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Development of Metalworking Industries in Developing Countries

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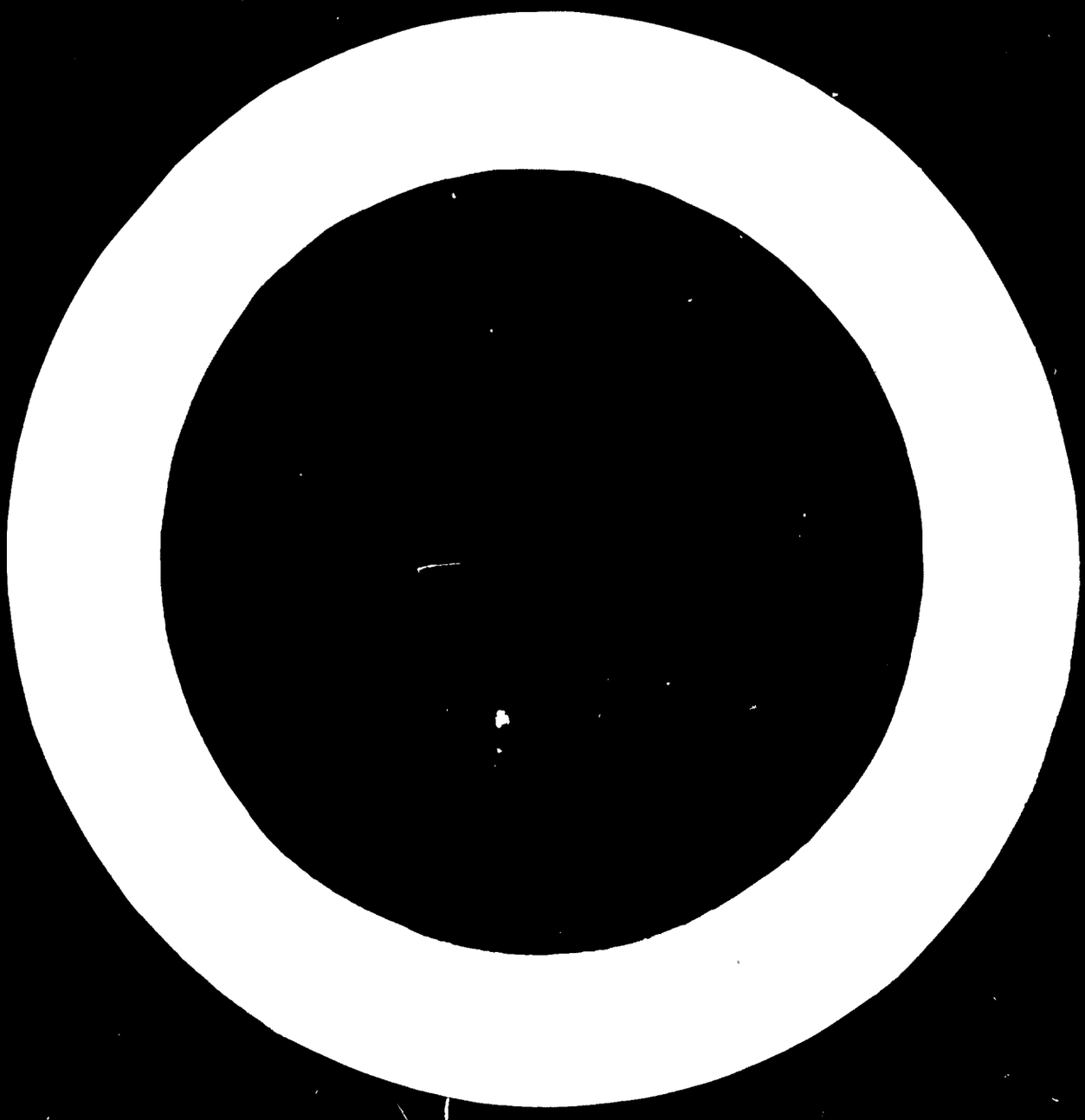

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DESIGN OF MACHINE-TOOL PLANTS FOR DEVELOPING COUNTRIES

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Introduction

This report is about the design of machine-tool plants for developing countries organizing national engineering industries. Examples are given of projects and their basic characteristics and structural principles; specialization and co-operative ties; goods produced; structure of workshops and services; equipment; labour; architecture and layout.

The report utilizes materials from projects undertaken by Giprostanok in accordance with foreign orders.

Based on the practical experience in designing machine works for a number of developing countries enjoying Soviet technical aid, let us discuss some basic information and design solutions for a similar machine plant.

Machine plant

The plant is designed for a multi-purpose enterprise. It incorporates a machine assembly shop, a foundry to produce iron and steel castings, a forging welding shop to produce forged parts and welded structures, and space for auxiliary and administrative services.

If the country plans to build a central foundry, the plant may be supplied with castings on a co-operative basis. This method also may be applied to forged articles and press work; in this case, the structure of the plant should be modified.

The plant also is expected to produce spare parts to foreign order, to make and restore welded structures and to overhaul and restore some machinery and equipment.

Power

The rated power consumption amounts to 7,000 kilowatts.

Water consumption in production processes equals fifty-five cubic metres an hour.

Figures 1 and 2 depict the plant's architectural and structural setting, and the machine assembly building plans. The buildings of the works are simple and all production buildings have the same span of 18 ft metres and only two heights, which allow extensive standardization of structural elements. Basically, the structures include ferro-concrete sectional or monolith columns and metal girders with sheet aluminium or asbestos-cement roofing.

The plans for other major buildings, as well as the administrative buildings, are represented in other figures.

Transportation inside the buildings is provided by overhead travelling cranes; motor transport and electric cars provide for intershop transportation.

The foundry has modern equipment, including that for cleaning castings (grit machines, mechanized shake-out grilles, hydro-chambers) and mechanized systems of supply and preparation of holding and core sand.

Table 1

PLANT'S YEARLY OUTPUT

Article	*Weight in tons, yearly output*	*Notes*
Spare parts from other enterprises to orders ..... including:	1,500	
(*a*) Heavy parts	650	Up to five tons
(*b*) Medium and small housings and flat parts ..	350	
(*c*) Shafts and bushings	300	
(*d*) Gears	170	
(*e*) Standard small parts	30	
Overhaul and restoration of some machinery and equipment	700	Up to ten tons
Production and restoration of welded metal structures	1,000	Up to five tons
Castings not processed mechanically, to external orders:		
(*a*) Iron castings	900	Maximum weight three tons
(*b*) Steel castings	1,225	Maximum weight 2.5 tons
Total	5,325	

Machine-tool plants

While working out the nomenclature of machine tools to be produced at a designed machine-tool plant in a developing country, stress is laid primarily on meeting the need of the country for multi-purpose machine tools used in various branches of industry, agriculture and transportation and capable of becoming items of export to other developing countries.

These include the following machine tools: toolroom lathes, shapers, multi-purpose cutters and upright drilling machines.

To work out the nomenclature of machine tools to be included in the programme of the designed plant, the list of those produced in the Soviet Union's machine-tool enterprises was studied to choose those most widely applied because of dimensional characteristics and the modern standard of technology. As a result, the following four types have been chosen: Screw-cutting lathe, model 1A616; Shaper, model 7B35; Cutter, model 6H80; Upright drilling machine, model 2H125.

Mention of these machine tools by no means restricts the range of machine tools to be produced by such plants.

When the plant is operative, other machine-tool models might be produced within the limits of rated weight and precision characteristics, which will involve some additions to the standard stock of machine-making shops and some modification in the amount of machine tools produced, depending on the labour needed for the new models. The project of machine-tool plants for developing countries envisages three types of machine-tool producing enterprises, different in volume of output and nomenclature of production, but similar structurally and in their co-operative ties and specialization:

(*a*) A plant to produce 400 machine tools of one of the four adopted models, with four possible programmes;

(*b*) A plant to produce 800 machine tools of two of the adopted models, with two possible programmes;

(*c*) A plant to produce 1,600 machine tools of the four adopted models.

Table 2

Composition, room area, equipment and personnel of the plant

Building	Services	Floor area (sq.m.)	Equipment, pieces		Personne	
			Main	Auxiliary	Total	Workers
Foundry building	Foundry shop: iron tons; castings, 2,400 tons; steel castings, 2,000 tons; non-ferrous castings, 50 tons ..	6,512	16	26	198	178
Forging-welding building	Forge shop: 255 tons	742	4	2	13	11
	Metal structures shop: 1,050 tons	1,500	24	5	52	47
	Blanks section of machine shop	234	4	2	4	4
	Woodworking shop	648	13	10	42	37
	Storage	1,412	—	—	4	3
Machine assembly building	Machine assembling shop: 2,200 tons	4,944	111	14	310	281
	Heat treatment shop: 332 tons	504	10	18	18	14
	Electroplating workshop	324	30	—	13	12
	Electric equipment repair shop	432	13	5	31	26
	Tool room	744	34	9	73	65
	Storage	756	—	—	7	5
	Total	18,752	—	—	765	683
Administrative building	Managerial, services and laboratories	3,470	—	—	80	—

The plants are designed as machine assembly enterprises characterized by extensive co-operation; it is assumed that all the necessary blanks (castings, forged items, press work, welded assemblies) are supplied from other national enterprises. Such enterprises may include the above-mentioned mechanical works or other enterprises of developing mechanical engineering industries which specialize in producing semi-manufactured goods.

Prior to establishment of such enterprises in the developing country, all complete parts (electric motors, electric equipment, bearings, pumps, hydraulic units, etc.) should be supplied from the country whose models of machine tools are to be produced by the plant.

The plants incorporate: the mechanical, assembly and heat treatment shops, tools and repair rooms, necessary laboratories including a technology laboratory, painting and electroplating workshops, compressor room, trans-

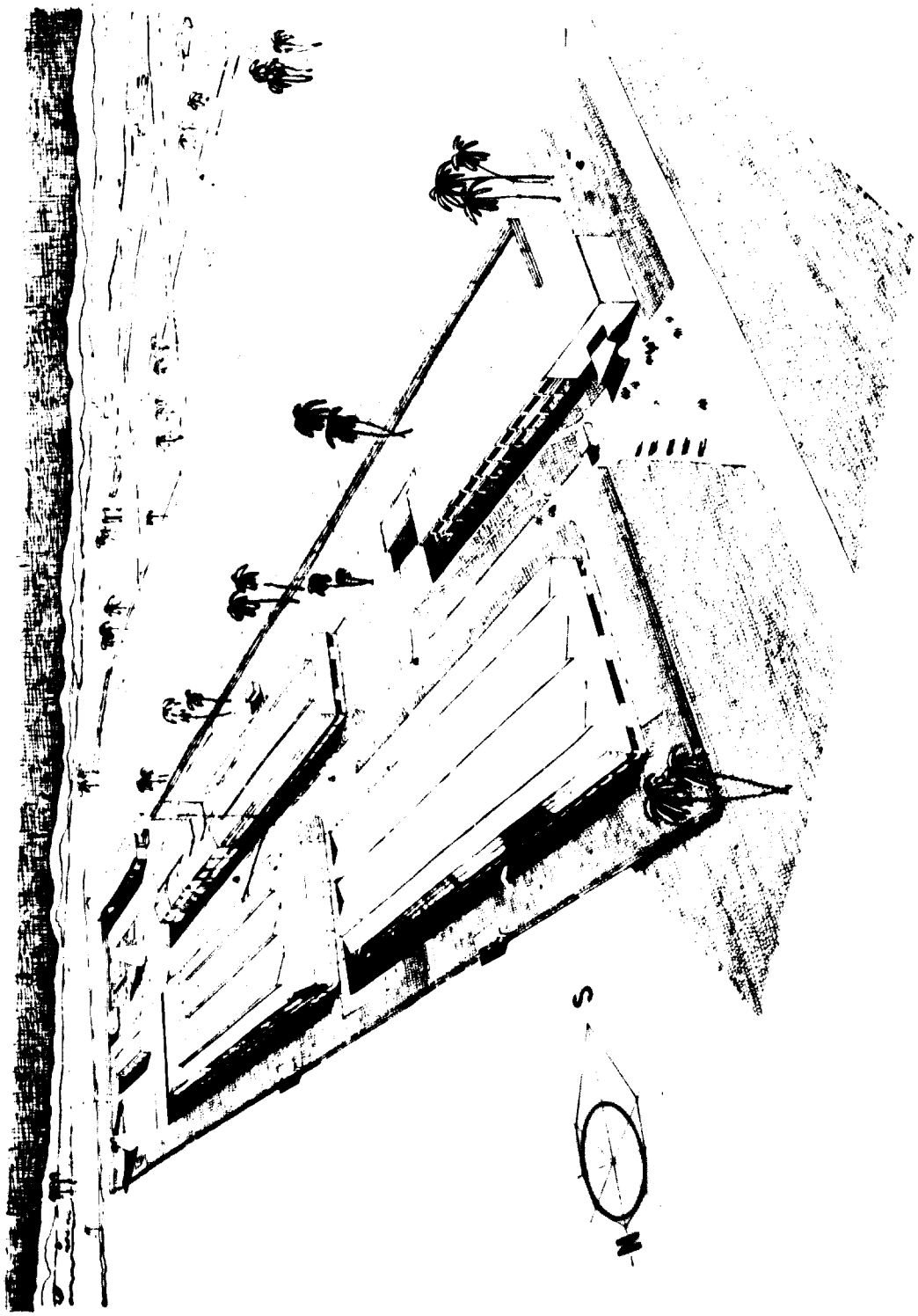
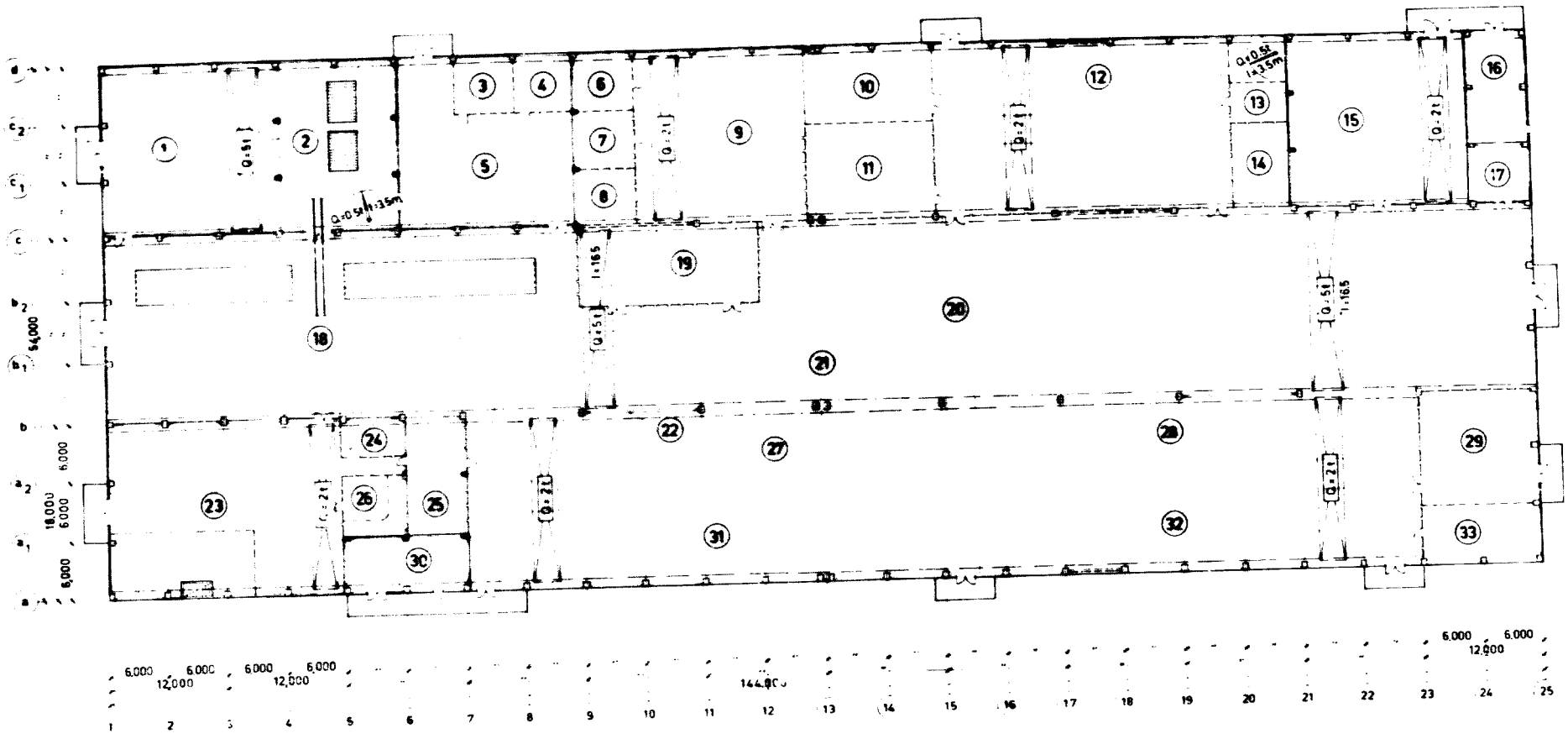


Figure 1
MECHANICAL WORKS. PERSPECTIVE



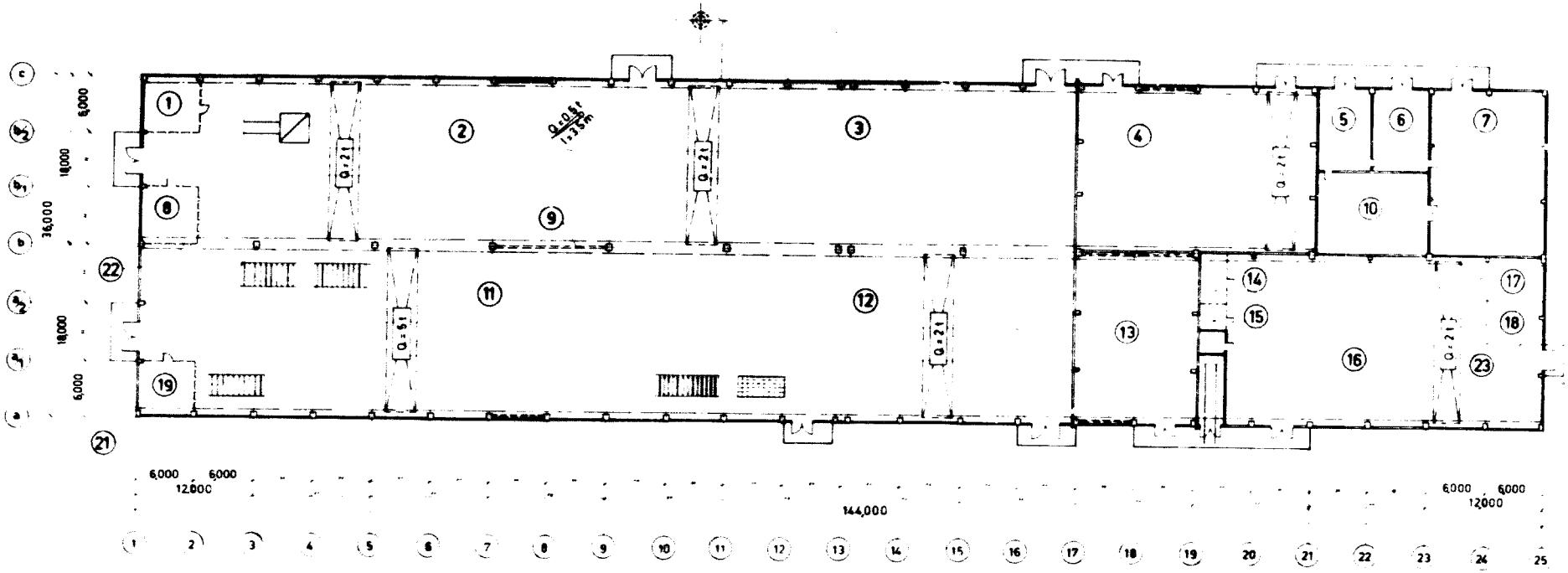
Key for symbols:
Block walls
Metal net partitions
Glazed partitions

Explanation of premises

1 Packing department and finished parts storehouse
2 Painting section
3 Section of tables production
4 Grinding polishing section
5 Electroplating workshop
6 Soaking drying section
7 Testing station
8 Store room
9 Electric equipment repair shop
10 Sharpening shop
11 Tool distributing store room
12 Tool room
13 Intershop store room
14 Blanks store room
15 Central materiel
16 Transformer substation
17 Emulsion workshop
18 Assembly department
19 Storehouse of finished parts
20 Machine assembling shop
21 Section of large parts
22 Vertical connections
23 Heat treatment shop
24 Checking department
25 Intershop store room
26 Cleaning section
27 Gears section
28 Section of medium and small parts
29 Blanks storehouse
30 Transformer substation
31 Section of shafts and bushings
32 Section of standards
33 Offices

Figure 2

MACHINE-ASSEMBLY BUILDING



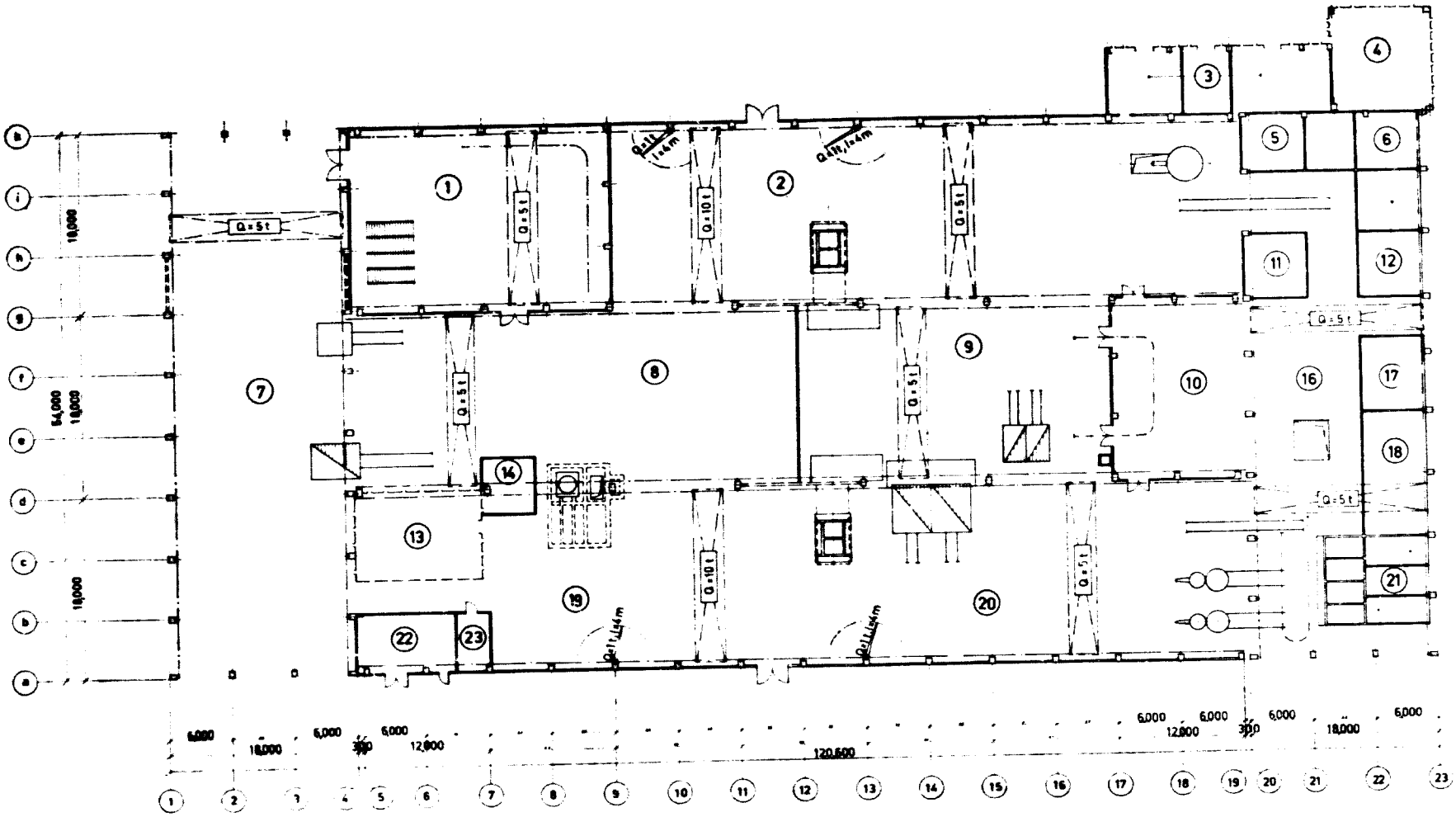
Explanation of premises

1 Ventilation area
2 Forgeshop
3 Metal storehouse
4 Patterns storehouse
5 Transformer substation
6 Assistant station mastr
7 Compressed air station
8 Spare parts store room
9 Vertical connections
10 Distribution point
11 Metal structures shop
12 Metal storehouse
13 Boiler house
14 Store room
15 Office
16 Woodworking shop
17 Sharpening room
18 Pattern painting section
19 Auxiliary materiels store room

20 Key for symbols
21 Block walls
22 Metal net partitions
23 Glazed partitions

Figure 3

FORGING-WELDING BUILDING



Explanation of premises

1 Castings priming department
2 Moulding department for steel castings
3 Transformer substations
4 Department of sand regeneration and water clarification
5 Bins for metal charge
6 Bin for regenerate
7 Trestle for castings and mould boxes
8 Fetling department
9 Core department
10 Sand preparation department
11 Bin for metal charge
12 Bins for sand
13 Intermediate patterns storehouse
14 Pumping station
15 Vertical connections
16 Storehouse for charge and moulding material
17 Bin for clay
18 Bin for coke
19 Non-ferrous castings section
20 Moulding department for iron castings
21 Bins for metal charge
22 Transformer substation
23 Laboratory of proximate analysis

Key for symbols:
Block walls
Metal net partitions
Glazed partitions

Figure 4

FOUNDRY BUILDING

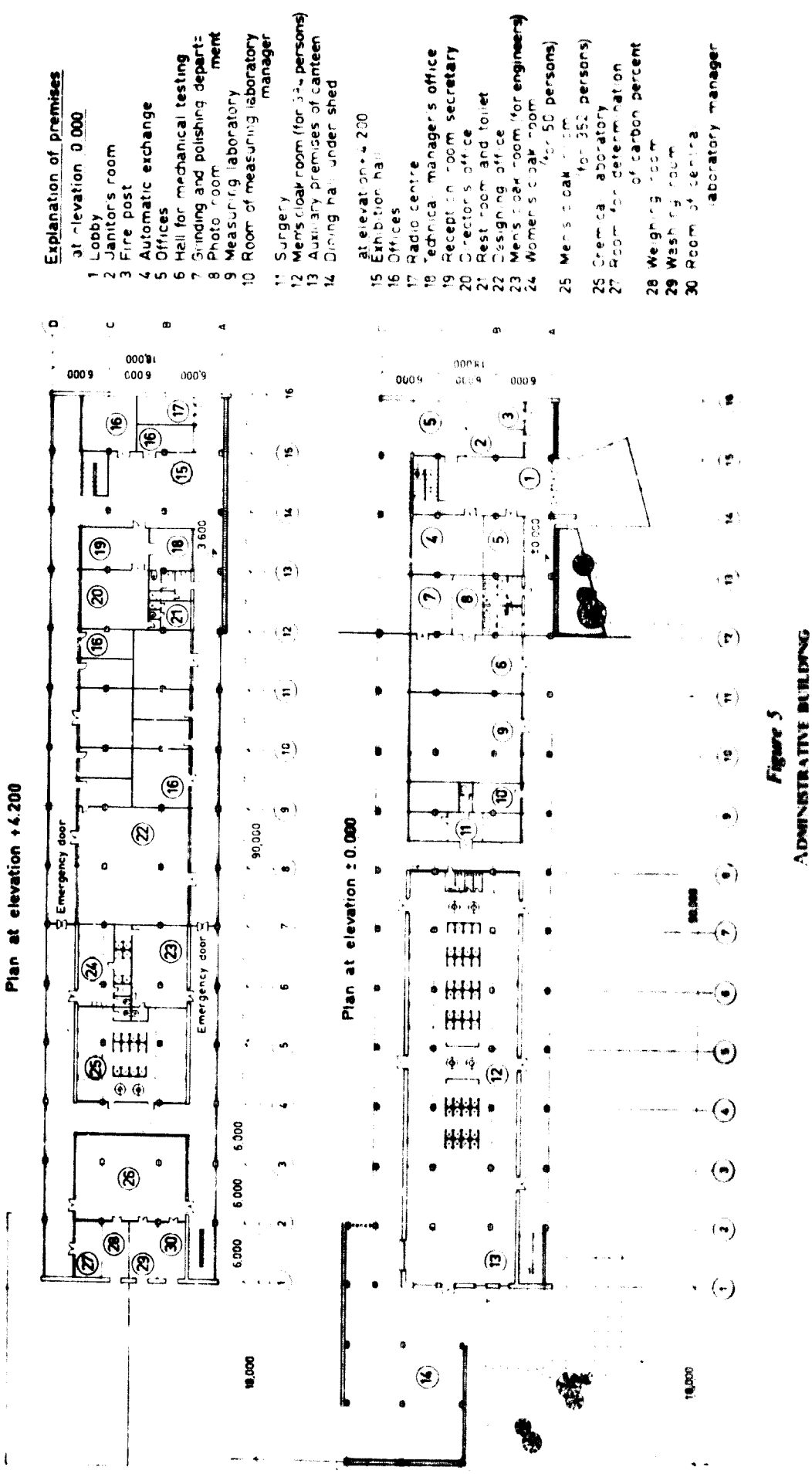
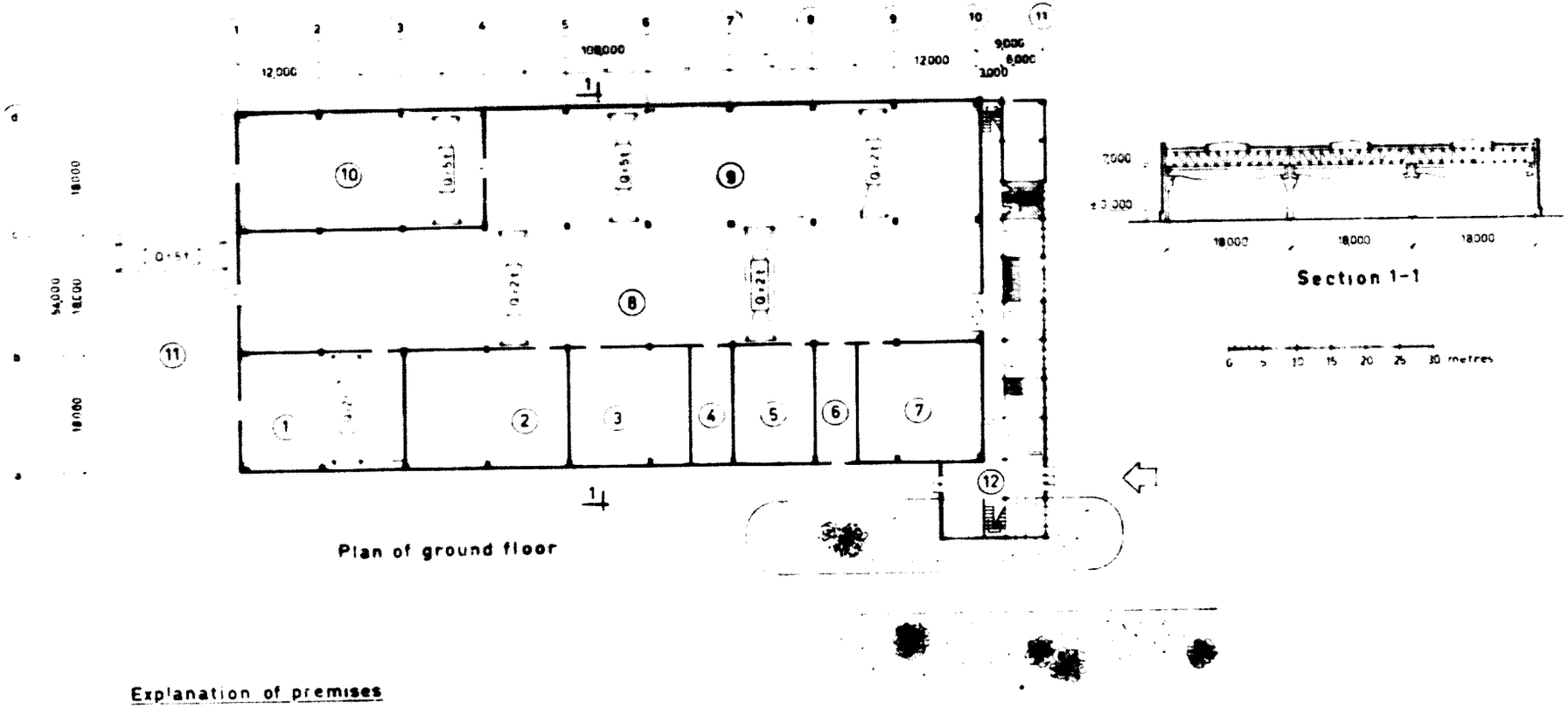


Figure 5
ADMINISTRATIVE BUILDING

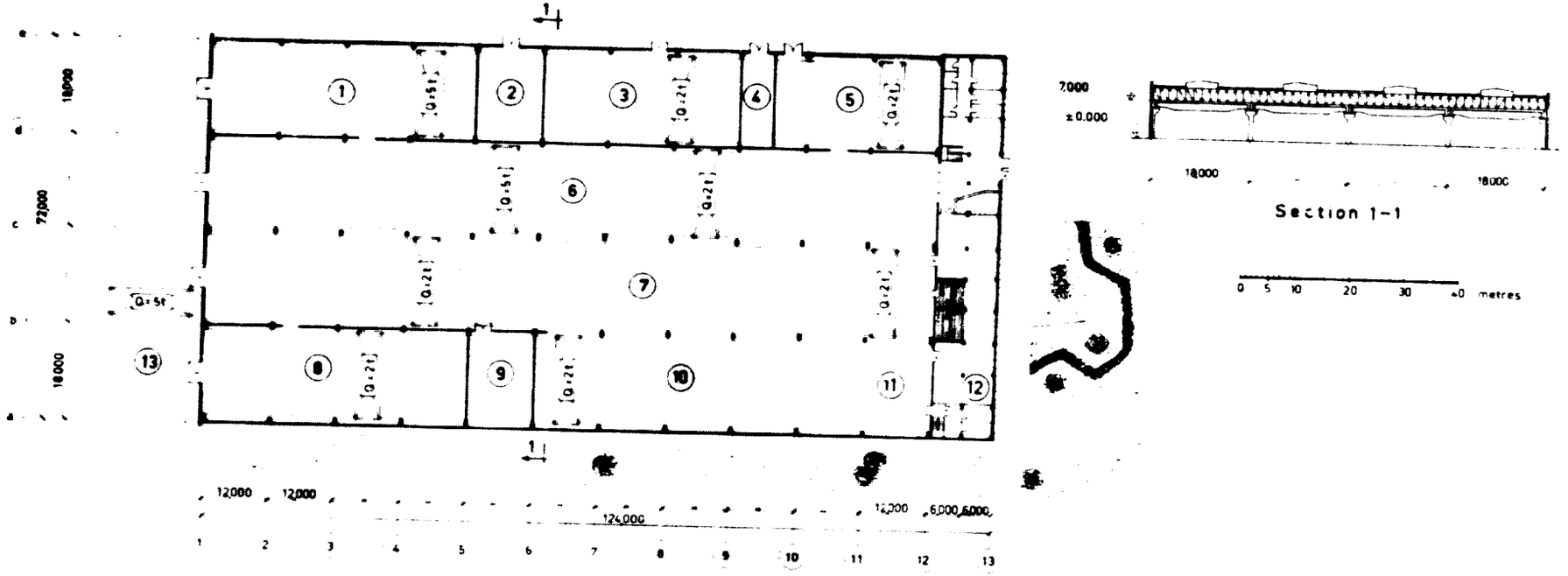


Explanation of premises

1 Store of metal
2 Tools repair room
3 Heat treatment room with electroplating section
4 Transformer substation
5 Compressor room
6 Store of chemicals and lubricants
7 General store of materials
8 Machine department
9 Assembly department
10 Painting, packing and store of finished products
11 Gantry
12 Administrative-welfare building

Figure 6

PLANT WITH YEARLY PRODUCTION OF 400 MACHINE TOOLS



Plan of ground floor

Explanation of premises

1 Painting, packing and store of finished products
2 Compressor room
3 General store of materials
4 Transformer substation
5 Heat treatment room with electroplating substation
6 Assembly department
7 Machine department
8 Store of metal
9 Technology laboratory
10 Tools repair room
11 Machine and repair room
12 Administrative-welfare building
13 Gantry

Figure 7

PLANT WITH YEARLY PRODUCTION OF 800 MACHINE TOOLS

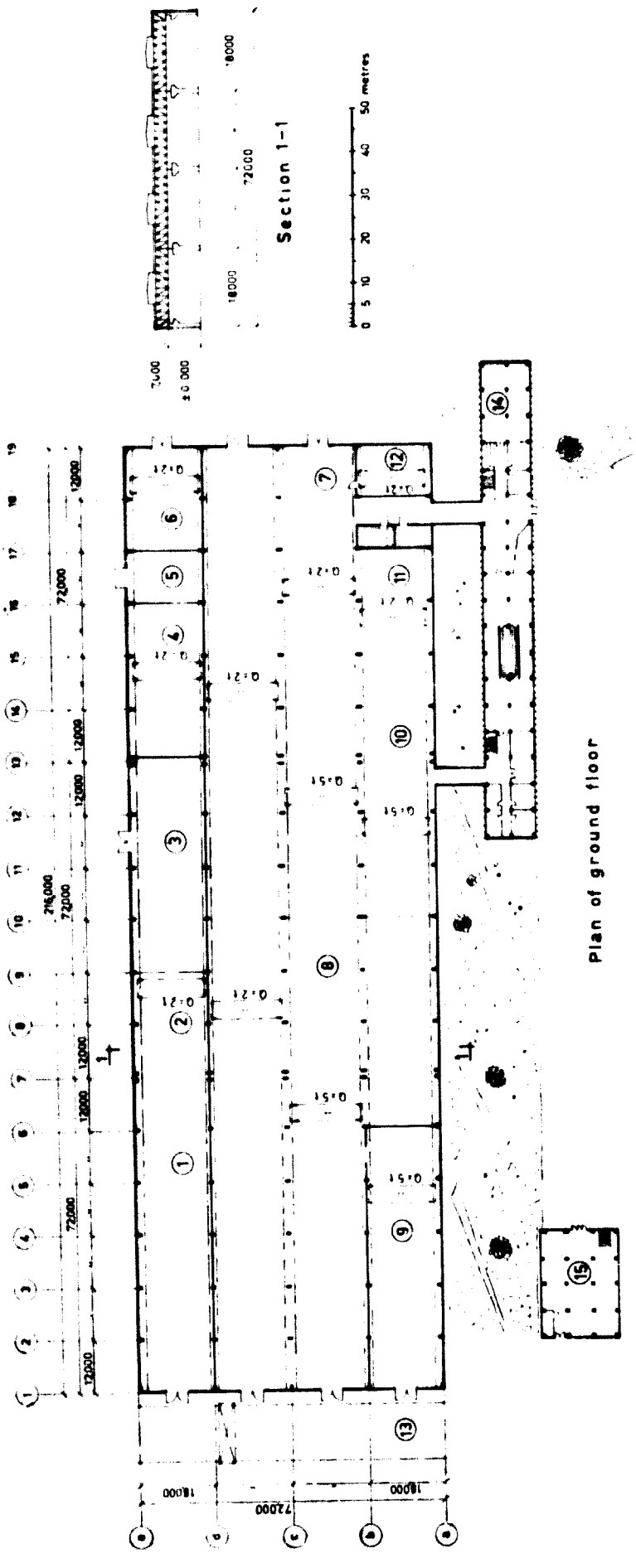


Figure 8

PLANT WITH YEARLY PRODUCTION OF 1,600 MACHINE TOOLS

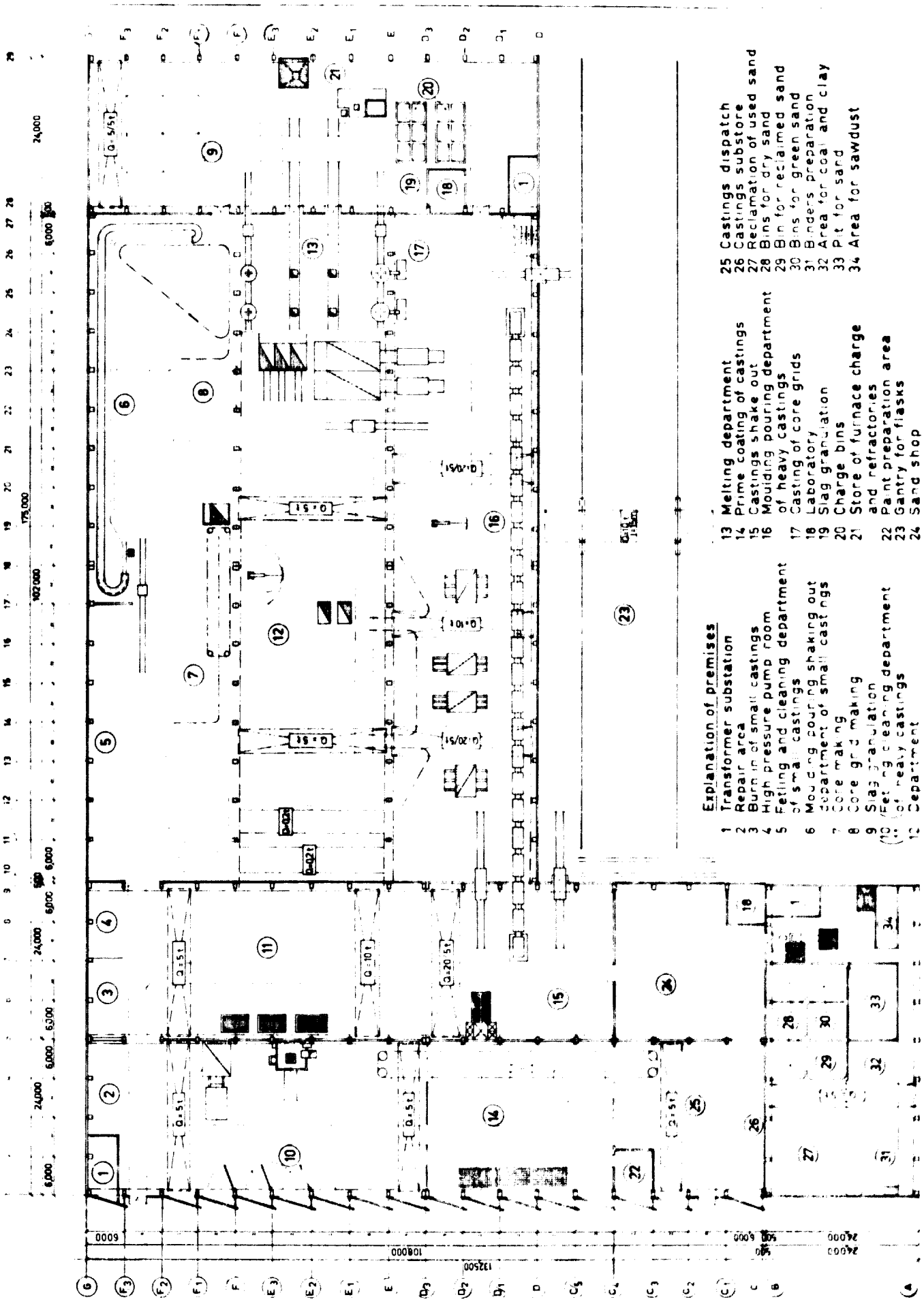
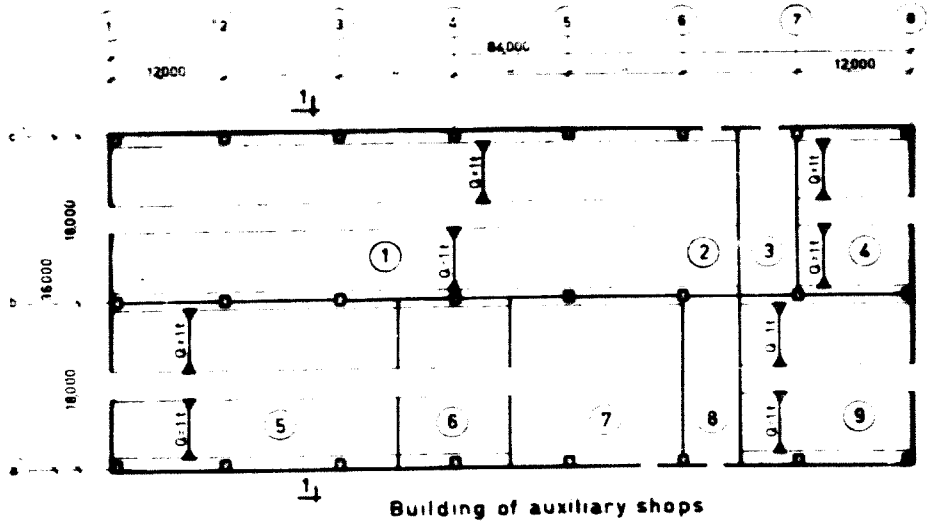
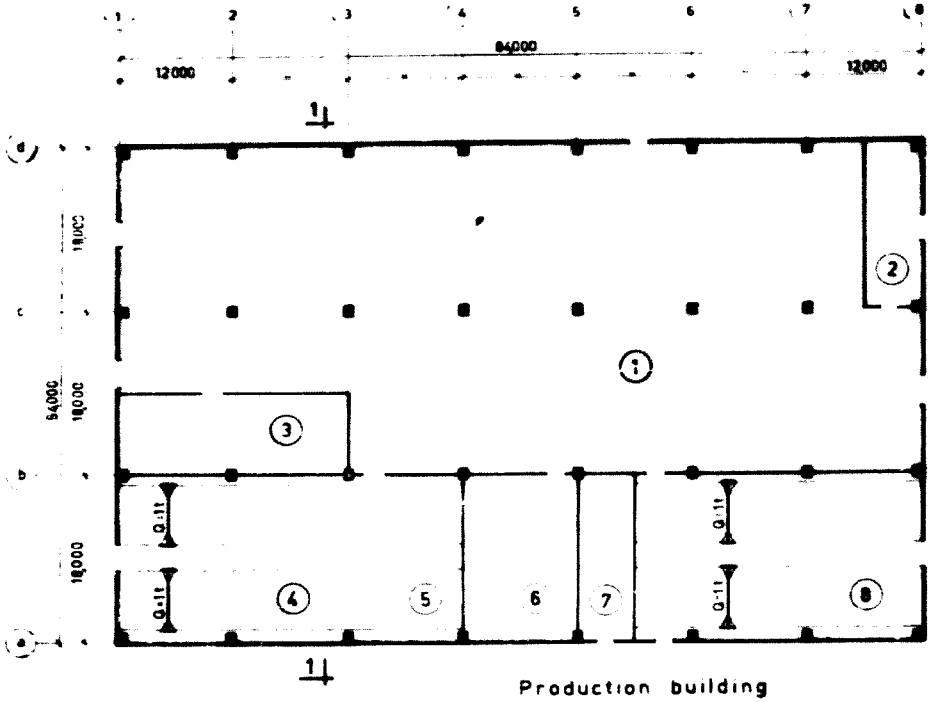


Figure 9

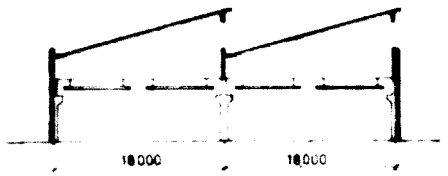
FOUNDRY SHOP FOR HEAVY CASTINGS



Building of auxiliary shops



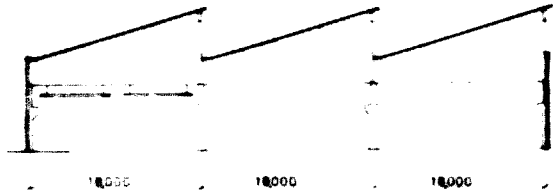
Production building



Section 1-1

Explanation of premises

1 Tool room
2 Machine repair shop with electrical equipment repair department
3 Transformer substation
4 Compressor room
5 Metal store
6 Department of cut blanks tools and hack-saw bands
7 Forge-welding shop
8 General tool store and general abrasive store
9 General materials store



Section 1-1

Explanation of premises

1 Machine shop
2 Emulsion room
3 Technological laboratory and tool testing
4 Store of finished products
5 Packing and despatch
6 Electroplating department
7 Transformer substation
8 Heat-treatment shop

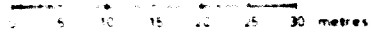


Figure 10

LAYOUT OF TOOL FACTORY

Table 3

PLANT FOR 400 MACHINE TOOLS YEARLY

Yearly programme

Item	Model	Pieces	Weight in tons: Unit	Weight in tons: Yearly programme
Variant 1				
Screw-cutting lathe	1A616 (diameter 320 - 710mm)	400	1.5	600
Spare parts and accessories				3
Total		400		603
Variant 2				
Shaper	7B35 (length of ram stroke 500 mm)	400	1.8	720
Spare parts and accessories				3
Total		400		723
Variant 3				
Horizontal milling machine	6B80 (table 200 - 800 mm)	400	1.2	480
Spare parts and accessories				2
Total				482
Variant 4				
Upright drilling machine	2H125 (diameter 25 mm)	400	0.87	348
Spare parts and accessories				2
Total				350

Number of shifts: two

Composition, room area, equipment and personnel of plant

Shops and services	Floor area (sq.m.)	Equipment, pieces: Basic	Equipment, pieces: Auxiliary	Personnel: Total	Personnel: Workers
Machine department	1,940	50	11	105	92
Assembly department	1,300		18	70	59
Painting, packing and store of finished products	650		5	10	8
Heat treatment room with electroplating	330	20	25	10	8
Tool and machine repair room	430	10	8	25	20
Laboratories	250	—	—	4	1
Storage facilities	870	—	—	4	3
Compressor room	220	2	—	4	3
Transformer substation and telephone exchange	110	2	—	8	6
Total	6,100	84	67	240	200
Management, offices, canteen, welfare, etc.	1,530	—	—	25	3

Power

The rated consumer motor power amounts to 2,200 kilowatts.

Water consumption in production processes equals 7 m^3/hr.

former substations, storage facilities to keep complete parts, blanks, and finished goods, and all necessary administrative, welfare and engineering service areas.

The plants are planned within one technological building to include all production and auxiliary services, and only the largest of them has administrative, welfare and engineering services areas removed to a separate block connected with the main technological building by covered passages.

As far as the architecture and setting up are concerned, the buildings of the three plants are identical, with parallel bays eighteen metres wide and eight metres high from the base of the truss. Each bay has an overhead travelling crane and crane beam capable of carrying five tons. The structural design includes sectional or monolith ferro-concrete columns and metal roof trusses.

Tables 3-5 give basic information on the varieties of machine-tool plants.

Table 4

PLANT FOR 800 MACHINE TOOLS YEARLY

Yearly programme

Item	*Model*	*Pieces*	*Weight in tons*	
			Unit	*Yearly*
Variant 1				
Screw cutting lathe	1A616 (diameter 320 - 710 mm)	400	1.5	600
Upright drilling machine	2H125 (diameter 25 mm)	400	0.87	348
Spare parts and accessories				5
Total		800		953
Variant 2				
Shaper	7B35 (length of ram stroke 500 mm)	400	1.8	720
Horizontal milling machine	6H80 (table 200 - 800 mm)	400	1.2	480
Spare parts and accessories				5
Total		800		1,205

Number of shifts: two

Composition, room area, equipment and personnel at plant

Shops and services	*Floor area (sq.m.)*	*Equipment, pieces*		*Personnel*	
		Basic	*Auxiliary*	*Total*	*Workers*
Machine department	3,240	101	16	218	193
Assembly department	1,510	—	33	159	145
Painting, packing and store of finished products	860	—	7	16	15
Heat treatment room with electroplating	540	20	25	12	10
Toolroom	650	18	8	29	25
Machine repair room	650	15	11	34	30
Laboratories	510	—	—	7	2
Storage facilities	1,800	—	—	7	5
Compressor room	220	2	—	4	3
Transformer substation and telephone exchange	110	3	—	8	6
Total	10,090	159	100	494	434
Management, offices, canteen, welfare, etc.	2,340	—	—	38	5

Power

The rated power consumption amounts to 3,400 kilowatts.

Water consumption in production processes equals 10 m^3 hr.

Table 5

PLANT FOR 1,600 MACHINE TOOLS YEARLY

Item	*Model*	*Yearly programme, pieces*	*Weight in tons*	
			Unit	*Yearly*
Screw-cutting lathe	1A616 (diameter 320 – 710 mm)	400	1.5	600
Shaper	7B35 (length of ram stroke 500 mm)	400	1.8	720
Horizontal milling machine	6H80 (table 200 – 800 mm)	400	1.2	480
Upright drilling machine	2H125 (diameter 25 mm)	400	0.87	348
Spare parts and accessories to machines				10
Total		1,600		2,158

Number of shifts: two

Composition, room area, equipment and personnel at plant

Shops and services	*Floor area (sq.m.)*	*Equipment, pieces*		*Personnel*	
		Basic	*Auxiliary*	*Total*	*Workers*
Machine department	6,480	175	19	385	346
Assembly department	2,810	—	44	269	250
Painting, packing and store of finished products	1,080	—	10	25	23
Heat treatment room with electroplating	650	25	32	16	15
Tool room	860	25	10	35	31
Machine repair room	860	18	12	44	40
Laboratories	660	—	—	10	3
Storage facilities	2,380	—	—	9	7
Compressor room	430	2	—	5	4
Transformer substation and telephone exchange	220	4	—	8	6
Total	16,430	249	127	806	725
Management, offices, canteen, welfare, etc.	3,450	—	—	52	8

Power

The rated power consumption amounts to 5,000 kilowatts.
Water consumption in production processes equals 15 m³ hr.

FOUNDRY

A foundry is necessary for a developing country to produce metal-processing machine tools and other products of machine-building industries.

The modern principle of specialization and co-operation of mechanical engineering enterprises, including machine-tool plants, predetermines the economic efficiency of producing blanks, and castings in particular, at specialized foundries or in founding shops designed to meet the needs of a number of machine-building enterprises. Thus, it is hardly reasonable to organize foundry production in developing countries by setting up small founding shops designed only to meet the needs of the plant on the premises, although there are exceptions to the rule.

Following are projects of a specialized founding shop for an output of 15,000 tons of iron castings a year, which can be self-supporting as a small foundry if a models shop, storage facilities for models, compressor room, transformer substation and administrative and welfare services are added. The shop is designed to supply machine-building enterprises, including machine-tool plants, with shape castings. Production is organized in large or small series with castings distributed by weight as shown in table 6.

The founding shop is an L-shaped, one-storey building with co-perpendicular spans twenty-four metres wide provided with overhead travelling cranes with a load-lifting capacity of twenty tons.

Mechanization of production and transportation is envisaged: a mechanized store of furnace load as well as mechanized supply of charge into the cupola, pre-

Table 6

Up to 5 kg.	1,250 tons
5-20 kg.	2,750 tons
100-200 kg.	1,600 tons
200-500 kg.	3,800 tons
500-1,000 kg.	2,600 tons
1,000-2,000 kg.	1,700 tons
2,000-5,000 kg.	1,300 tons

Maximum weight of casting, 5,000 kg.
Maximum size of casting: 4.7 × 1.6 × 1.0 m.
Number of shifts: two.

Composition, room area, equipment and personnel at plant

Shops and services	*Floor area (sq.m.)*	*Equipment, pieces*	*Personnel*	
			Total	*Workers*
Founding shop	11,420	40	421	369
Repair room	80	3	16	14
Laboratories	70	—	4	—
Storage facilities	4,130		5	5
Total	15,700	43	446	398

Power

The rated power consumption amounts to 5,330 kilowats.
Water consumption in production processes equals 50 m^3 /h.

paration and supply of moulding and core mixtures, shaking-out, cleaning and prime coating of castings.

Pouring and assembly of small and heavy castings are to be effected on conveyor lines, and removal of cores in hydro-chambers. The mechanical shop is up to all modern standards.

The buildings are planned to be made of monolith ferroconcrete.

The establishment of such a specialized founding shop should precede building of customer enterprises: machine-tool plants and other machine-building enterprises.

Tool factory

Though the problems of designing tool factories for developing countries are in no way the theme of the present report, it seems useful to cite briefly some information on a project of a tool factory, designed for developing countries, which is to meet the needs of machine-building industries.

The factory is a complex enterprise intended to produce cutting tools.

The factory is to make the basic types of cutting tools: normal cutting tools, drills, reamers, taps, threading dies, cutters, hacksaw bands and small quantities of other tools in small series.

The main technological and auxiliary shops are located in separate buildings.

The factory buildings are simple and composed of parallel spans eighteen metres wide and seven metres high provided with suspended travelling cranes wherever necessary.

Technical and economic characteristics organization of design and production

Some of the following technical and economic characteristics are entirely tentative, as well as indices concerning machine-tool plants, since in developing countries labour costs, the costs of power, local materials and manufactured and semi-manufactured goods vary widely.

Similarly different are the norms of depreciation, overhead expenses, and the costs of storage, transportation and procurement. Plant and shop expenses are also different.

Wide variations can be observed in the cost of building and mounting a plant in these countries, as well as in the prices of purchased goods and equipment to be installed, depending on where these goods and equipment are bought.

Since the above factors making up the prime cost of produced goods and determining capital investment in plant construction vary to a great extent, these two technical and economic indices can also vary substantially, depending on the specific conditions existing in the developing country in which the plant is being built.

Therefore, to obtain objective technical and economic indices of the designed plant, the economic part of the project must be formulated in view of the specific conditions of the developing country undertaking construction of the plant.

To obtain preliminary estimates of the basic technical and economic indices and projects suggested, rough calculations were carried out on the basis of the average values of critical cast factors, in dollars, for the toolroom lathe, model 1A616, produced at a plant designed for 400 machines of this model yearly.

As a result, the prime cost of the lathe at this plant was estimated at $2,980, including 40 per cent for materials, semi-manufactured goods and purchased articles, 55 per cent in shop and over-all plant expenses and basic wages of the workers engaged in production and 5 per cent in overhead expenses outside the plant.

Rough estimates were also performed to calculate tentatively capital investment, in dollars, necessary to build the three types of machine-tool plants. This investment is:

Plant to produce 400 machines yearly, $2,900 thousand, including: equipment, $1,900 thousand, or 65 per cent;
Plant to produce 800 machines yearly, $4,800 thousand, including: equipment, $3,200 thousand, or 67 per cent;
Plant to produce 1,600 machines yearly, $7,800 thousand, including: equipment, $5,400 thousand, or 69 per cent.

Since the economic effectiveness of building powerful machine-tool plants is self-evident, two or more developing countries may co-operate in establishing a comparatively large enterprise under certain conditions.

Design of machine-tool plants for developing countries is to be first organized by formulating the basic technical and economic estimate containing an analysis of the need for the machines to be produced in view of the country's development targets and export possibilities, followed by preparation of the design programme, collection of initial data and selection of the site for the project, accompanied with the technical and economic estimates of the possible locations for the enterprise. This work is, as a rule, performed by agencies of the developing country, assisted by competent advisers from the country undertaking the general plant design.

It is desirable, when designing a plant, to attract national engineers, especially to design external com-

Table 7

FACTORY YEARLY PROGRAMME

Item	*Size in mm*	*Yearly programme, pieces*	*Weight in tons*
Cutting tools		320,000	205.7
Drills	Diameter 0.5–50	338,000	47.24
Reamers	Diameter 3–100	84,000	16.03
Counterbores	Diameter 10–100	25,000	12.94
Cutters, all types		70,000	64.85
Taps	Diameter 2–52	239,000	34.23
Threading dies	Diameter 3–52	195,000	13.6
Toothing tools		3,500	30.55
Hacksaw bands		640,000	22.4
Knives, spare		51,000 sets 552,000 knives	39.46
Other tools			33.0
Total			520.0

Composition, room area, equipment, and personnel at factory

Building	*Services*	*Floor area (sq.m.)*	*Equipment, pieces*		*Personnel*	
			Basic	*Auxiliary*	*Total*	*Workers*
Main building	Machine shop	2,630	150	13	255	220
	Heat treatment shop with electroplating	760	43	55	55	42
	Dispatch office and packing department	220	—	2	8	6
	Technology laboratory	220	7	—	5	2
	Emulsion room	110	—	5	2	2
	Store of finished products	30	—	—	2	1
	Repair department	60	4	—	9	8
	Transformer substation	110		—	3	2
	Total	**4,540**			**339**	**283**
Auxiliary shops building	Forge-welding shop	330	7	6	21	17
	Blanks section of machine shop	220	20	2	30	28
	Tool room	540	30	10	55	47
	Machine repair shop with workshops	640	26	14	56	48
	Metal store	540	—	3	4	4
	General materials store	330	—	5	3	3
	General tool store	110	—	—	2	1
	Compressor room	220	2	—	4	3
	Transformer substation	110	4	—	3	2
	Total	**4,040**			**178**	**153**
Store building	Store of oil and lubricants	430	—	4	1	1
Administrative building	Central and test laboratories, offices, canteen, welfare	—	—	—	58	8

Power

The rated power consumption amounts to 4,000 kilowatts.

Water consumption in production processes equals 12 m^3/hr.

munications and facilities, water supply systems, signal communication, access roads, sewage, and power supply systems as well as for elaborating shop drawings.

This gives a strong impetus to design work, enables more adequate utilization of local resources and materials and, most essential, makes it possible to train skilled national specialists (designers) within short periods.

If a favourable situation is available, maximum use should be made of the developing country's national enterprises and shops of a mechanical specialization to produce relatively simple metal structures, some unique equipment and other articles uneconomical to import. The manufacture of the above items in accordance with the drawings of the general designer and under the supervision of his instructors will make it possible to enhance the construction of the plant, train skilled workers and

save currency. Systematic supervision by specialists from the country carrying out general design work and supplying the equipment is essential in securing good quality of work and compliance with the project.

The period within which a plant becomes fully operational in a developing country depends on timely training of specialists and workers for its operation, which can be carried out either in the country of the general contractor or in the developing country with the assistance of instructors, provided adequate conditions prevail.

Of great importance also is timeliness of design work and manufacture of technological rigging (special appliances and tools) and working out of the operational technology to provide for the needs of production processes without which manufacture is impossible.

It takes considerable time to manufacture the rigging for a machine-tool plant.

As an illustration, putting the tool room, model 1A62, into production involved about 1,200 special appliances, tools and dies at a cost of $350,000.

Training of personnel and preparatory technological work necessary to start manufacture should be carried out while the plant is still being built, so that these problems may have been mainly solved by the time the plant is started.

It is desirable, during the initial period of operation of the plant, to purchase in the general contractor's country some dozen sets of machine castings, particularly basic and frame types, to use in training personnel under the guidance of skilled instructors and for assembling the first machines.

Conclusions

1. Designing of machine-tool plants for developing countries is not a problem by itself but is to be solved in co-ordination with promoting mechanical engineering in these countries.

2. It is reasonable, during the initial phases of developing machine building in developing countries, to set up a small multi-purpose complex type machine plant designed for maintenance, repair and restoration of equipment, manufacture of spare parts, simple machinery and welded metal structures to meet the needs of industry transport and agriculture. This works will serve as a training centre for personnel and the basis for further expansion of specialized mechanical engineering including machine-tool production.

3. Machine-tool plants should be designed to produce a limited number of multi-purpose tool models which can find wide application in the various branches of industry and become items of export. Projects must provide for replacing the models with new ones, within the limits of rated weight and precision characteristics.

4. Machine-tool plants should be designed as mechanical assembly enterprises with extensive co-operation in the supply of semi-manufactures, such as castings, forged pieces and stampings, parts, purchased articles, standards and normal tools.

5. Modern principles of specialization and co-operation demand that developing countries set up economically effective specialized plants or shops to manufacture castings and forged and stamped pieces to satisfy the demands of a number of machine-building enterprises.

6. Along with establishing machine-tool plants, it is desirable to promote tool production, first as a small specialized factory to manufacture cutting tools such as cutters, drills, reamers, taps, threading dies and hack-saw blades.

7. Designing of machine-tool plants for developing countries must be based on comprehensive technical and economic calculations in view of the country's development targets and with participation of national specialists, which will make possible training of national designers and enhancement of design work.

8. To bring a ready plant to its rated capacity within the shortest practical time, it is important to perform timely technological preparation of production processes, to design and make the technological rigging and special tools, to formulate operational technology and train specialists and workers. These problems must be solved through extensive co-operation of the country giving technical assistance.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