1100 m^2 of roof area.

(AH) F. BERGER and E. BERNASCONI

MACHINE FOUNDATIONS

621-218.2

It was necessary to develop suitable foundations for the diverse machinery in the workshops. The foundations decided upon satisfy the various requirements regarding positioning, convenient working height, vibration insulation and coolant and lubricating oil leakage.

THE GREAT demands made on machine tools these days regarding accuracy, freedom from vibration and noise necessitate attention to these points at the installation stage. As a wide variety of machines had to be considered in our case, such as presses, stamping machines, machine tools, furnaces, etc., particular attention was devoted to their individual requirements. The foundation design was encumbered by the fact that each machine, even weighing up to 40 t, had to be installed in a workshop over a basement.

To a large extent the following aspects were the design determinants:

- Machine tools which comprise several parts or have long beds must be readily adjustable.
- All machines must have a convenient working height, particularly the vertical lathes, planers and shapers.
- Machines which are affected by vibrations, such as grinders, and those which generate vibrations, such as presses or slotters, must be insulated.
- Machines which operate with coolants but do not have built-in drainage must have their drainage systems incorporated in the foundations.

Securing the Machines

To enable adjustments to be carried out at any time the larger machines which had no self-levelling devices were mounted on wedge adjusters which were designed for static loads of 1·5, 3, 6 or 12 t. The adjusters are designed so that rotation of the centre-screw adjusts the machine bed height and avoids any stresses on the bed (Fig. 1).

The smaller machines were mounted on steel plates set in concrete, levelled with steel shims and then bolted down. Machines which have inherent rigidity and are not subject to torsional loads were fixed down on special cork or rubber tiles which in turn were glued down to the floor. Several older machines which had no other practical means of fixing were grouted in.

Installation of Machinery for Winding, Assembly, Welding and Jig Shops

It was assumed that the 43 cm thick concrete floor would support most of the machinery without necessitating any special foundations. A 17 cm thick layer of concrete was laid on the supporting surface and this was covered with a layer of cement 2 cm thick. Wooden blocks 6 cm thick were placed on this which means in fact that the total floor thickness is 68 cm. Thus 25 cm were available

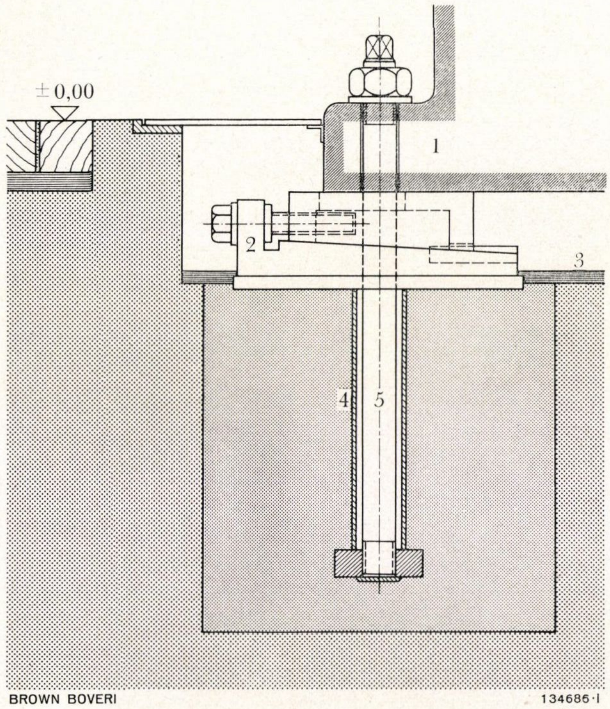


Fig. 1. – Machine anchorage using wedge-type adjusters

1 = Machine fixing foot
2 = Wedge adjuster
3 = Oil resistant coating
4 = Spacer tube
5 = Threaded bolt

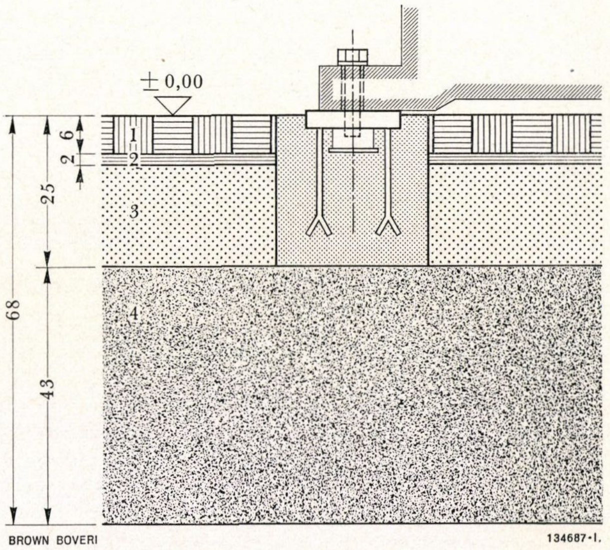


Fig. 2. – Machine bedplate on normal floor surface

1 = Impregnated wooden blocks
2 = Cement layer
3 = Concrete topping
4 = Supporting member

between the top surface of the supporting floor and the actual floor surface. It is possible, therefore, to install machinery at any time without encroaching upon the supporting surface (Fig. 2).

Several machines could not be installed in this simple manner, mainly hydraulic presses, broachers and winding machines. As radical changes are not expected in the industry within the forseeable future, all depressions and cut-outs in the concrete were filled in.

Machine Tool Department

The conditions in the machine tool shop were entirely different. The number and variety of machines required in this department necessitated special consideration with regard to future repositioning or replacement. Primary consideration was devoted to the following problems which led to the solutions described later in the text.

a. Convenient working height.

b. Vibration insulation.

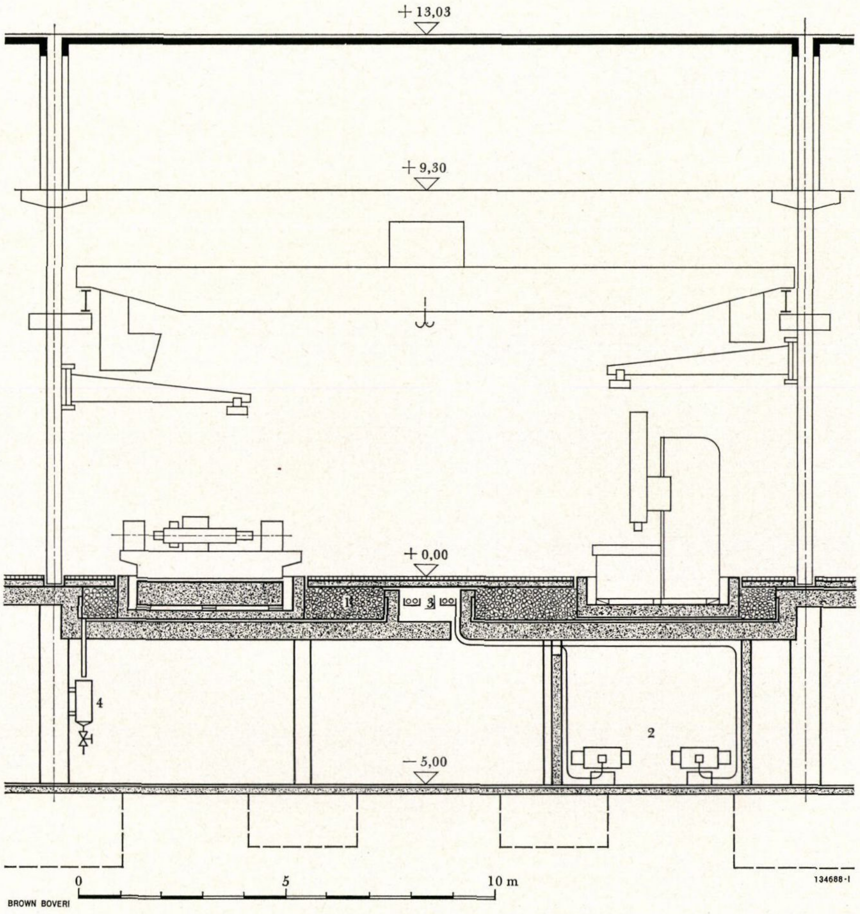
c. Coolant drainage.

a. Had the machines been fixed directly to the shop floor the inconvenient working heights would have had to have been compensated for with the aid of platforms. This is permissible in isolated cases but increases the accident risk if it has to be done with every machine. Another solution would have been to recess the floor under each individual machine but this would have seriously encumbered repositioning and new installations due to the expensive drilling and civil engineering operations involved.

b. Small machines with reciprocating masses and a rigid housing are merely rested upon cork or rubber insulating material. This solution is unsuitable for machines with long beds or those which are made up of several component parts. For example, if a large grinding machine is stood directly upon insulating material, the bed is subjected to torsion due to the heavy masses, which means that it is innaccurate in operation and is subject to a great deal of wear. For this reason all heavy grinders were fixed to heavy concrete blocks

Fig. 3. – Section through machine shop

1 = Basin
2 = Converter room
3 = Service duct
4 = Fluid collector



through wedge adjusters and the complete assembly was then rested upon insulating bodies. The mass of the machine was considerably increased by this, which greatly reduced its susceptibility to vibration (Fig. 4).

c. While the smaller machines are adequately equipped for coolant drainage this is unfortunately not the case with the larger machines. Therefore the foundations have to be adapted to cope with it, which means a depression in the workshop floor.

A special solution was found for this problem in the machining section. The supporting floor was arranged 90 cm below the workshop floor and formed as a basin. Even after lowering the supporting floor the basement storage space still had 310 cm headroom. This solution simultaneously gave another important advantage. Most of the machines use a soluble oil coolant and also leak a certain amount of oil, be it lubricant or hydraulic fluid, which over an extended period of time attacks the concrete and can pollute the natural ground water through seepage. To alleviate this contingency the drainage basin was

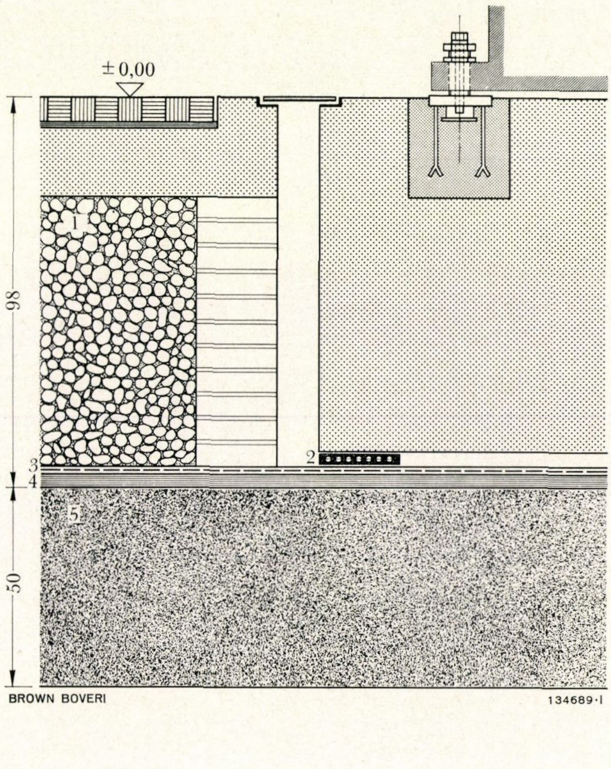


Fig. 4. – Vibration-insulated machine installation

1 = Vibrated concrete
2 = Damping material
3 = Glass-fibre-reinforced polyester covering
4 = Cement covering
5 = Supporting member

Fig. 5. – Foundations in the machine shop during construction

covered with a layer of glass-fibre-reinforced synthetic resin. At various points drainage tubes were let into the concrete which allowed the fluid to flow into containers mounted on the supporting columns in the basement. At predetermined time intervals these containers are emptied and the oil-water mixture is disposed of in an incinerater developed and constructed by Brown Boveri. The individual machine foundations were concreted on to the synthetic covering and the remaining spaces filled with vibrated concrete upon which the 15 cm thick workshop floor was laid (Fig. 3).

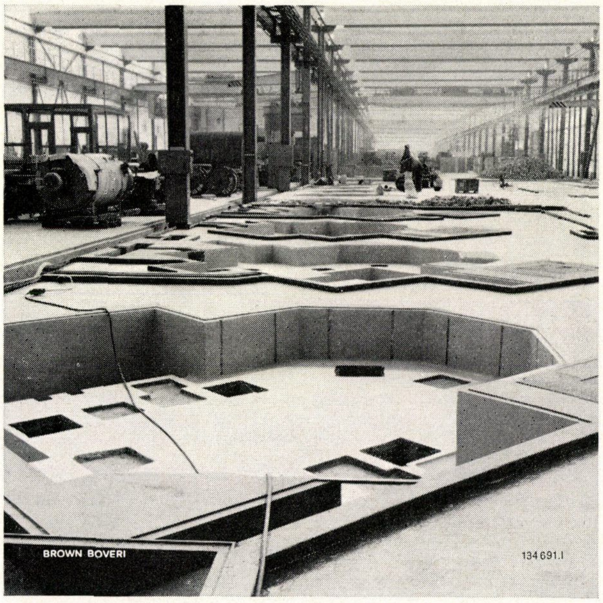


Fig. 6. – Finished machine foundations in the machine shop

Press Shop

Particular problems arise in the press shop as we are dealing with machines which act as vibration generators of the first order. Particular attention had to be devoted to the insulation of the presses so that no disturbing vibrations are transmitted to machine tools in neighbouring workshops. It should also be borne in mind that we were dealing with unit weights of up to 50 t.

As the slotters have a low unit weight (appr. 800 kg) they were bolted to concrete blocks, forming a complete unit which was then merely placed upon insulating material on the shop floor. The concrete plinth serves a double purpose by raising the mass and also compensating the varying working heights of the machines.

Presses weighing from 1 to 20 t were stood on insulating material on the shop floor. Inclinable presses and those with small bases were fixed to steel plates so as to distribute the load over a wider area. Larger presses operating at 30 t were mounted on concrete bases which were then rested on insulating material in special recesses in the floor (Fig. 7). This method has the advantage that replacement or repositioning of the machinery does not involve expensive floor modifications. Repositioning merely involves exchanging the concrete bases. If the existing base is deemed to be unsuitable when replacing the machine, the base may be removed simply by lifting it out and casting a new one in situ.

However, this method was considered unsuitable for presses weighing between 30 and 50 t. Foundations were constructed for these machines which were completely divorced from the shop floor and reached through to the floor of the basement (Fig. 8). Springs were used as insulators. Although the results obtained are very good the basement in this area is unusable.

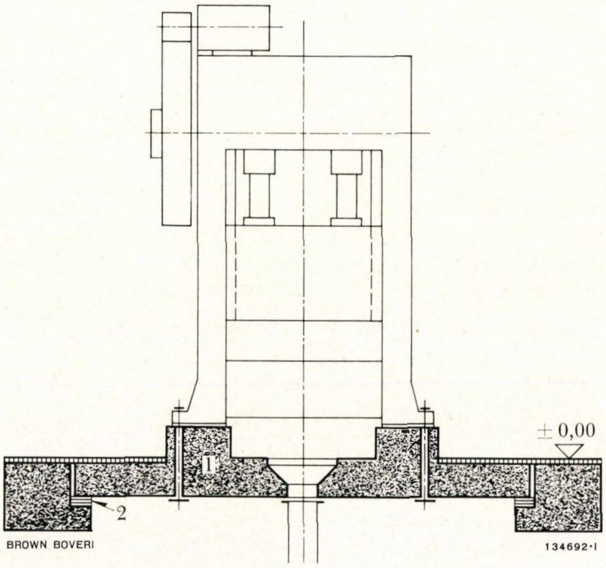


Fig. 7. – Installation of a 30 t press

1 = Concrete base 2 = Insulating material

- Every machine should be provided by the manufacturer with means for adjusting its level. Hollow adjusting bolts were found to be very suitable for this purpose.
- Machines which are fitted with liquid coolant systems should also be fitted with adequate draining facilities.
- More consideration should be given to swarf disposal.

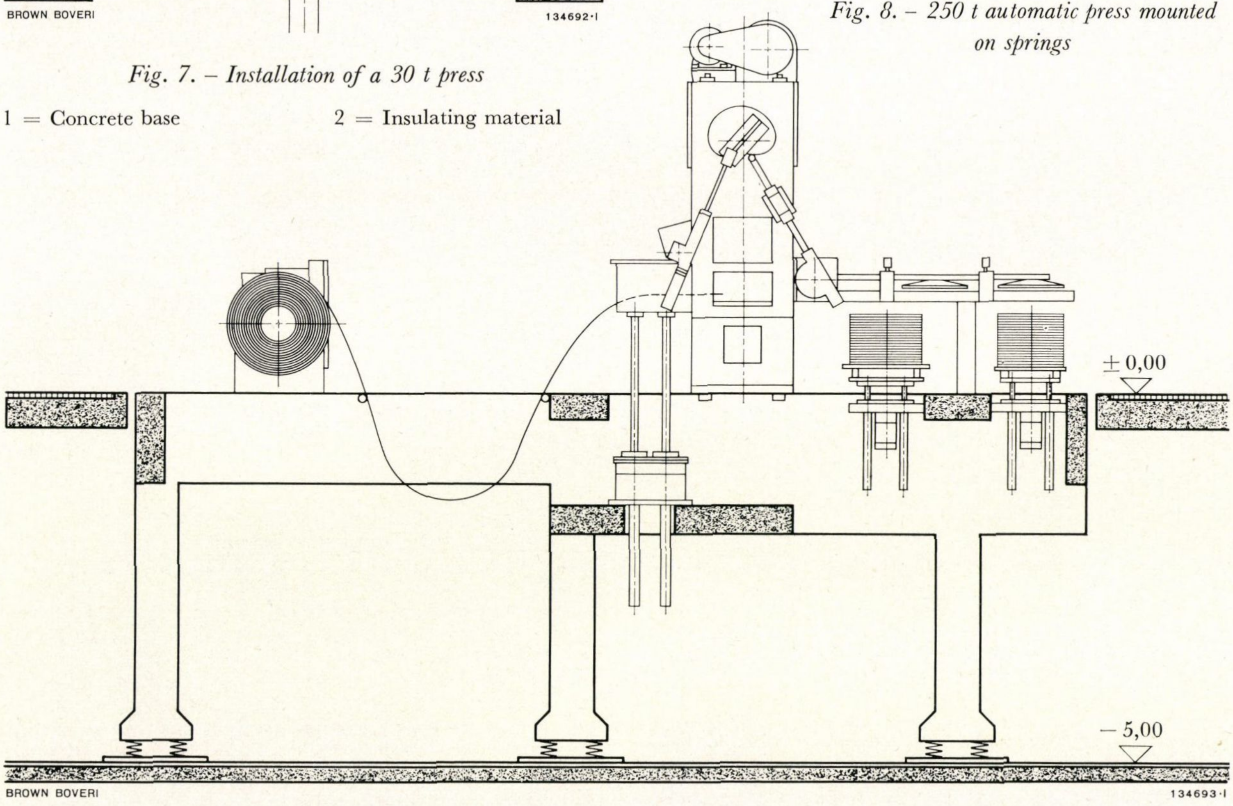


Fig. 8. – 250 t automatic press mounted on springs

Finally attention is drawn to certain points which incurred additional expense at the planning stage and later at the erection stage, but which should have been considered and catered for when the machines were being designed.

- Had more consideration been devoted to convenient working heights it would not have been necessary adjust the machine height and would have made repositioning considerably easier.
- Machines which generate vibrations and those which are susceptible to vibrations should be fitted with adequate vibration dampers by the manufacturer.
- More consideration should be given to the noise problem during the design stage.
- If ring bolts were fitted it would make erection and repositioning far easier.

(AH) J. CHRISTELER

NEW PRODUCTION METHODS AND PLANT

658.52

At the same time as the existing plant was moved from Baden to Birr efforts were made to reduce production times by means of rationalization. Certain items had to be adapted to suit changes in technique.

UNTIL a few years ago, the magnet segments for large machines were made from sheet (Fig. 1) cut into strips corresponding to the segment width. The strips were fed into the press by hand and each segment was stamped out individually with the aid of a "two-hand release". The segment had to be removed from the machine by hand, and the strip had to be pulled through for the next pressing. After 3–4 operations the scrap was taken out of the machine and thrown into a bin (Fig. 2).

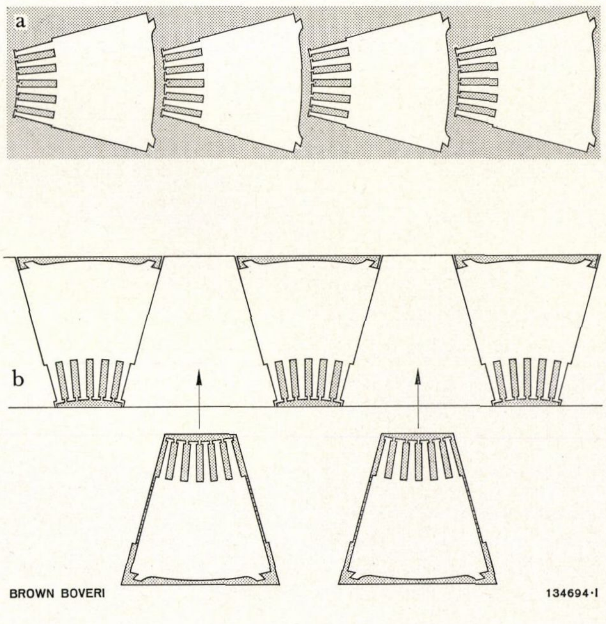


Fig. 1. – Stampings of magnetic segments

a: by the old method from sheet
b: by the new method from strip

The technique of stamping has changed with the introduction of new automatic equipment (Fig. 3). The operator is largely relieved of manual operations, though ensuring that the machine works perfectly demands a high sense of responsibility.

The segments for turbogenerators are now stamped from rolls of metal sheet. Firstly, only every second segment is stamped out, and the piece in between is cut into a trapezium shape by cutters built into the

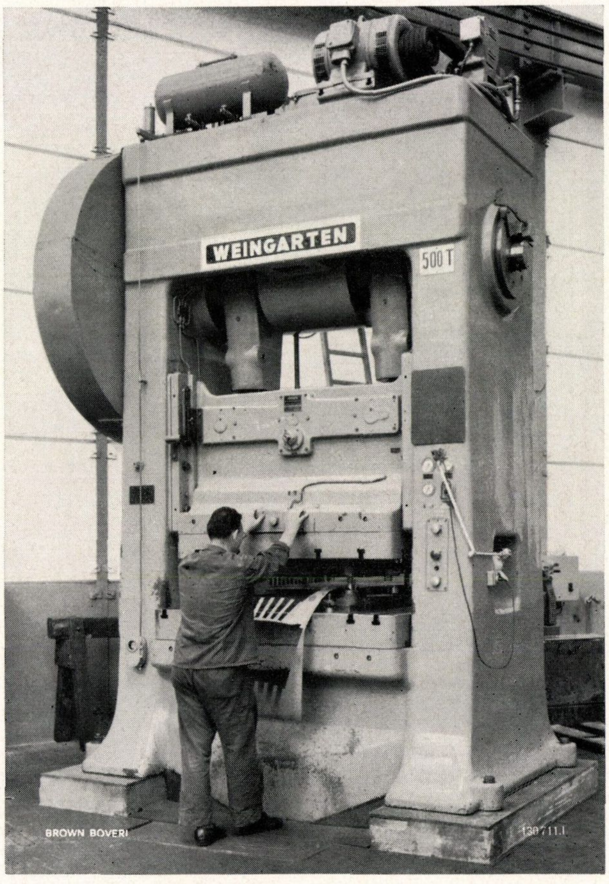


Fig. 2. – Pressing single magnet segments, two-hand release

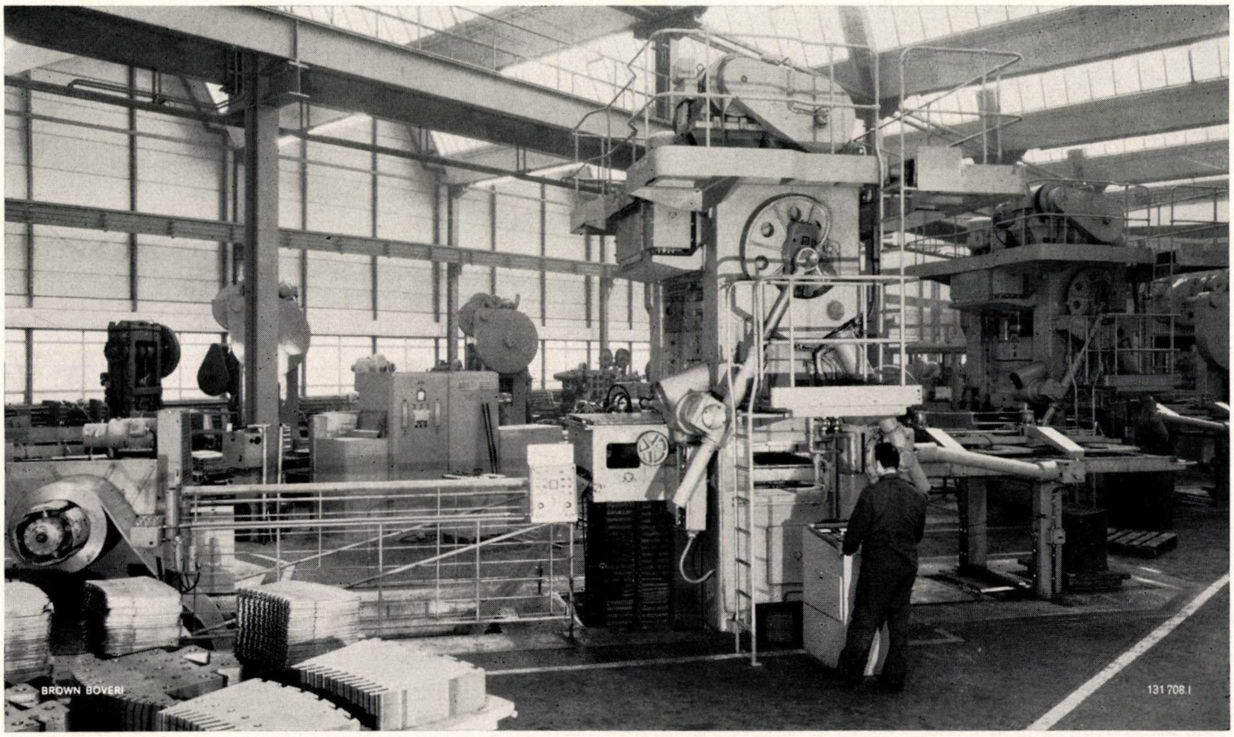


Fig. 3. – Automatic stamping of magnet segments from strip

machine. Both segment and trapezium are removed from the machine by magnetic grabs and placed in separate stacks. The relatively small amount of scrap is conveyed to bins in the basement by means of magnetic grabs and chutes. In a second pass, the trapezium-shaped pieces are taken from the stack by suckers and placed in the machine. The new automatic press results in a saving in materials of about 20% and a time saving of up to 50%.

Plant and Equipment for the Fabrication of Windings

There have been many new developments over the last twenty years in the field of insulation technology, and the number has increased rapidly in recent years. Thorough testing in the laboratory and with prototypes is essential for selecting the most suitable techniques, and this requires close contact between the design and manufacturing departments.[1] The economics of the finished product as far as the customer is concerned, must always be considered the main object. Maintenance and repairs, particularly in the case of traction motors, must be kept to a minimum. These points lead to winding insulation which must satisfy the following requirements:

- Consistently good heat removal from the active copper of the winding to the cooling air, and hence a long service life for the insulation with little ageing.
- High overload capacity without changes in the insulation system.
- Non-hygroscopic insulating materials and good protection against moisture resulting from appropriate special treatment.

In the field of insulation, however, the use of new materials is to a very large extent dependent on their characteristic handling properties, and so the industrial application of such materials requires special equipment and suitable processes.

The fabrication of bars and coils (Fig. 4) presents an extremely diverse picture of the types of winding

[1] H. Largiadèr: Modern insulation systems for traction motors. Brown Boveri Rev. 1965, Vol. 52, No. 9/10, p. 732–9.

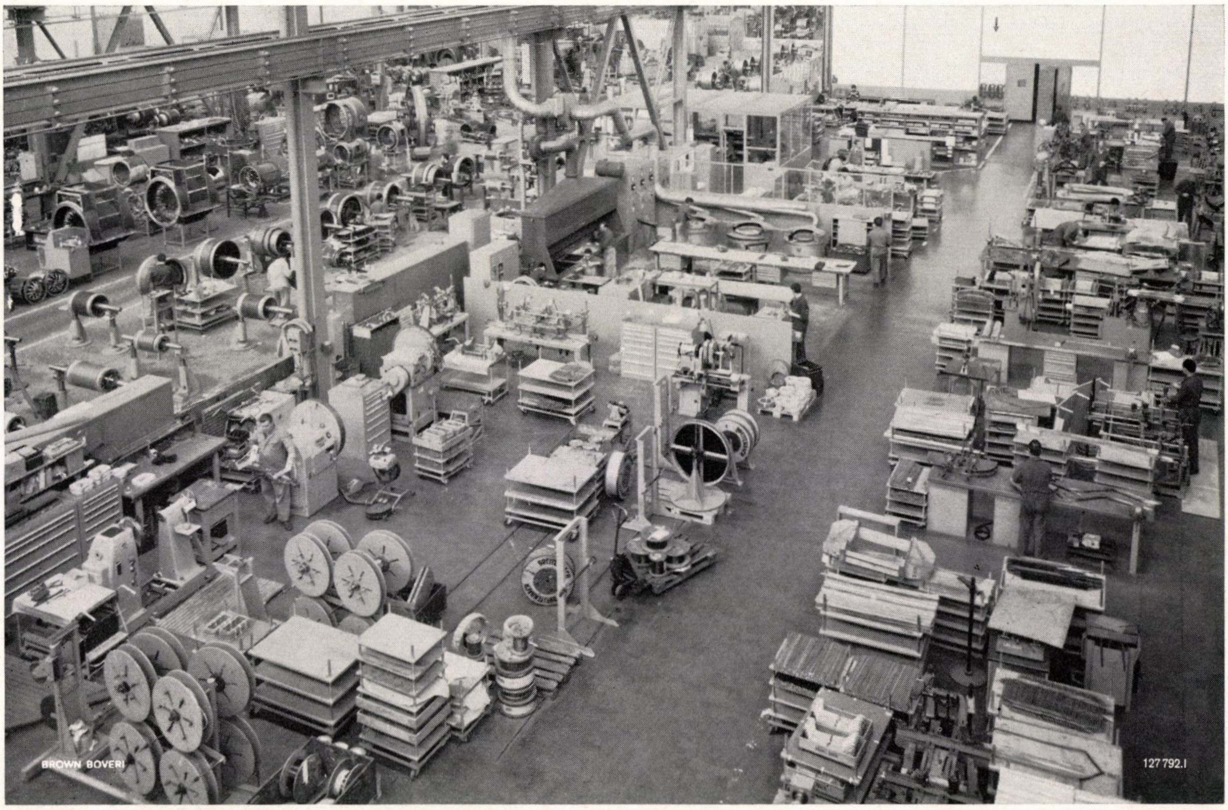


Fig. 4. – Bar and coil winding shop, with tinning plant included in the production line

The door to the impregnating room can be seen in the background. The windings are assembled in the bay on the left.

and sequences of operations. Since up to twenty operations are needed for each bar, a conveyance has been devised which can be passed from one workplace to the next until the winding is installed. Separate trays are stacked on a frame fitted with castors. This combined pallet arrangement has eliminated the extra cost of frequent re-stacking and re-loading. At the same time, the risk of damaging the delicate winding insulation has been very much reduced. An efficient exhaust system over the pickling and tinning baths enables the insulation to be installed in a rational manner within the production sequence.

Special new presses (Fig. 5) have been brought in for fastening the bundles of conductors and insulating the slot portions of bar windings. These hot-cold presses allow temperatures up to 250 °C and are therefore suitable for handling insulation systems for classes F and H. The heating system is electric, with resistance heaters, while air and water are used for cooling. The change to water cooling is automatic when a temperature of 120 °C has been reached with air.

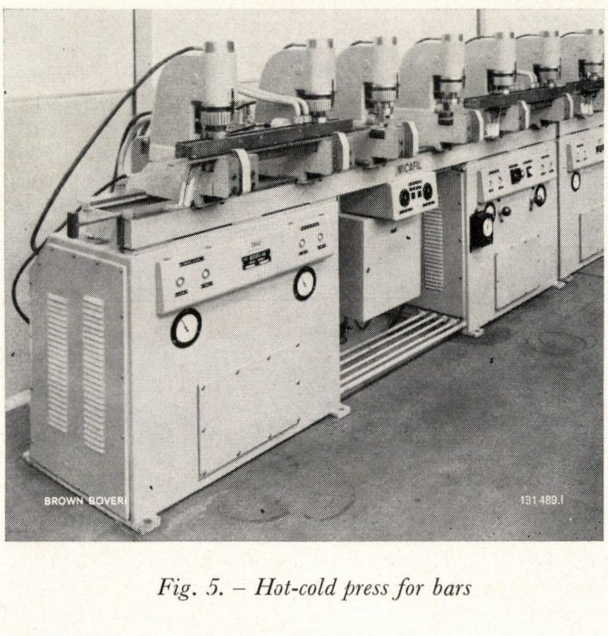


Fig. 5. – Hot-cold press for bars

The impregnation bay next door contains special workplaces at which toxic resins are handled. The bay is completely divorced from the rest of the production line and is separately ventilated, the air being renewed six times every hour. Extraction fans in the basement ensure a slight negative pressure compared with the other bays and discharge the exhaust air into the open by way of a chimney. This ventilation arrangement and the enclosed space also provide the best possible solution as regards fire prevention. The floor is surfaced with plastic tiles to facilitate cleaning.

The impregnation room has been fitted with new equipment:

- Drying ovens with recirculating air for 250 °C maximum
- Vacuum-impregnation plant for coils
- Vacuum-impregnation plant for wound rotors and stators (Fig. 6)
- Cooling plant for the resin-agitator vessels (in the basement)
- Cold store for intermediate storage of insulating tape
- Spray booth with water curtain
- Washing facilities at the workplaces

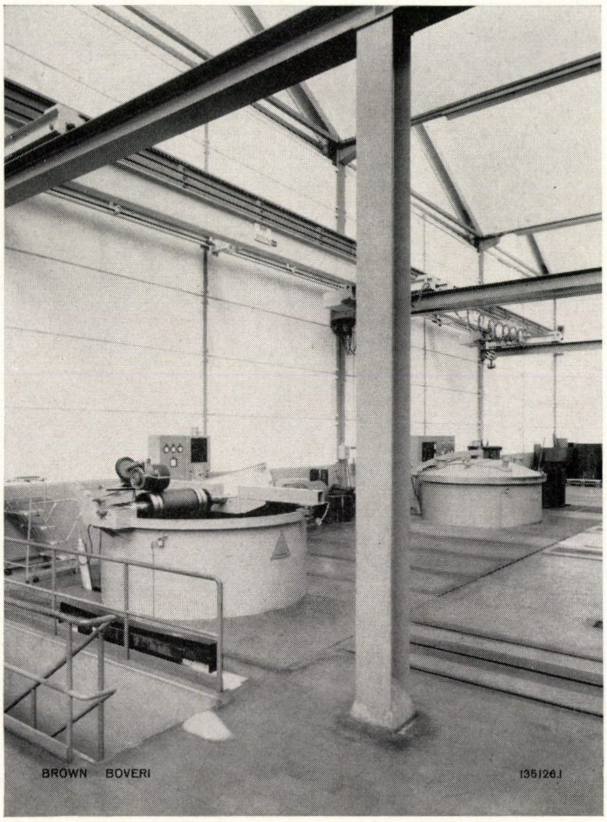


Fig. 6. – Vacuum-impregnation plant for rotors and stators

The workers in the impregnating shop have a special changing room. The half for working clothes is separated from the half for everyday clothes by a washroom with showers.

Following modern trends as regards traction motors, special high-melting lead-silver soft solders are used for assembling the windings. These solders ensure good joints, even under overload conditions. In view of the high fusion temperatures of the solders, each soldering position has its own extraction system in order to protect the operator from the harmful effects of inhaling traces of metal vapour. For this purpose, branch ducts have been built into the floor and provided with covers. The ducts lead to a central exhaust system working at a large negative pressure. After removing the nearest cover, the operator inserts a flexible metal hose into the branch stub and thus has a fully operational fume-extraction system at his own workplace.

Nowadays, a special glass-fibre epoxy-resin bandage is used almost exclusively for traction motors, instead of the steel-wire winding bandage. Melting of the bandage joints is therefore no longer possible, either as the result of overloading or in the form of secondary damage in the event of serious damage to the motor. Furthermore, with the glass-fibre bandage the manhours required have been reduced by 15–30%. New bandaging benches with special braking devices have been developed and put into service so that the bandages can be applied to the windings with the correct amount of pretension.

Innovations in Assembly

Assembly of the motors offers little opportunity for mechanization. The emphasis has therefore been laid on improving facilities at the workplaces.

One new machine mills the insulation from the commutator almost automatically (Fig. 7). Scanning probes control the rotor to turn by one segment each time. The cycle of cutting with the miller,

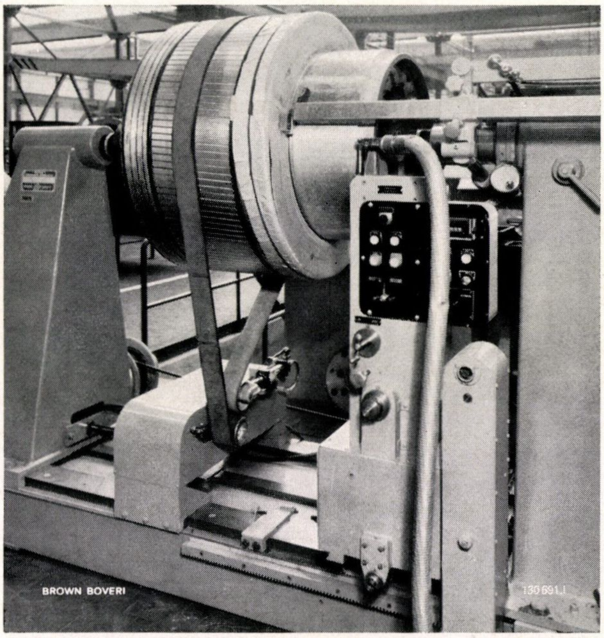


Fig. 7. – Automatic milling of commutator insulation

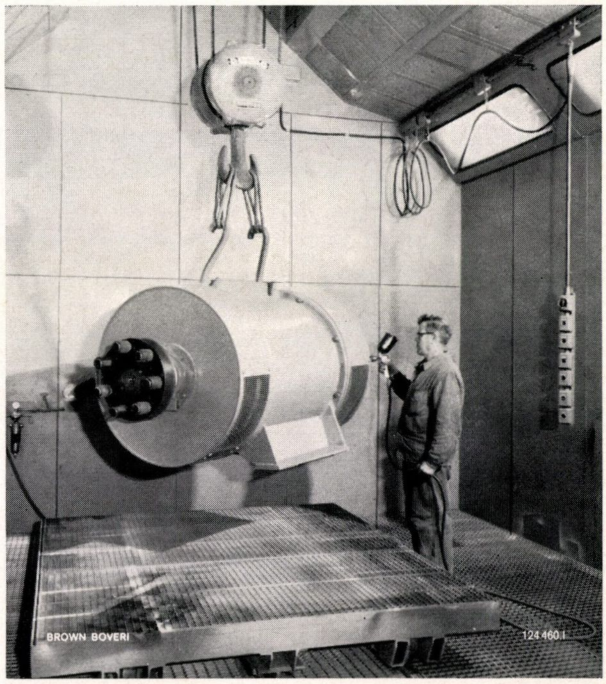


Fig. 8. – Spraying the finished machines in the spray booth

fast cutter return, and turning the rotor, continues automatically. For the same tool costs, it has been possible to reduce the job time by about 40%.

High-speed rotors are balanced in a room in the cellar, usually at the full rated speed. Overspeed tests can also be carried out on the same rig, even with rotors running at 3600 rev/min. In contrast to the individual test runs required previously on the overspeed test bed, no time is required for moving equipment from place to place, nor is production time lost at any other workplace. Since every overspeed test incurs a certain amount of risk, the appropriate safety measures have been implemented. The massive reinforced concrete walls are further protected on the inside by baulks of timber. The access door above is closed with a heavy wooden hatch. During testing, the test bed is controlled from outside.

When complete and tested, the motors are painted in a closed spray booth (Fig. 8). Because of the sizes of the items, an open spray bay would have necessitated an extremely high air change rate in order to maintain proper hygienic conditions in the paint shop, which is actually on the production line. Fresh air from the basement (36 000 m^3/h) is heated to 20–25 °C and cleaned in dry filters. The air enters the spray booth at the top and passes vertically downwards at a velocity of 35 cm/s. A washing system removes paint particles entrained in the exhaust air. For easy cleaning, the booth walls are coated with a removable paint.

M. AMMANN
P. MARTI

(DJS)

VERTICAL LATHE WITH THYRISTORIZED CONTROL

621.941.232-83

After a brief description of the application range of the vertical lathe the factors governing the planning of the main drive are presented. Wiring, controls and design are described in detail.

THE FACTORY at Birr includes machine tools of the most modern design. Apart from numerically controlled borers and milling machines in the housing construction section, which have been described in detail elsewhere [1], there is a vertical lathe in the same production line which is of particular interest as its drive is fed directly through thyristors. The lathe is used for turning operations on medium-sized electrical machine housings. Iron castings, steel castings and welded fabrications up to 6 t in weight and up to 1800 mm in diameter are machined on it. It has two cross-heads and one vertical head (see Fig. 1). It has fine measurement apparatus and adjustment controls for machining to fine limits.

Drive Requirements

The primary drive must be capable of producing the total cutting power as well as overcoming the friction loads of the face-plate drive and the feed drive loads [2]. The acceleration and braking conditions must be scrutinized because of the calculated capacity or turning moment. Adjustment of the cutting head is achieved through drive shafts and feed gears from the main drive.

From the technological characteristics of the workpiece material and the cutting tool, as well as the dimensions of the workpiece we can calculate the required speed in revolutions per minute of the face-plate thus:

$$B = \frac{n_{max}}{n_{min}} = \frac{v_{max}}{v_{min}} \frac{d_{max}}{d_{min}} = B_v B_d$$

$$B \approx 95$$

B_v = cutting speed range

B_d = diameter range

In order to be able to carry out face-cutting operations with constant cutting speeds the face-plate speeds must be infinitely variable in the range

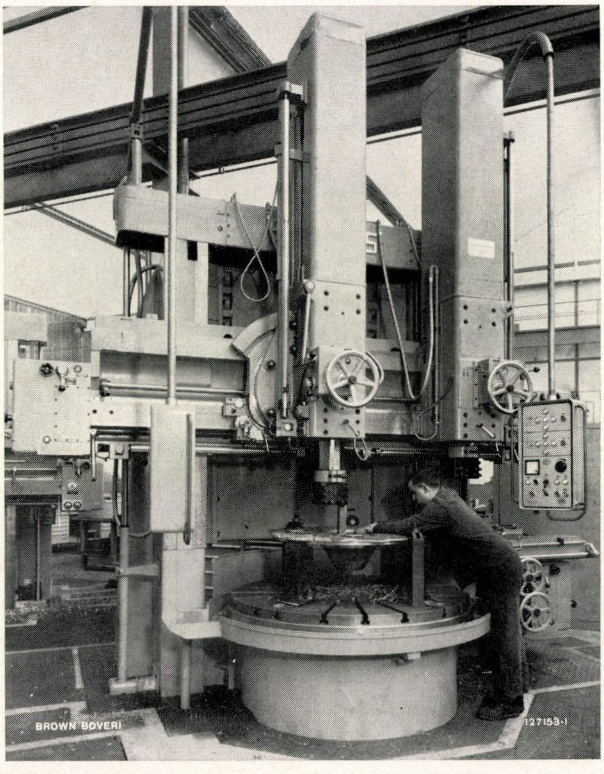


Fig. 1. – Twin-head vertical lathe with thyristorized drive for combined armature voltage and field control for diameters up to 1800 mm and face-plate speeds of 2·0 to 190 rev/min in four gear stages

The right hand cross-beam head is equipped for traversing at constant cutting speed.

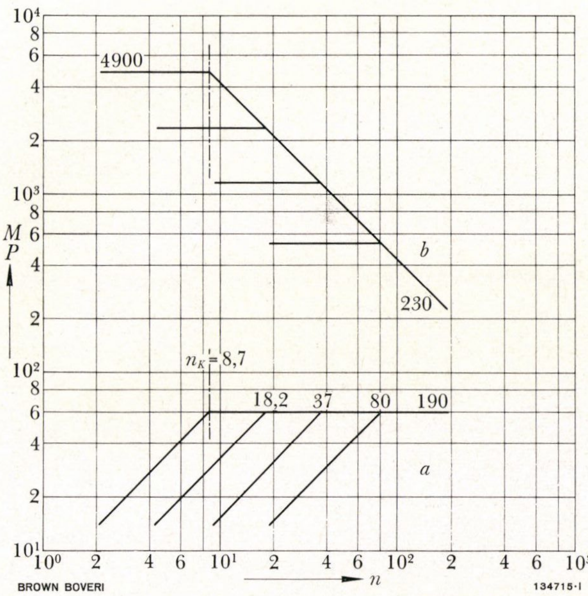


Fig. 2. – Characteristic curves of the face-plate drive

P = Spindle power (hp)
M = Torque (kgfm)
n = Spindle speed (rev/min)
n_K = Characteristic speed of gearing
a = Permissible capacity of the gear stages 14·2/60/60 hp at 2·0/8·7/190 rev/min
b = Permissible spindle torque for the stage gearing appr. 4900/230 kgfm at 2·0/8·7/190 rev/min

between the ratios 1:3 and 1:6 relative to the direction of cutting-head adjustment.

In the lower cutting speed ranges the machine should be operated at maximum capacity. The progression gearing must be capable of transmitting maximum motor output torque up to a turntable speed of n_K rev/min. At higher cutting speeds only smaller tractive forces are required. Both requirements are best fulfilled by a d.c. motor with combined armature voltage control and field variation. In contrast to armature voltage control alone, this allows the design rating of the motor to be reduced in proportion to the range of field variation (1:2 to 1:3).

A natural safeguard for the machine tool is achieved at smaller motor design ratings by matching the gearing and motor characteristics. The gearing, which is the weakest link in the transmission, is protected by making its characteristic speed n_K coincide with the inflexion in the power/speed curve of the lowest gear stage. Fig. 2 shows the characteristic used in dimensioning the drive unit consisting of a variable-speed d.c. motor and speed-change gearing.

The control unit allows the face-plate to be driven at constant speed of rotation or constant cutting speed within the speed range. Both values are infinitely variable within any gear stage. The machine tool motor is governed to protect it from excess speed when operating at constant cutting speed. As the reduced moment of inertia of the rotating masses acting at the motor spindle often varies by more than 1:100, the controls must be correspondingly flexible. When turning parts with an interrupted cut the reaction time (transient load response at suddenly applied loads of 100 %) must be so short that the section profile is not affected.

The Drive

The very precise regulation and control requirements of large modern machine tools are almost without exception fulfilled with the aid of electronic techniques today. Within the range of the Brown Boveri electronic system there is a comprehensive and adaptable programme of units which is available for the most diverse problems involved in power drives [4, 5].

The variable-speed d.c. motor for driving the vertical lathe can be fed by rotating converters with additional aid from intermediate amplifiers or through static converters fed direct from the three-phase mains.

The best solution from a technical aspect is offered by a static converter with thyristor power stages, in short, a thyristorized drive [3]. The advantages lie in the use of static elements which give a lower noise level, greater efficiency compared to the rotating converter and significantly more favourable dynamic behaviour.

Thyristors are controlled silicon rectifiers which permit alternator voltage to be converted into direct voltage and this to be uniformly varied between zero and maximum values. Due to the similarity between their current/voltage characteristic and that of gaseous discharge tubes the grid-controlled valves are also called Si thyratrons.

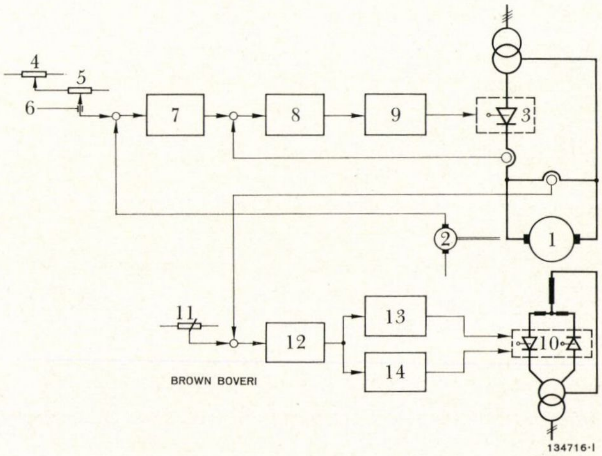


Fig. 3. – Schematic diagram of the main drive of a vertical lathe

1 = Variable-speed d.c. motor
2 = Tacho-generator
3 = Thyristor unit for armature feed
4 = Potentiometer for actual value of spindle speed
5 = Potentiometer for constant cutting speed
6 = Cutting head adjustment drive
7 = Speed control
8 = Current control
9 = Grid control set for armature correcting element
10 = Thyristor unit for field feed
11 = Potentiometer for field control range
12 = Field regulator
13,14 = Grid control set for field control unit

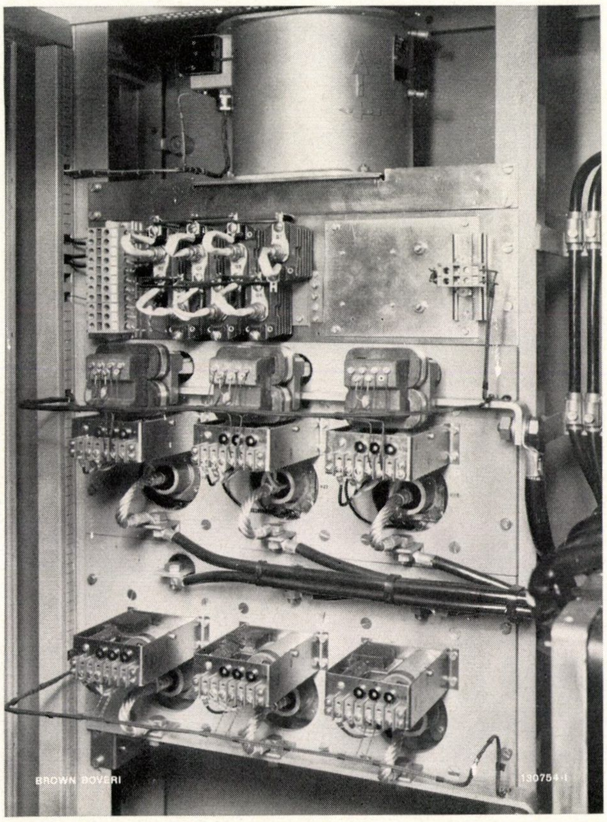


Fig. 4. – Veritron power stage with six thyristors, matching transformers, protective gear and fan

Suitable for 450 A and 500 V d.c., directly connected to 3 × 380 V, 50 c/s three-phase mains.

In contrast to mercury-arc rectifiers they operate economically even at low capacities owing to the very small voltage drop in the valve. Thyristors operate almost instantaneously but nevertheless have a dead-time which depends on the delay, the frequency and the number of phases of the supply network. If thyristors are worked against a back-e.m.f. or with an inductive load (field winding) they can also be used as inverters.

Circuitry and Control

The circuit diagram for combined armature voltage/field control of the main drive is shown in Fig. 3. A power stage with six thyristors in three-phase bridge connection for rectifier and inverter operation (Fig. 4) serves as armature feed for the independently air-cooled variable-speed d.c. motor. The speed control system with current limitation is built as a cascade circuit. The speed controller works within the speed variation range so that the output signal (reference current value) produces a reference speed value proportional to the motor speed or tacho-generator voltage. The reference current is limited and allows the accelerating and braking currents to be adjusted independently of each other. The output signal from the current controller acts through the grid control set on the thyristor controls.

The start of field regulation, i.e. the inflexion in the power/speed curve in Fig. 2, is adjusted in relation to the armature voltage. The separate excitation winding is fed from a regulating unit with 2 × 2 anti-parallel thyristors in single-phase mid-point connection for rectifier and inverter.

The field reversing circuit enables the drive to be operated in the positive and negative power quadrants. Braking results in a recuperation of the kinetic energy in the rotating masses. The braking process follows reversal of current in the excitation circuit. The drive is not regulated during the very short period of field reversal.

Design

The two power stages 3 and 10 in Fig. 3, together with the appropriate control part, are complete units. They are adaptable and constructed from elements of the Brown Boveri electronic system. The complete control system for the vertical lathe is housed in mounting frames in a two-section cabinet. Two suspended control units are fitted for operating the vertical lathe, which has been in operation since March 1964. The mechanical and electrical equipment is well coordinated, the control equipment being continuously in operation and fulfilling every requirement.

(AH) W. SEIFERT

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METROLOGY LABORATORY

531.71.006.2

The main requirements of a metrology laboratory are constant temperature and freedom from vibration. Precision measuring machines are used for inspecting the production measuring instruments and for special measuring problems in production.

IN THE PRODUCTION of standardized parts the dimensions and shape of the parts must comply with the tolerances given on the drawings. To safeguard this accuracy the machines, tools and above all the measuring instruments used in the production of these parts must have a correspondingly high degree of accuracy. The measuring problems involved can only be solved satisfactorily in a metrology laboratory where apparatus set to the international standard metre is available.

The prime object is the inspection of gauges and all other measuring instruments. This requires an accuracy of 1/10 000 mm. All gauges and measuring instruments must be checked before they go into service and as they are subject to wear and individual changes, periodic inspections must also be carried out on them.

It is essential for production that suitable measuring instruments are available so that tolerances may be kept to a minimum with commercial devices. It is also imperative that the laboratory staff have suitable training to enable them to carry out the requisite tests.

Many components have to be measured in the laboratory, sometimes because they have to conform to exceptionally fine limits but very often to check the overall dimensions of an assembly. In many cases a graphical description of the discrepancy is desired.

Measuring the geometric contours of a body entails not only the dimensions, shape and position but also the surface roughness. Surface roughness specimens are on display in all workshops for comparison purposes in normal operations and processes. However, it is often necessary to measure the surface roughness and supply a graphical representation. All of these measurement problems can be solved in the new metrology laboratory which is situated in the basement of the new factory at Birr.

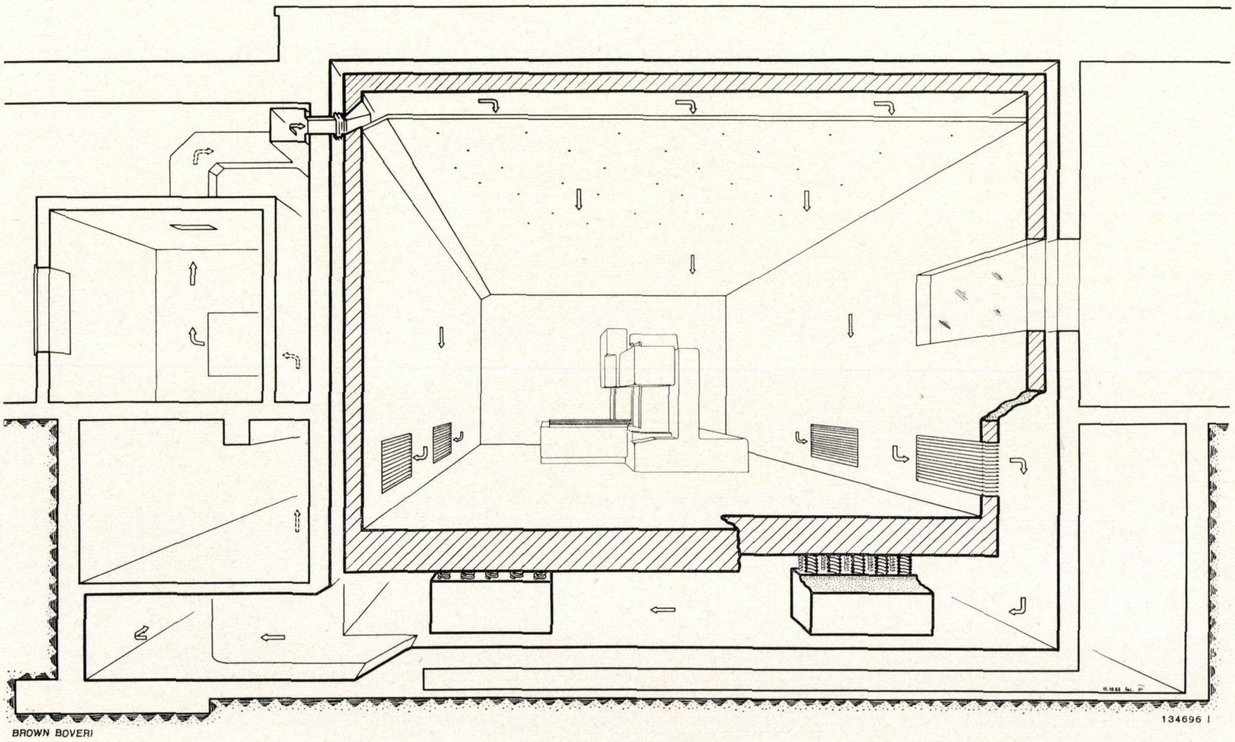

Fig. 1. – Cross section through the double-shell metrology laboratory. The inner shell rests on springs

Conditioned air circulates through the cavity between the walls. Spent air is extracted from the whole room (see arrows).

The main requirement of the metrology laboratory is strict temperature control to within ± 0·2 °C. As international standard measurements are taken at 20 °C the room temperature limits are 19·8 to 20·2 °C.

The room has a double-shell construction. There is constant air circulation between the two shells. The air conditioning plant for the laboratory is thermostatically controlled (Fig. 1). Accurate temperature control is particularly essential for large

Fig. 2. – Interior of the laboratory

components. For example a steel rod 1 m long expands by 0·0115 mm per degree rise in temperature. The articles for inspection are stored until their temperature is the same as the room temperature. In some cases this requires many hours, depending upon the size, weight and material of the component to be measured. The higher the degree of accuracy required, the longer this process takes.

To protect the expensive precision instruments from corrosion and for the health and well-being of the staff a relative humidity of 55%+5% is maintained by the air-conditioning system. The air is recirculated 21 times an hour and filtered because dust is the worst enemy of accurate measurement.

As vibrations also affect accuracy of measurement and make the reading of fine optical instruments more difficult, and also have a detrimental effect on the reproductions of the graphic recording instruments, the complete 450-t room was placed on spring shock absorbers.

The following instruments in the metrology laboratory are worthy of mention:

- Coordinate measuring machine of the Société Genevoise d'Instruments de Physique (SIP), the Superoptic, for measuring parts in three coordinates with adaptation for graphic reproduction of errors in shape and position.
- Universal length measuring machine (SIP) for lengths up to 4000 mm.
- Universal measuring stand (Leitz-Strasmann) for measuring in two axes for diameters, threads, profiles, etc.
- Abbé length measurer (Zeiss), primarily for testing tolerance plug gauges.
- Sigma electric comparator for comparison measurements of slip gauges.
- Talysurf surfaces measurer for measuring the surface roughness with graphical reproduction.

The new facilities for measuring and reproducing the geometric shape of fabricated parts gives valuable evidence for estimating and ensuring the quality. The scatter of the measured values can also be controlled, i.e. the actual values can be evaluated far more accurately.

H. Wegmüller
A. Berli

(AH)

THE NEW TEST BAY FOR MEDIUM-SIZED MACHINES

621.317.2:621.313

The new test bay is composed of measuring stations provided with basically the same facilities. The individual test areas are fitted for their particular functions by means of special additional equipment, although they can easily be adapted to prevailing conditions should the production programme be modified. A central room for recording oscillograms in conjunction with decentralized measuring positions enables full use to be made of expensive modern instruments. Sound-proofed instrument cabins and oil and cooling-water supply systems are essential for safe and rational testing.

A TEST bay has been set up for testing medium-sized electrical machines. It lies across two adjacent shops (numbers 13 and 16) and constitutes the end of the whole production sequence. In addition to the test stands in these two shops, other test beds for purposes of special measurement and research and development have either been built or are under construction, such as the ventilation laboratory for studying heating problems and air flow in electrical machines. In the basement there are also testing facilities for brushes and slip rings, while in the north wing there is a laboratory for development work and special measurements on small items and models.

Power Supply

All the test beds, including those for large machines in shops 2 and 5, draw most of their power from the converters in the central machine house via line selectors (Fig. 2).[1] In addition to having connections to the line selectors, all those test beds which often, or always, require a particular voltage or frequency are provided with their own power sources. These are located near the test beds, mostly in the basement below. There are, for example, exciter machines for 220 V d.c. (the permanent d.c. system is at 110 V), high-current low-voltage d.c. machines for feeding the interpole winding when testing d.c. machines (commutation curves), Ward-Leonard generators for special drives, heavy-current machines for slip-ring tests, load impedances for taking up high active powers, and so on.

The Test Beds

The test beds in shops 13 and 16 form the nucleus of the new laboratory. The intention was to create a testing facility which is adequate for the varied production programme, able to accommodate changes of emphasis in the programme and which makes for testing which is as practical as possible, and yet accurate.

Both shops are within the range of the crane hook and provided with a slotted bedplate, the level of which can be adjusted. Below floor level and between the slots there are 52 power connections and 16 connections for cooling-water and lubricating oil (Fig 3). Above floor level and evenly distributed round the slotted areas are eleven small switchgear cabinets which provide auxiliary power (380/220 V, 50 c/s and 110 V d.c.). The facilities for setting up and moving the items under test are thus extremely versatile.

In view of the broad production programme, the two slotted-floor sections are divided into 18 test areas containing a total of 38 test beds. Twenty positions can be supplied with power independently, i.e. separately and simultaneously. The number of test beds makes it possible to utilize the unavoidable

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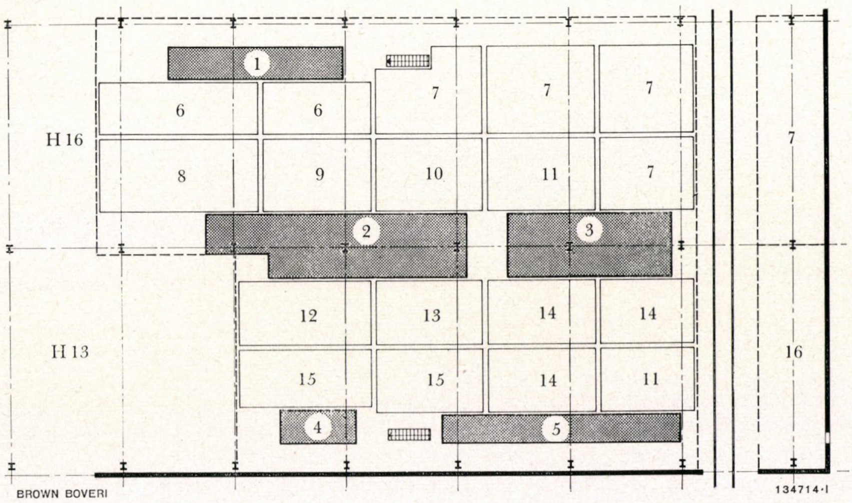

Fig. 1. – The test bay for medium sized machines

1–5 = Instrument cabins
6 = Medium-frequency machines
7 = Development
8 = Traction motors
9 = Heavy-current synchronous machines
10 = Machine-tool drives
11 = Exciters
12 = A.C. commutator machines
13 = A.C. synchronous machines
14 = D.C. machines
15 = Asynchronous machines
16 = Workshop

periods of waiting between measurements by working on another bed. Also, in many cases the size of a machine means that it has to occupy two positions.

In general, the power supply and control systems are basically the same for all the measuring stations, so that each test bed can be used for any test specimen.

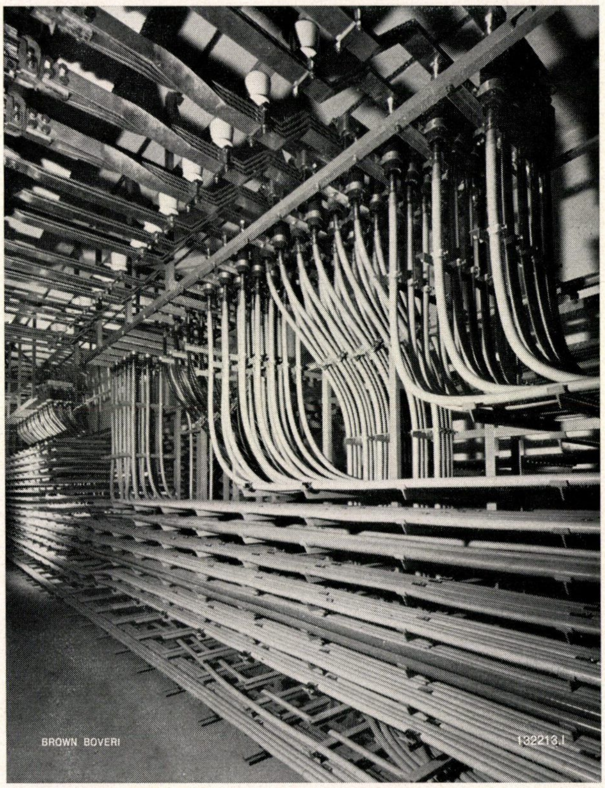

Fig. 2. – Connections from the line selector to the test beds

A degree of flexibility has thus been achieved which means that in the future it will be possible to accommodate fairly large changes in the production programme at little capital cost. In the interests of rationalization, however, the separate test beds are provided with additional facilities such as measuring gear, small individual power sources, permanent-magnet generators, cooling-air blowers, etc. It is these extra items of equipment which make the test beds particularly suited to specific purposes (Fig. 1).

Testing

The different activities in the test bay, mounting the machines to be tested, connecting them up electrically, and finally the testing itself, are as varied as the production programme. Nevertheless, there are a number of recurrent problems which necessitate a degree of rationalization. The item for testing is conveyed to the appropriate bed by crane, there set in the required position, fastened down and, if necessary, coupled to a second identical machine or to a motor. The levelled bedplate is provided with T-shaped slots and enables the test specimen to be fixed in any position. Similar machines can be connected together without the need for time-consuming lining up and adjustment. If the machines have centres at different heights, coupling them up is made simple and quick by using calibrated cast packing pieces with T-slots, varying in thickness from a tenth of a millimetre up to 1·2 metres.

The most frequent wiring arrangements for normal tests, such as "no-load", "short circuit" and "load", have been included in the corresponding measuring gear for a proportion of the items tested. With these it is sufficient to connect the terminals of the test specimen to those of the measuring station. The various basic circuits can easily be made up by changing round isolators and links at the measuring station. The necessary power is switched on at the instrument bench, the operation being depicted on an illuminated circuit diagram. Control of the circuit-breaker and excitation of the generator voltage are also effected from the instrument bench. From the same position the power can then be switched on or off, or its voltage or frequency regulated as desired by means of built-in potentiometers. Other connections between the power source in the machine house and the measuring gear in the test bay can be made with the aid of the line selectors in order, for example, to be able to measure the voltage of the power source before closing the circuit-breaker.

Other essential services, such as lubricating oil and cooling water, are laid on at each test position and removed when testing is complete. Reliable piping and ducts between the test specimen and the nearest connection point can be assembled very quickly by means of a system of pipes of different lengths, bends, and valves, etc., which can be combined as desired with the aid of quick-release couplings and be fitted with manometers and thermometer stubs according to requirements.

The Oscilloscope as a Measuring Aid

More advanced manufacturing and testing techniques, and the directly associated methods of calculation, etc., require the use of the oscilloscope as a means of measurement. As the oscilloscope is a highly sensitive instrument it should not operated continuously by different people or be transported from one test bed to another. It was therefore decided to build a central oscilloscope room connected to every test bed by means of screened cables (Fig. 4). The instruments are then tended by only one person and there is no need to move them about. A further advantage is that two or three test beds can be served by one oscilloscope, because the actual time taken to record an oscillogram is very short compared with the time spent in setting up and the

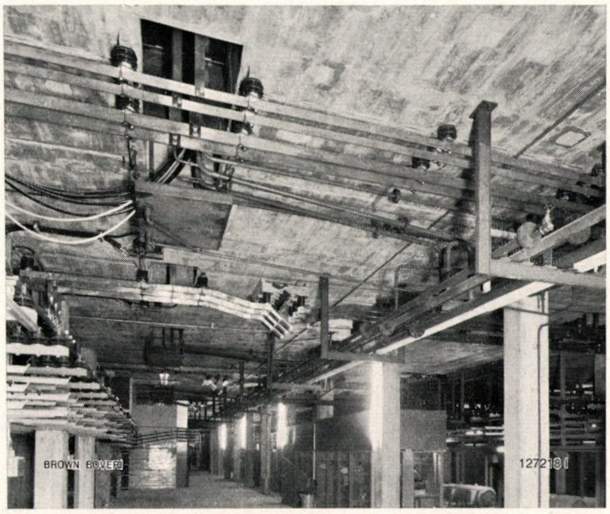

Fig. 3. – The basement, showing the power distribution to the test beds

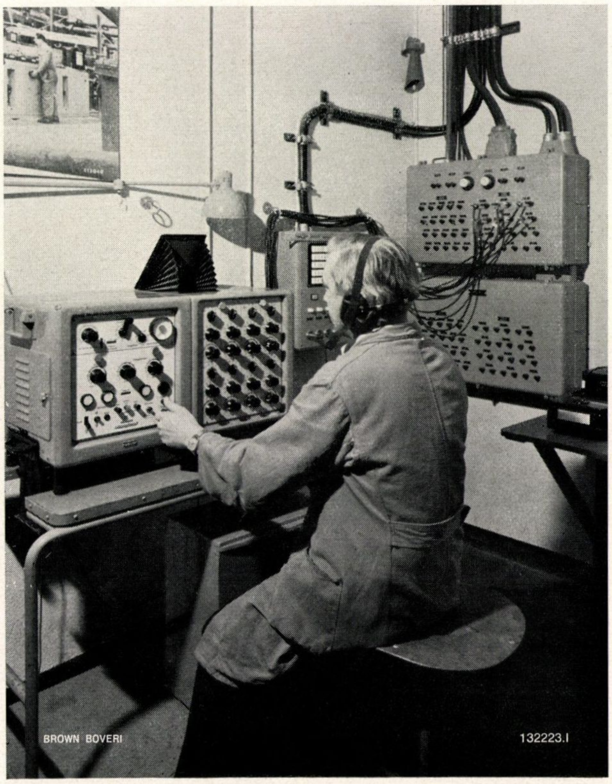

Fig. 4. – The central oscilloscope room with intercom

pauses between measurements. A test bed requiring oscillograms is allotted a number of cables and its circuit can be set up independent of the other beds. Oscillographic studies can be extended over protracted periods without having to incur waiting times of more than half an hour. Continuous speech communication between oscilloscope room and test bed is maintained by means of a five-channel intercom system with headset and lip microphone. Next to the oscilloscope room is a well equipped darkroom in which a finished oscillogram can be produced about 30 minutes after photographing.

Measuring Rooms

Very accurate measurements can be achieved only by employing the most suitable methods and high quality instruments. Selecting the correct method is the responsibility of the engineer conducting the test. When designing the circuitry of the measuring equipment it was possible to make provision for only a few of the most common cases. High quality instruments (class 0·2) are electrically and mechanically very sensitive and are relatively expensive. For this reason the banks of instruments are large and of heavy sheet-steel construction. In general, the instruments are mounted on thick foam rubber pads. Also, those parts of the measuring equipment on which the instruments themselves stand are located in measuring rooms (Fig. 5). These can be compared to laboratories and have double glazing and an acoustically insulated ceiling to protect those inside from the noise of the test bay. Movement of the instruments has been largely excluded and mechanical damage avoided by allocating the most important of them to separate benches.

Ancillary Services

The test beds are also provided with supplies of cooling water and lubricating oil. In view of the comparatively high cost of fresh water it was decided to build a separate closed-circuit cooling-water plant, since at times it is necessary to have large quantities of water which must not become significantly contaminated. From the 750 m^3 cooling basin the water passes to a series of pumps, each of which feeds a distribution network containing a number of similar or neighbouring consumers. The discharged cooling-water flows by gravity into small collecting tanks (one for shop 13 and 16, one for shop 2 and 5 and one for the acoustic laboratory), from which it runs back into the cooling pond via large level-controlled pumps. The different networks can be connected by opening certain gate valves so

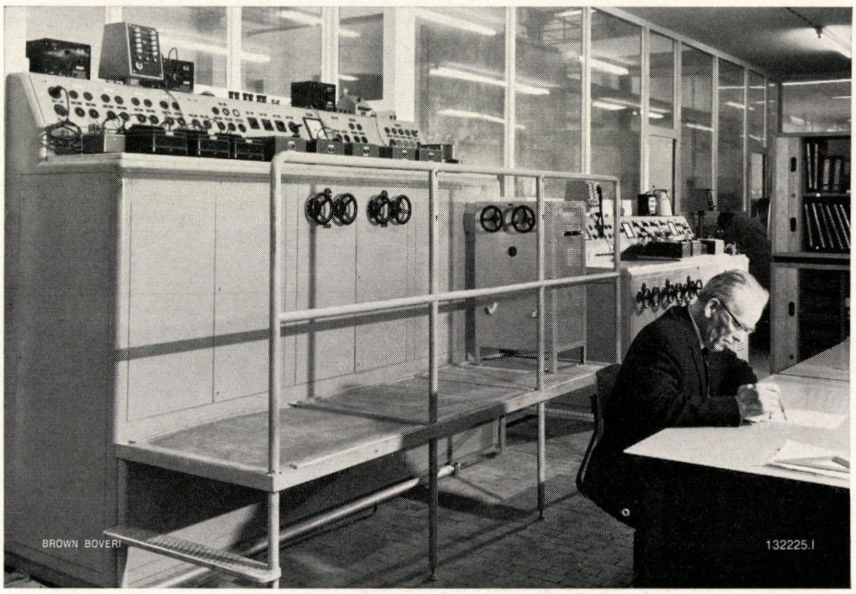

Fig. 5. – View of an instrument room

that the pumps can be overhauled without causing any interruption. If a return pump fails, the cooling-water involved passes through an overflow into the drainage system. In the case of high temperatures the returning water runs into the cooling pond by way of cooling towers (of the evaporative type). The water lost through evaporation is made up with fresh water. Except in warm weather the cooling towers are used comparatively infrequently, since with an output of 1000 kW the entire content of the cooling system, amounting to more than 800 m^3, heats up by only about 1 deg C per hour.

Since, in the event of a power failure, all the pumps stop, even though cooling water may still be required, the connection points can be supplied with fresh water.

The oil system is much smaller and serves only shops 13 and 16 (shops 2 and 5 have their own installations), but for this reason it is designed for maximum reliability. The oil is pumped from a 7000 litre underground reservoir to the distribution network via filters and coolers. Part of it is diverted into a high-level tank of 2000 litres capacity. The excess flows back into the underground tank. In the event of a power failure the pump stops and the pressure in the pipes drops until a check valve opens, whereupon oil can again flow from the high-level tank with a head of 10·5 m. The 2000 litres is ample to cover the rundown times of all the machines.

An automatically controlled 100-kW diesel unit serves as an emergency source of power for the test bay. There are also all the necessary workshops, together with comprehensive stores for switchgear, driving machines, rheostats, cables, instruments, pipe fittings and connectors.

(DJS) G. WUNDERL

A NEW ACOUSTIC RESEARCH LABORATORY

534.006.2

The new acoustic laboratory is for studying rotating electrical machines and transformers. The anechoic room has high insulation values for air-borne and solid-borne sound and high absorptivity. On the other hand, the reverberation room contained in the same building has a reverberation time which is as long as possible. The power supply can handle capacities up to 1000 kW.

IT IS A FEATURE of electrical machines that the trend towards ever higher power-weight ratios is unfortunately accompanied by an increase in the amount of noise developed. The magnetic noise produced by rotating electrical machines is increasing as the result of the change from cast to welded constructions, and the improved electrical utilization of the active material. With high-speed units it is the fan noise which is of greatest importance.

Although the performance of a machine is not generally adversely affected by the noise it produces, the effect of excessive noise on the general health of people presents problems which necessitate ways of suppressing the noise, and this requires research. An acoustic laboratory is essential for the appropriate development work; it can be used for establishing the acoustic characteristics of machines or parts of machines in order to determine any shortcomings, to define principles for new designs or to ascertain the effectiveness of measures taken to reduce noise.

The new acoustic laboratory at Birr is intended primarily for studying rotating electrical machines and transformers. Nevertheless, it can also be used for testing or developing structural components or devices connected with sound, but which are not directly associated with machines.

Requirements

The main requirements of the acoustic laboratory were four in number:

1. The laboratory should be able to take items of up to 10 t in weight or 2 × 2 × 3 m in size.
2. The test rooms themselves must have extreme acoustic properties, i.e. there must be at least one chamber having extremely little resonance, and one with maximum reverberation.
3. The background level in the test rooms must be so low that even the lightest objects can be studied without being affected by extraneous noise.
4. It must be possible to test rotating machines under mechanical load, in which case the noise of the machine providing the load must not interfere with the tests.

The third of these led to the construction of a building on the north side of the site, completely separate from the factory (Fig. 1 and 2).

Anechoic Room

The most important part of the building is a large anechoic room. It is of double-shell construction and passively insulated. The inner shell, of reinforced concrete, rests on springs mounted on two foundation blocks in the basement, and is thus insulated from vibration. With this construction, the average attenuation of solid-borne noise is about 40 dB, while that of air-borne noise is more than 80 dB.

Inside, the walls, floor and ceiling are covered with highly effective acoustic insulating material, con-

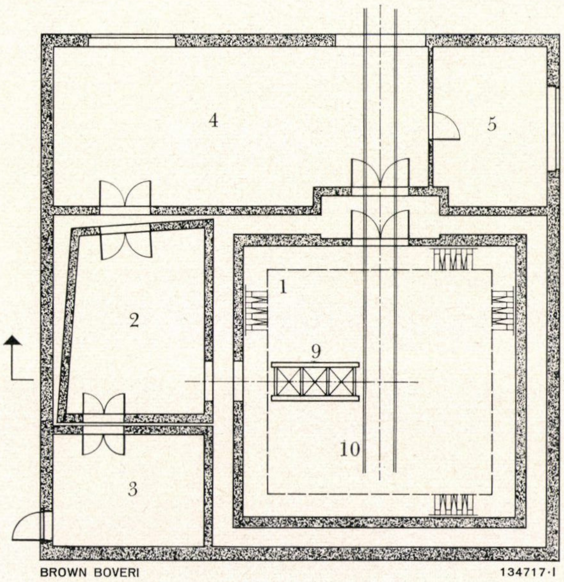

Fig. 1. – Ground floor plan of the acoustic laboratory

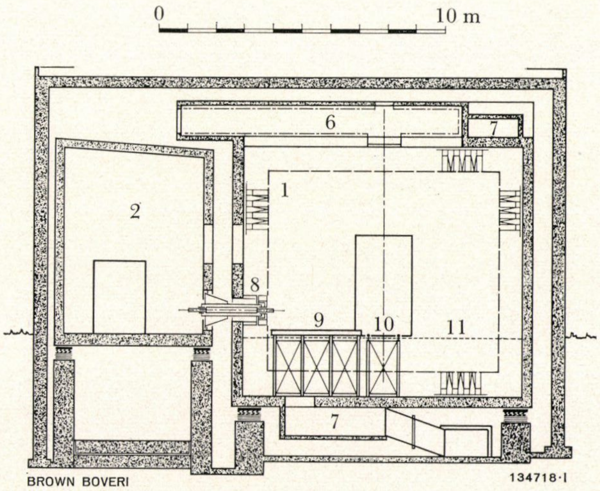

Fig. 2. – Section of the acoustic laboratory

Legend to Fig. 1 and 2:

1 = Anechoic room
2 = Reverberation room
3 = Vibration measurement
4 = Outer room
5 = Control room
6 = Crane-track housing
7 = Ventilation ducts
8 = Connecting shaft
9 = Mounting frame
10 = Rails
11 = Walk-way

sisting of a layer 850 mm thick of wedge-shaped mineral-wool slabs which above their threshold frequency of approximately 95 c/s give an absorption coefficient of more than 99%. The effective dimensions of the room are 8 × 8 × 7 m.

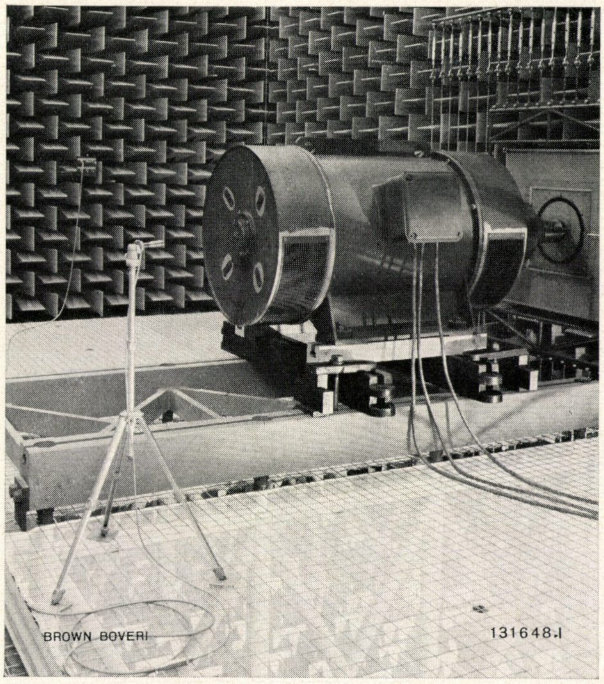

Fig. 3. – Measuring the noise of a motor at rated load in the anechoic room

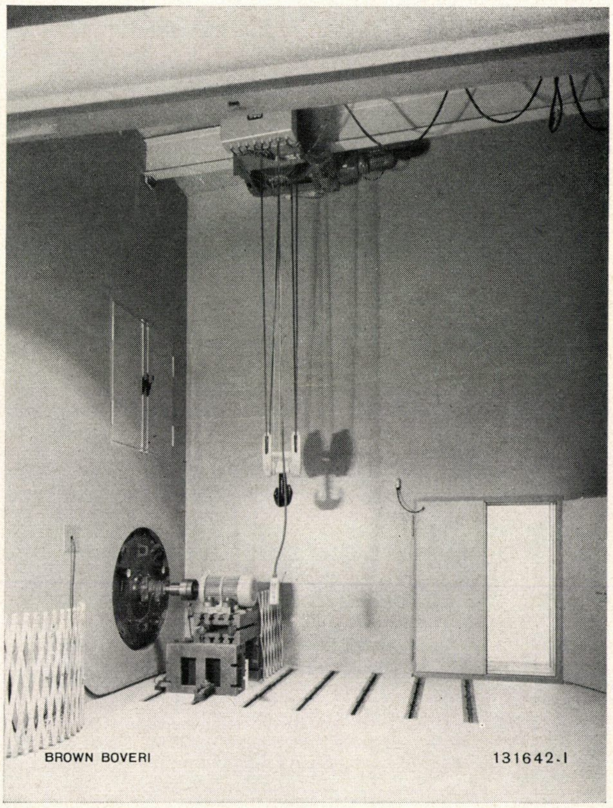

Fig. 4. – The reverberation room, showing the mechanical connection to the anechoic chamber

The items to be tested are brought into the anechoic chamber on trolleys from the neighbouring store through two insulated doors providing an opening of 2 × 3·5 m. As the floor of the chamber is lower than the door sill the rails for the trolleys rest on a tubular steel frame. At right angles to the rails there is a mounting frame for machines being studied under mechanical load. Lifting gear is provided for unloading and setting up the equipment. To allow access to the chamber there is a suspended steel-rope walkway slung at the height of the door sill.

The free-field conditions required in the anechoic chamber must not be significantly affected by these items. For this reason the smallest possible profiles and cross sections have been chosen, and in part these are again clad with mineral wool. Also, the hoist carriage is contained in its own housing, insulated with mineral wool, above the ceiling. If the requirements as regards lack of echo are particularly stringent, the mounting mentioned earlier for rotating machines can be removed from the chamber.

The chamber can be used not only for standard noise measurements on items of equipment up to 10 t in weight, but also for determining directivity patterns and specific noise sources with a relatively high degree of accuracy. Special-purpose investigations are also possible, as, for example, in the development and testing of electro-acoustic equipment.

Reverberation Room

The reverberation room has a volume of 200 m^3 and, like the anechoic chamber, is of double-shell construction and passively insulated. In order to attain the longest possible reverberation time with the room empty, the walls and ceiling are polished smooth and coated with a synthetic resin. As can be seen from Fig. 1 and 2, no surface is parallel to another. Standing waves, which can give rise to an uneven distribution of acoustic energy, are thus largely avoided. The two most important properties which an echo chamber must possess are as long a reverberation time as possible and a locally uniform distribution of energy density.

For reasons of building layout, the reverberation room was also chosen as the place for the machine providing mechanical load. This machine compensates the mechanically absorbed or emitted energy of a rotating machine being tested in the anechoic chamber. The mechanical link between the two consists of an acoustically insulated shaft passing through the wall (Fig. 5). Basically this is a cantilever tube, 2 m long, serving as a carrier for the connecting shaft, which has two bearings. One end of the tube is supported at the wall of the echo chamber while the other extends through acoustic insulation into the anechoic chamber, without touching the wall. The extremely high attenuation of airborne and solid-borne noise between the two

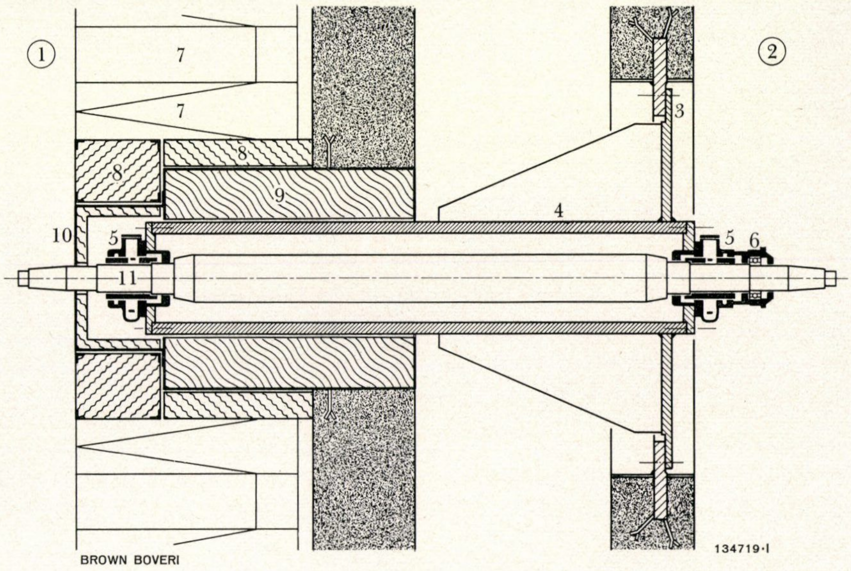

Fig. 5. – Connecting shaft between reverberation and anechoic rooms

1 = Anechoic room
2 = Reverberation room
3 = Cantilever tube mounting
4 = Cantilever tube with flange
5 = Water-cooled plain bearing
6 = Guide bearing
7 = Mineral-wool wedges
8 = Noise-absorbent filler
9 = Acoustic insulation
10 = Noise-absorbent cap
11 = Connecting shaft

chambers is thus retained. Measurement of the item under test is unaffected by the noise of the load machine, even when the background noise level is low. The insulated shaft can transmit torques up to 600 mkg at speeds up to 3600 rev/min.

Above the shaft there is an opening of 1·4 × 1·4 m, fitted with removable soundproof doors, which joins the reverberant and anechoic chambers. Silencers, or models of them, are inserted in this and their attenuation determined by measuring the sound pressure levels in the two chambers.

The echo chamber is used chiefly for determining the absorption coefficient of insulating materials under random noise conditions. It can also be used for measuring the sound power radiated by small and medium noise sources.

Vibration-Measurement Room

The echo chamber is adjoined by a vibration-measurement room (Fig. 1) which is mainly used for investigating smaller test specimens or other components. In conjunction with the echo chamber, however, it is also possible to measure the airborne noise attenuation of samples of generator casings, dividing walls, etc. For this, the doors connecting the two rooms are removed, and the item under test is inserted in their place.

Small Anechoic Room

The basement of the building contains a small anechoic chamber. It is of simpler design than the large chamber, and the passive insulation consists mainly of a floating floor surface and elastically suspended panels over walls and ceiling. The sound-absorbing material is mineral wool in panels of saw-tooth profile, 280 mm long and with a threshold frequency of 250 c/s. The effective dimensions of the chamber are 4·2 × 3·2 × 3·0 m.

The chamber is used for standard noise testing of small motors taken from the production line in order to check them for noise. It also serves to relieve the large chamber from routine measurements, so that it is available for development tests over longer periods of time.

Ventilation, Power Supply, Measuring Equipment

Special fans are provided to remove any heat caused by losses from a machine being tested in either the echo chamber or the large anechoic room. The air flow rate can be continuously regulated and its direction can be reversed at will. The air is delivered and exhausted through acoustically insulated ducts with flexible connections between the inner shells and the building foundations. The purpose of these connections is to prevent any solid-borne noise from being transmitted along the duct walls.

The four rooms are fitted with the necessary connections for supplying power to the equipment under test. A special converter station in the north basement of the main factory serves as the power source for capacities up to 150 kW. From there up to about 1000 kW the power has to be taken from the power plant supplying the test laboratory. The converter station provides direct and alternating voltages between 16 and 100 c/s, and these can be fed to the different test rooms via a line selector. The north basement is linked with the laboratory building by an underground walk-through tunnel insulated against solid-borne noise. It contains the cables and also lines for water, heating and compressed air. The line selector and all the other ancillaries (circuit components, water resistance for the machine providing load, fans, cable junctions, etc.) are in the basement of the acoustic laboratory.

The converter station is started and controlled from the laboratory building control room, which contains all the instruments required for acoustic testing. Several special-purpose cables lead from the control room into the individual chambers. With the aid of plug-in contacts it is possible to establish any desired connection between the instruments and the electro-acoustic transducers (microphone, vibration pickup, etc.) associated with the equipment being tested.

(*DJS*) B. PLONER

PASSENGER LIFTS IN THE OFFICE BUILDINGS

621.876.114

The Veritron lift-control system is composed of elements of the Brown Boveri electronic system, and provides an effective answer to the requirements of modern lift installations fitted with Ward-Leonard drives. The earlier magnetic control system and the new electronic type are compared briefly below.

EACH of the two five-storey office blocks contains two lifts with duplex control designed to carry 1200 kg at a speed of 1·75 m/s. They are powered by our well-tried Ward-Leonard drives with magnetic control. Fig. 1 shows the lift machine room of block B. From left to right can be seen the two Ward-Leonard converter sets, in one unit with the exciter built on, and next to them one of the two sheaves with the motor.

A new electronic lift-control system has been designed to accompany the recently developed Veritron controller. With a view to testing the new system in normal use, one of the four MVL 1200-Si magnetic control systems was replaced by a prototype of the HKDPA la Veritron lift-control system. The trials yielded excellent results as regards per-

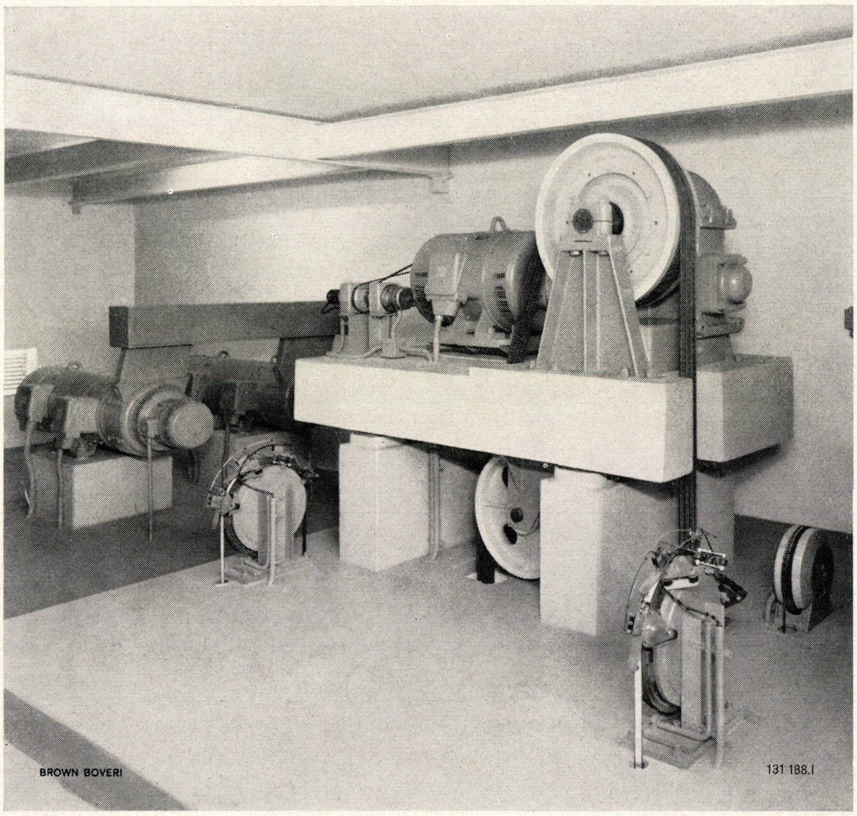

Fig. 1. – Lift machine room in one of the office blocks at Birr

(Lifts supplied by C. Haushahn, Stuttgart, Germany.) Left, the two converter sets built as one unit, right, one of the two sheaves with its driving motor, 21 kW, 60 % duty cycle, 1100 rev/min.

formance, positional accuracy and comfort. The two systems are described briefly below.

The Magnetic Lift-Control System

The MVL 1200-Si magnetic lift-control system[1] consists basically of a magnetic amplifier as the speed controller, a magnetic amplifier as the power stage, and a mechanical reference unit.

The reference unit functions on the well-established rolling-sector principle. When the signal to start has been given, a voltage is applied to the rotating system of the reference unit, whereupon the rolling sector moves slowly up to an end stop, and a uniformly increasing voltage is picked off at the rolling sector as a reference value for the lift speed. For slowing down, the voltage is disconnected from the rotating system. This is returned to its zero position by a spring. Acceleration and braking can be set independently of each other by means of the voltage and the tension of the spring. A blocking magnet limiting the travel of the rotating system enables the speed to be set at an intermediate value.

The reference value thus obtained is compared with an actual value in the form of the voltage of a tacho-generator driven by the sheave-motor, and the difference is amplified in the magnetic control amplifier. The output of the control amplifier regulates the amplifier power stage which in turn feeds the field of the Ward-Leonard generator.

The drive is stabilized via a feedback winding on the Ward-Leonard generator to the magnetic control amplifier. The MVL 1200-Si magnetic control system, illustrated in Fig. 2, is mounted on five chassis and, from top to bottom, comprises the rolling sector reference unit with adjustments for lift speed, controlled stopping, approach speed and acceleration, the magnetic control amplifier with its rectifiers and adjustment resistors, the power stage consisting of two toroidal-core transductors, diodes, resistors and fuses, the magnetic stabilizer and the main transformer, together whith the auxiliary transformer for the power stage.

[1] Cf. J. Sidler, O. Kolb: Transductor-controlled Ward-Leonard drives for lifts. Brown Boveri Rev. 1957, Vol. 44, No. 11, p. 514–18.

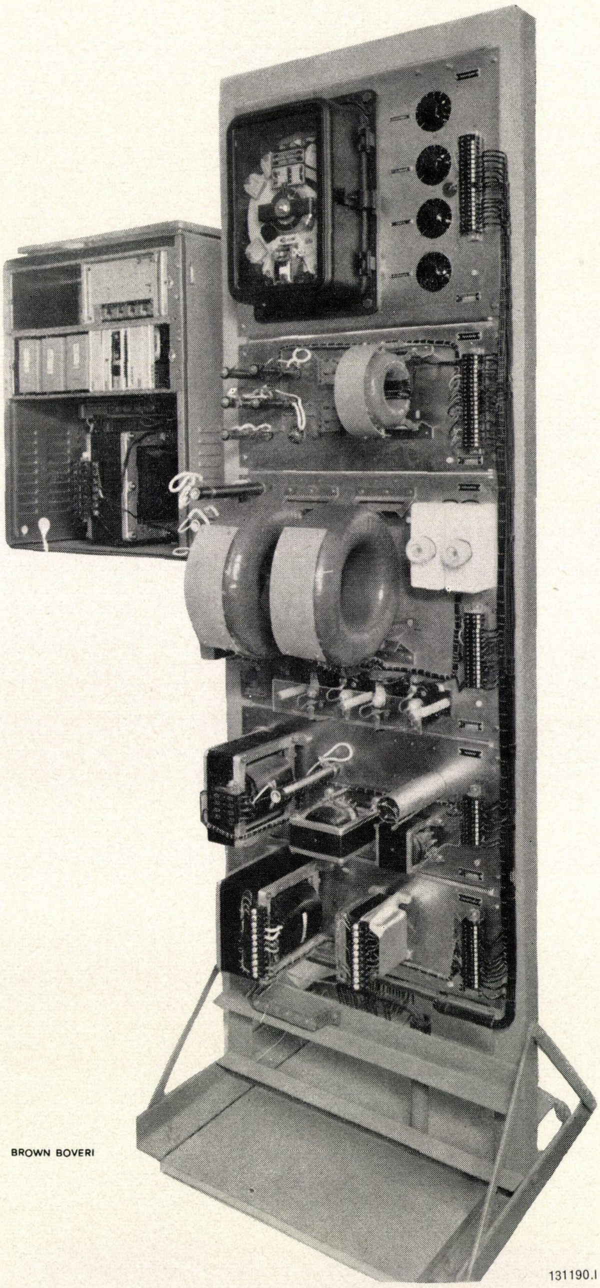

Fig. 2. – The two control systems compared

Left, the prototype HKDPA la Veritron lift-control system, right, the earlier MVL 1200-Si magnetic amplifier control system.

The Veritron Miniature Controller for Lift Drives

In Fig. 2 the experimental electronic control equipment is seen alongside the MVL 1200-Si magnetic system. The space requirement alone illustrates the advances which have been made. The entire controller is contained in two tiers of the Brown Boveri electronic system and yet can perform a wider range of functions than the earlier MVL 1200-Si. The principle of operation is essentially the same as with the magnetic system. The reference value, however, is produced by an electronic integrator. As a result, acceleration and retardation, as well as three different lift speeds, can be set absolutely independently. The speed regulator is in the form of an RT 006 transistor amplifier with an RZ 504 adjustable time element. This element gives the controller a PID characteristic, thus ensuring optimum control of the drive. The output of the speed regulator passes to a thyristor-type power stage via a transistorized grid control set which is compensated for any fluctuation of the mains voltage. All parts are of the plug-in type and so are easily accessible. The system is unusually easy to install, making commissioning simple. All signals are switched via externally actuated relays with gold contacts within the tier so that no difficulties can occur in connection with the power circuits. The relays have a life expectancy which is commensurate with that of the whole installation.

The HKDPA la Veritron controller for lift drives is illustrated in Fig. 3. The upper tier contains, from left to right, the two switching relays for the tacho-generator voltage, two capacitor modules, though these are only necessary for high lift speeds, the SR 002 electronic reference unit and its integrating amplifier.

The front of the reference unit has screwdriver slots for setting three speeds, the approach speed and start, acceleration, deceleration, for matching the tacho-generator and adjusting the rate of electrical braking.

The range for adjusting the tacho-generator voltage and acceleration and deceleration can be altered in a ratio of 1 : 2 by changing round two plugs. Below the adjustment slots are the switching relays for selecting the desired duty.

The lower tier contains the speed regulator itself. This consists of two LH 016 power stages, a BZ 002 protective module, the RT 006 control amplifier, the RZ 504 adjustable time element and the GT 029 grid control set.

The connection terminals and the ultra-fast fuses for protecting the semiconductors are located underneath the tier and cannot be seen in Fig. 3.

The lift drives have performed excellently, but the one fitted with the Veritron control system has acquitted itself particularly well. The approach distance is shorter with this drive, and it also stops more accurately than the other units. This is be-

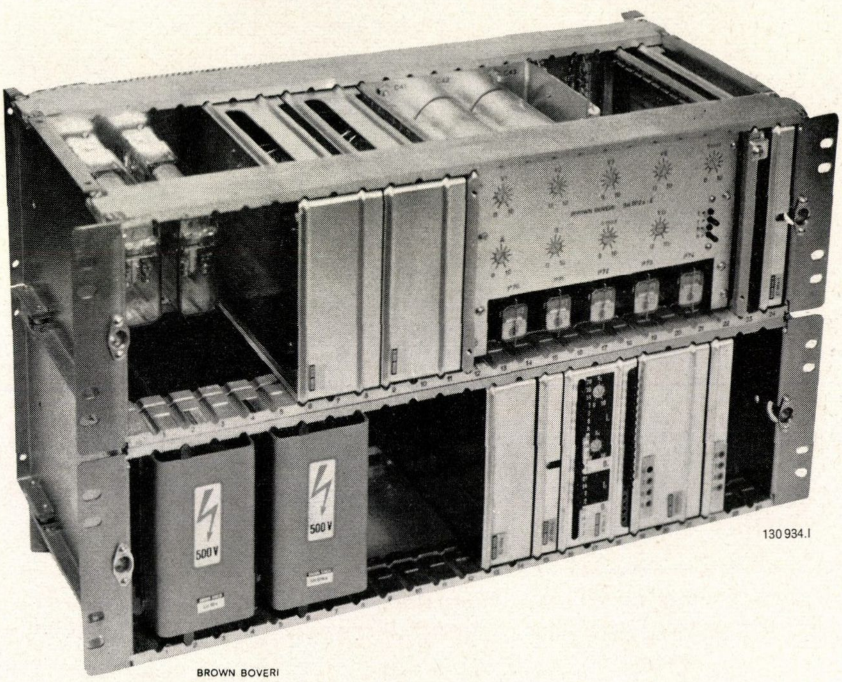

Fig. 3. – The HKDPA 1a Veritron lift controller

Built from elements of the Brown Boveri electronic system, the upper tier contains the electronic reference unit and the necessary relays, while the lower contains the controller and the power stage.

cause of the greater control amplification and the more favourable behaviour in relation to time. The Veritron controller has been in service for nearly two years, and during that time there has been no breakdown and no readjustment has been necessary, thus confirming the reliability of the new unit.

The experience gained from this trial has been taken into account in the final design of the Veritron lift controller. As a result, the numerous Veritron miniature controllers which have since been installed for lift drives in a variety of installations are well-proven and reliable, representing as they do the logical development of the long-established magnetic system.

(DJS)

E. ALZINGER
J. SIDLER

NEW HOUSING AT BIRR

728

In view of the 2000 new jobs at Birr, Brown Boveri are building a housing estate containing 530 flats directly beside the factory. Of these, 448 are already finished. An estate of detached houses has been established near the centre of the village, together with a number of owner-occupied houses. The "new town" first put forward as an idea ten years ago is rapidly taking shape.

THE BUILDING of the Birr factory gave rise to a considerable demand for housing, but the neighbourhood offered nothing suitable (Fig. 1). Brown Boveri therefore had to deal with the planning of housing accommodation at the same time as designing the factory. The Company purchased approximately 220 000 m² of building land in the Birrfeld area, of which 70 % is in a zone for blocks of flats and 30 % in a zone for single-family houses.

In 1959 Brown Boveri commissioned six architects to untertake design studies for a group of blocks on a 67 000 m² site directly beside the factory. It was no straightforward matter making the buildings harmonize with the large building masses of the factory and, furthermore, the situation of the site is such that from the start the housing estate forms a new centre in its own right, separated from the village of Birr, which will later become part of the "new town" of Birrfeld.

Although the site was to be utilized to the maximum, it was thought desirable to have the largest possible interconnected green areas: the families should live in a healthy and harmonious atmosphere, and the men should be able to find relaxation and recreation.

The result of the studies was that the two architects Prof. C.-E. Geisendorf and R. Winkler (assisted by K. Hintermann) of Zurich were commissioned to develop the project and put it into practice. The buildings comprise two slightly bowed blocks of flats 150 m long on the two long sides of the site, three square blocks along each short side, a self-service shop and a restaurant (Fig. 2). All the blocks have eight storeys. A uniform skyline was chosen on purpose, for psychological reasons, and the buildings

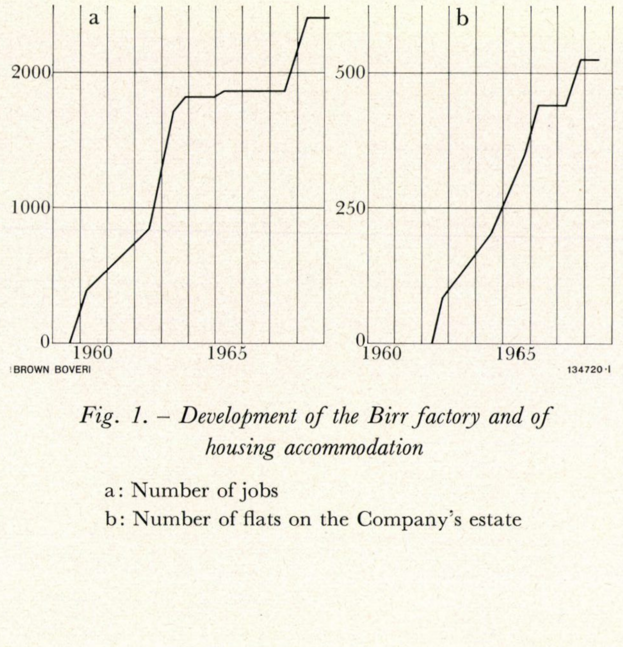

Fig. 1. – Development of the Birr factory and of housing accommodation

a: Number of jobs
b: Number of flats on the Company's estate

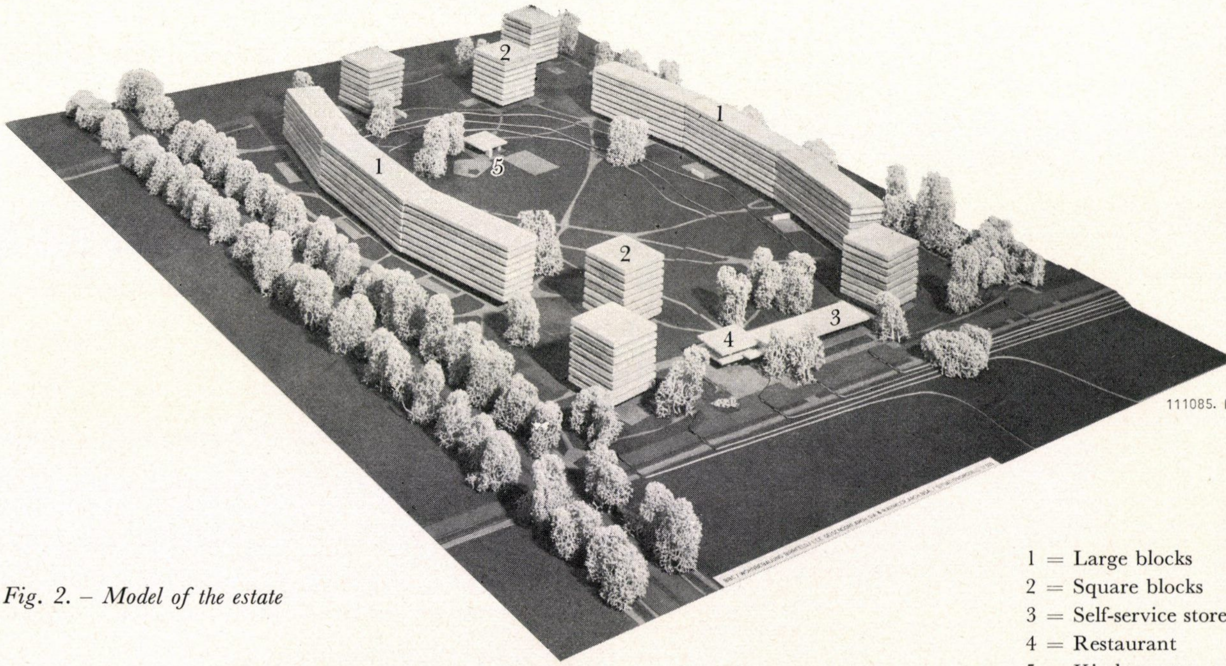

Fig. 2. – Model of the estate

1 = Large blocks
2 = Square blocks
3 = Self-service store
4 = Restaurant
5 = Kindergarten

were designed to fit in harmoniously with the factory. The site also contains a kindergarten, hobby rooms, specialized shops and other services. Despite the relatively high utilization factor of 0·75, within the perimeter there is a landscaped area with numerous playgrounds which is substantially larger than the area built on. The large distances between the individual buildings mean that there is little chance of being overlooked.

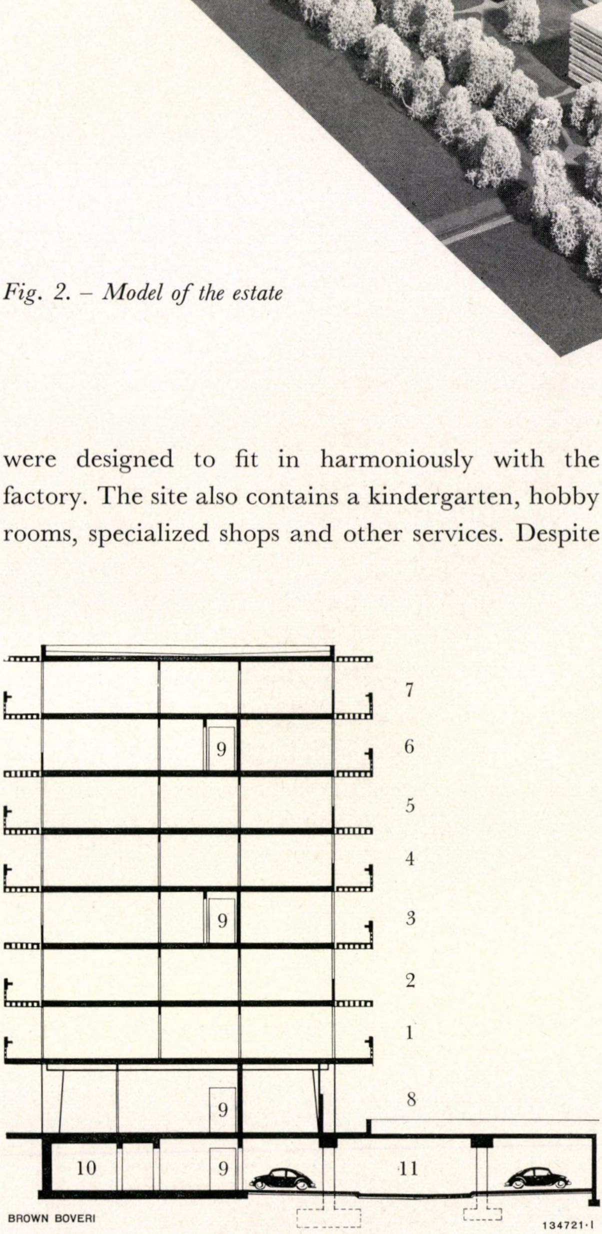

Fig. 3. – Section through one of the large blocks

1–7 = Upper floors
8 = Ground floor
9 = Lift stops
10 = Basement
11 = Parking space and access

A considerable volume of traffic is inevitable in a residential area which is eventually to house about 2000 people, and owing to the situation of Birrfeld, a car of one's own is the most suitable means of travel. It was therefore necessary to find a solution which, on the one hand, would provide sufficient opportunities for parking and, on the other, reduce to a minimum the inconvenience of having traffic in the residential area. A rational solution was found by dispensing with internal roads. Cars reach the underground garages from the ends of the estate. The garages, which run beneath the long blocks, contain about 200 parking spaces (Fig. 3) and at the same time provide access to two public roads. Pedestrians reach the blocks by way of covered verandahs which in wet weather provide a convenient place for the children to play.

The final total of 530 flats will consist of 20 % small flats, 50 % with 3½ rooms and 30 % with 4½ and 5½ rooms. The estate is being built in phases. When the third phase was completed early

Fig. 4. – The smaller blocks, showing the shops and restaurant

in 1966 there were 448 flats available in all. The final phase, comprising 81 flats, has begun and will be finished at the end of 1967.

Wide use was made of vibrated concrete. As early as the planning stage the need for a rational and economic method of building gave occasion for studies into the possibilities of prefabrication. The cores of the blocks in the first two phases were made of in-situ concrete, with the cladding walls of precast concrete panels.

Fig. 5. – Within the precincts of the estate, seen from the restaurant

With the buildings of the third phase, however, all seven storeys above the ground floor have been built of prefabricated components produced in a casting plant set up on the site. The system used was one which hitherto has been best known in France and western Switzerland. After initial difficulties had been overcome it was possible to erect all the structural members of a storey in 2½ days.

The flats in the square blocks differ from those in the long buildings chiefly in that they have larger floor areas. The design specifications for the flats were more generous than those for normal subsidized housing. The floor areas are larger than usual: 68–75 m^2 for the 3½-room flats, 80–88 m^2 for those with 4½ rooms, and 95–121 m^2 for 5½ rooms. In addition there are large balconies (up to 20 m^2) which form an extension to the living space. In conjunction with the large windows they create a link between the flats and the greenery outside. The bedrooms are separate from the other rooms, and the kitchen, dining area and sitting room are interconnected, an arrangement which makes for convenience. All flats with 3½ rooms or more include two outside walls.

Particular attention was paid to achieving an up-to-date construction of high quality which after several years would still not be dated and require only limited maintenance. In this respect, special mention should be made of the practical and well thought-out kitchen in the centre of the flat, and of the store-room within the flat itself. The aim of the well considered design was to ease the work of the housewife so as to provide some kind of compensation for the fact that her new surroundings do not include all the amenities of a town.

Buildings are also going up rapidly in the area for single-family houses near the village. In order to enable employees to buy their own homes under favourable conditions, the Company created the "Waldmatt" estate above the village centre. The 16 single-family houses, each with 5½ rooms, have a common garage and heating system.

Employees and villagers have also had other flats built in ordinary houses and small blocks. The local community itself has contributed its share towards the construction of link roads and extensions to the main services and drainage system. The large influx of families has also meant that new schools have had to be built. In short, the "new town" which was put forward as an idea ten years ago, and which since then has existed only as a model, is at last taking shape and providing homes for a growing population.

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Part of the Brown Boveri housing estate at Birr showing the single-storey shopping centre on the right.

BROWN BOVERI

Published by Brown, Boveri & Company, Limited, Baden, Switzerland. Printed by Kreis & Co. AG., Basle, Switzerland.
Obtainable direct from the publishers.