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HEATING, AIR-CONDITIONING AND VENTILATION; FACILITIES; AND LIGHTING 1/

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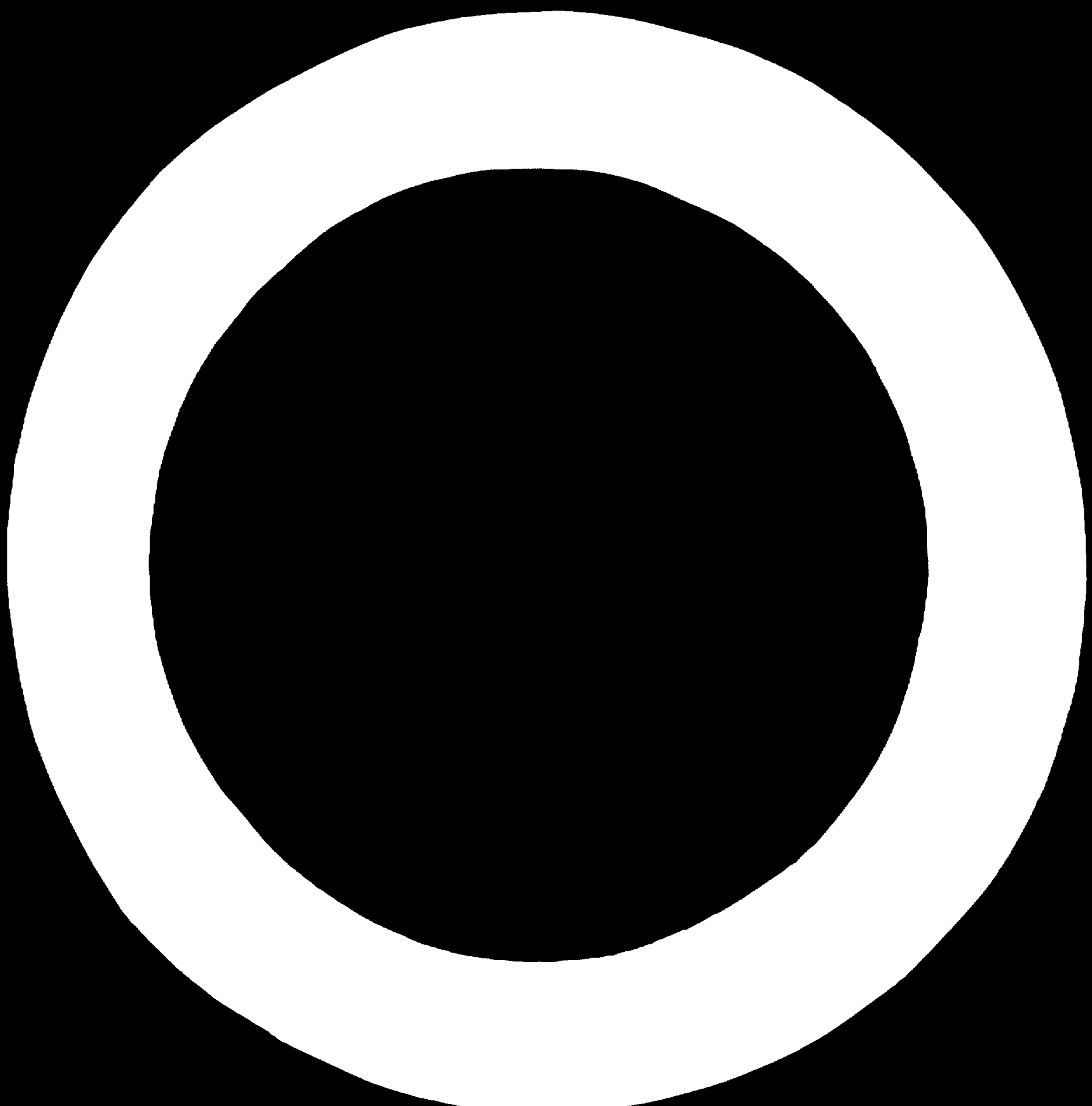

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Building and Facilities, Design and Lay-out for Industrial Research and Development Centres

I. HEATING, AIR-CONDITIONING, VENTILATION

In order to describe technical installations in research centres located in developing countries it seems useful to demonstrate planning problems by a sample building.

For this reason the new construction of an industrial research centre in Sudan has been selected as a case study.

(The following figures (I to III) will give you an overlook on the building project. The following ground plans (IV to VI) will show you the subdivision into different fields of function.)

A. Heating

No heating installation was necessary in the project chosen, which has been erected in the Sudan. During the past 30 years average outside temperatures (day-time) did not fall below + 15° C. Even minimum temperatures (December and January, night-time) average at about + 7° C.

(Annual maximum and minimum temperatures are shown in table 1)

B. Air-conditioning installation

Planning air-conditioning installation the following items have been of major importance:

(a) installation must be easily to carry-out, without specific technical know-how;

(b) in order to store spare parts mainly single units of same type should be installed which additionally prevents a complete breakdown in case of single faults;

(c) maintaining of air-conditioning installation may be time consuming, it should, however, also to be carried-out by un-skilled labour.

In order to evaluate the optimum solution table 2 has been designed. It can be seen that in our case, i.e. 60 per-cent full air-conditioning and 40 percent non-treated volume, a decentralized installation is preferable. The advantages of this system (table 3) also meet the requirements of the buil-ding sponsor taking up with the disadvantages.

Caused by high external temperatures the calculation of the air-conditioning installation excluded the use of single window cooling units. For this reason chests have been aban-doned in favour of small decentralized pieces of air-condition-ing apparatus with refrigerating machine, inlet, outlet and recirculated air. This apparatus is mounted inside a false ceiling in the offices. Openings in the facade are covered by the sun protection device. Air distribution is effected by by short tube system inside the false ceiling and by anemostats or ceiling grids.

This decentralized unit is shown in figure VII. In this case three offices are supplied by one apparatus. The number of rooms supplied by one apparatus has been fixed in a way that only one type of unit was necessary for the whole office area.

Workshops, halls, conference hall, library and stores are equipped with separate central units. All air-conditioning units have been placed on the roof (figure VIII). The units will be assembled by the modular principle using the split system, i.e. the condenser is separately mounted, the refrigerating machine, however, being built-in. Air distribution is effected by tubes inside the false ceiling and ceiling outlets. Each unit is connected with a sand filter, to guarantee operation during dust storms.

Exhaust air will be sucked-in by tubes also installed inside the false ceiling.

The device for exhaust air is connected to the supply air unit, to adjust a recirculated air rate for energy saving.

Laboratories are always connected with two rooms for office and preparation purposes (figure IX). Each laboratory is equipped with a separate air-conditioning unit which also supplies the rooms attached.

Exhaust-air is conveyed via heat-exchanger which is connected with a precooler as in these rooms exhaust air may not be recirculated and additionally high air-exchange rates are required (figure X).

Because of the aggressive media which must be conveyed, the exhaust air tubes will be made of PVC.

Basic technical data and directives for the air-conditioning installation are shown in table 4. European and German regulations and standards have been applied as local regulations do not exist.

C. Ventilation

The chemical store is equipped with a ventilating system. Supply- and exhaust-air devices have been mounted on top of the roof. Supply air inlets are installed in the ceiling.

(Figure XI shows a supply-air device)

Exhaust-air is sucked-in on floor level below bottles, to rapidly eliminate heavy chemical vapors (figure XII).

Supply and exhaust-air tubes are made of PVC, ventilating apparatus being explosion-proof.

Toilets and small annex rooms are equiped with exhaust-air device and ventilation unit mounted on the roof. Supply air is sucked-in via high pressure flaps from the corridors.

In the laboratories and various workshop areas fume hoods (figure XIII) have been installed. For safety reasons hoods will be connected to separate exhaust-air units (figure XIV). Fume hoods are designed to prevent vapors from penetrating into the laboratories.

Sniffling points in the laboratories and workshops have been provided at the places required (figure XV).

II. FACILITIES

A. Water

The main problems in the water supply were:

(a) low and differing pressure within the water supply net,
(b) high temperatures of the water depending on the climate,
(c) strong changes in degree of hardness of water and of its chemical composition.

The existing supply pressure of the water network is only 1.84 atm. By means of a pressure increase unit, the pressure was raised to 4.5 atm. To ensure supply when one of the units is not in operation two pressure increase units have been provided. Hot water heaters are installed where necessary, as a complete pipe system would have been too expensive.

The water supply distribution has been split into three systems:

(a) normal points of use, e.g. toilets, wash basins, etc.
(b) emergency showers which are installed at entrance doors of laboratories
(c) workshops and technical connections.

A separate pressure increase unit has been provided for the emergency showers. In case of a breakdown showers will automatically be connected with the main pressure increase unit.

Difficulties resulted out of the consistency and the average temperature of the water. As you may see from the following table (5), water temperature varies between 25°C and 36°C. Thus in certain laboratories and workshops it was necessary to install small water cooling apparatus which are manually switched-on when needed.

As emergency showers are only needed in case of accidents or burn a separate water cooling system was provided which automatically operates by flow switch.

A water treatment plant was provided to soften and demineralise the water, thus corresponding to the needs of the institute.

The distribution pipes are made of galvanised steel pipes which mainly have been laid inside the false ceiling. Only pipes conveying cooled water are insulated as normal water temperature exceeds room temperatures thus excluding condensation water. The following figures will show you part of the laboratory areas. (XVI-XVIII)

Supply of water has been calculated with 250 liter per person and day, the water network supplying 1/3 of this quantity at peak time.

B. Power Supply

For the power supply the following had to be considered:

- voltage : 415/240 volt 50 Hz
- the transformer station had to remain functionable even during high outside temperatures and air humidity
- additional supply had to be provided in case of power failure.

The installed capacity required for the whole building was about 1,700 kW. Cables were connected to a 11-kV overhead line in 300 m distance. For power supply a high-voltage switching and transformer station with two cells 630 kVA each was erected providing a mains voltage of 415/240 V and 50 Hz. (Fig.XIX) Transformers have been designed for tropic conditions and high air temperatures thus avoiding the installation of cooling systems. Internal distribution was carried-out with 4-conductor system.

(Table 6 shows power distribution in the axis areas of the building)

Receptacles generally have been mounted 0.30 to 0.40 m above floor covering. Distribution cables have been laid inside the false ceiling leading to the receptacles via vertical wall slots.

The workshops were regarded as rooms endangered by fire. For this reason, all electric equipment had to be of damp-proof type, mounted at a minimum height of 1.10 m above floor covering.

In case of power breakdown an emergency power generator has been installed, providing 30 kVA. Emergency lighting and emergency showers are connected to this generator which will automatically be switched-on in case of power failure.

C. Gas Supply

Since neither long range gas supply nor city gas was available, the gas consumption is covered by two propane cylinders containing 33 kg each. A third propane cylinder was provided as reserve.

The gas pressure is kept constant at 500 mm WS (head of water) by a gas pressure regulator. A reversing valve enables switching over to the second cylinder without interruption. The supply pipes made of seamless black tubes were laid inside the false ceiling. The gas supply unit has been planned on the basis of the DIN TVG-Gas 1969 standard.

(X)

Gas connections for equipment not solid installed have been provided with safety valves which automatically turn-off supply in case of defects.

D. Communications

Private telephone branch is connected with a central telephone exchange. In general, calls must be claimed in the telephone exchange. Only four internal telephones have direct exchange lines. Incoming calls may directly go to the extension line.

In the administrative section (directors) two intercommunication line installations for eight parties and one intercommunication installation for two parties has been installed.

In the lecture hall an amplifier installation with a capacity of about 50 W and two loudspeaker series have been provided. Moreover an interpretor installation with standard socket connections for headphones at 126 seats has been installed.

E. Safety

For safety in case of fire dry fire-extinguishing pipes have been installed in the staircases, equipped in each floor with tubes and spraying nozzles.

Outside the building fire extinguishing ground hydrants have been provided which are connected to a pressure increase unit also supplied by the emergency power generator. (Figure XX)

In rooms endangered by fire a sprinkler installation was suggested which, however, was rejected by cost reasons. As already mentioned each laboratory, however, is equipped with an emergency shower.

III. LIGHTING

A. Day-Light

Solar radiation is rather intensive as can be seen from table 7. Maximum values are reached in April and May.

The local habit to work in rather dark rooms corresponds to the necessity to protect rooms from sun penetration. However it is inconsistent with the requirements of work in laboratories and workshops. Hence major efforts were put into the design of an adequate sun protection which should achieve the following major characteristics:

(a) prevent the sun from penetrating into the weak point of the facades, the window

(b) reduce capacity of air-conditioning installation

(c) reduce running-costs of air-conditioning installation.

Effectiveness of sun protection device may be calculated by determining vertical and horizontal shadow angles at critical times. In our case we used solar charts which are most practible and sufficiently accurate for design.

The shaded time for the windows in the various facades are shown in the following figures (XXI-XXIV). As you will see, windows are shaded during critical times.

In order to provide sufficient light in the rooms, window areas from column to column have been prefered as against single windows.

As a general value we can take about 8 m as the maximum depth of rooms with natural lighting by windows. With this depth special works, however, already need additional lighting. Special areas with larger depths, e.g. workshops have been provided with dome lights which are insulated against heat (two shells).

B. <u>Artificial Lighting</u>

Lighting has been designed according to the following recommendations:

REQUIREMENTS BY TYPE OF WORK	GENERAL LIGHTING AVERAGE VALUES BY LUX		LIGHTING OF WORKING PLACE BY LUX	
	A [1]	B [2]	A [1]	B [2]
very low	30	60	-	-
low	60	120	-	-
medium	120	250	250	500
high	250	500	500	1000
very high	600	1000	1000	2000
extremely high	-	-	4000	4000 - 8000

1) In case of good general room conditions

2) In case of difficult visual and working conditions

Only very few areas of the institute had very high lighting requirements, e.g. tool grinding, grinding and polishing of metals and stones, colour testing and specific laboratory tests. Major institute areas had medium or high requirements respectively.

B.B Lamps Installed

- Pilot plant	hall reflector luminaires
- Offices, laboratories and rooms requiring medium to high luminous intensity	large-grid flush-type luminaires
- circulation areas	flush-type lamps
- workshops and additional rooms without false ceiling	surface mounted lamps

Lamps in offices, laboratories and circulation areas are built-in in the false ceiling.

For illumination of the escape routes via corridors and staircases, all-glass lamps, directional markers and flush-type lamps with filament lamps were provided. During power failure, these lamps are operated by two automatically cut-in emergency light switching gears with Ni-Cd-battery mounted underneath. For the lighting fixtures, the following special provisions were envisaged:

- special surface treatment and tropic-proof lacquer coating
- special tropic-proof ballast units, all-round metal clad and compound filled
- tropic-proof capacitors
- special tropic-proof sockets
- silicone wiring.

B.C Light Coloration

Luminaires generally are available in three different light colorations: warm white light color, white and day-light. Light colorations are measured by color temperature (^oKelvin). Light colorations comprise the following color temperatures:

warm white light color	3000 ^oK
white	4200 ^oK
day-light	6500 ^oK.

For the laboratories luminaires with white light coloration should be installed. For special works in laboratories, e.g. microscopic analysis, titration and color testing luminaires with day-light coloration are preferable.

B.D Orientation of Lighting

In large rooms, e.g. workshops, pilot plant, etc. lighting should not be oriented to facade or working places. In this case, luminaires should be neutrally directed.

In office rooms luminaires may be installed in rows left hand above desks. It is most important that no direct or indirect dazzle can occur. Brightness differences should not exceed a proportion of 1 : 3.

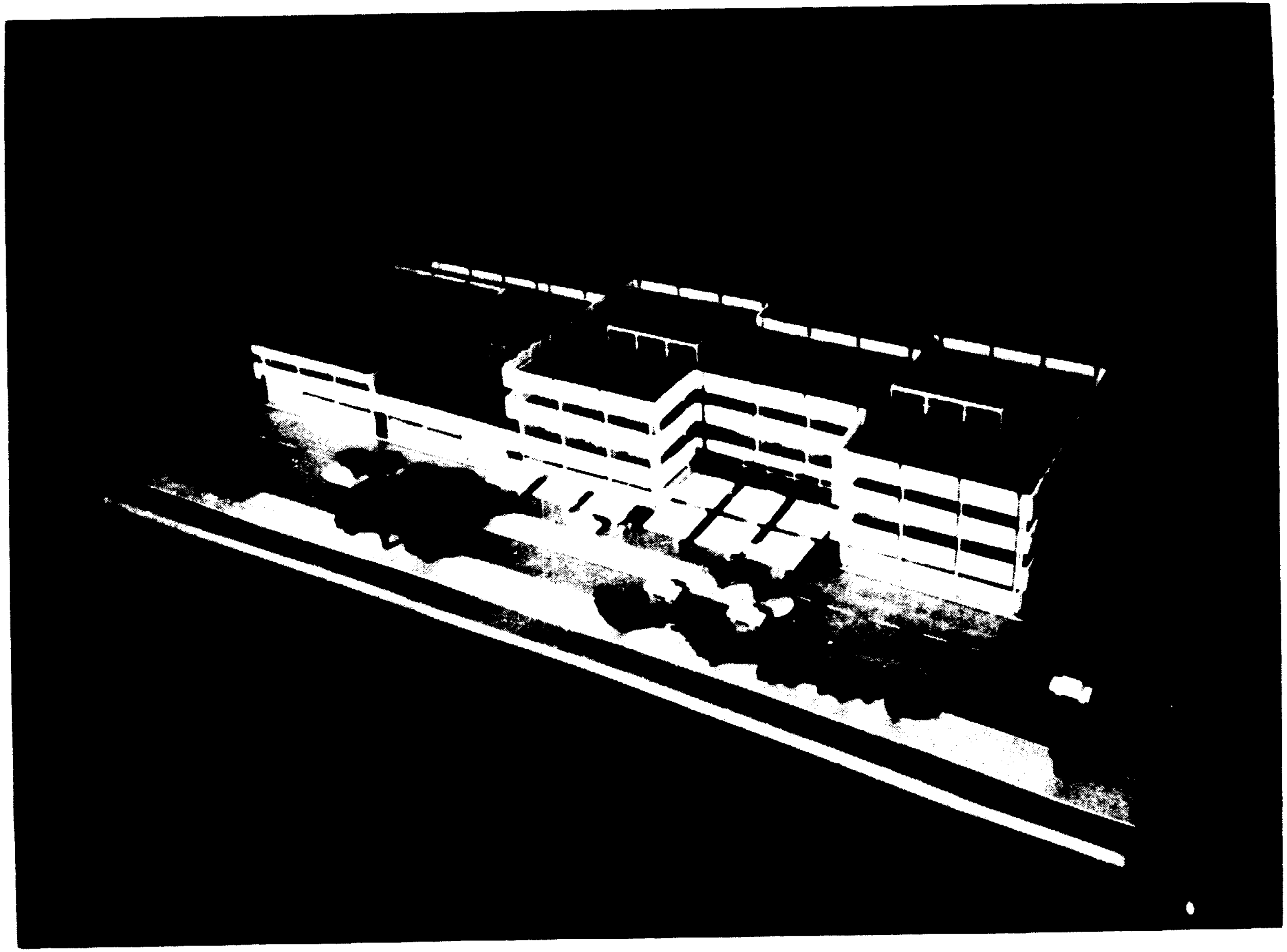


FIGURE 1 : FRONTVIEW

S. Barthelmess, "Industrial Research and Development Centres"

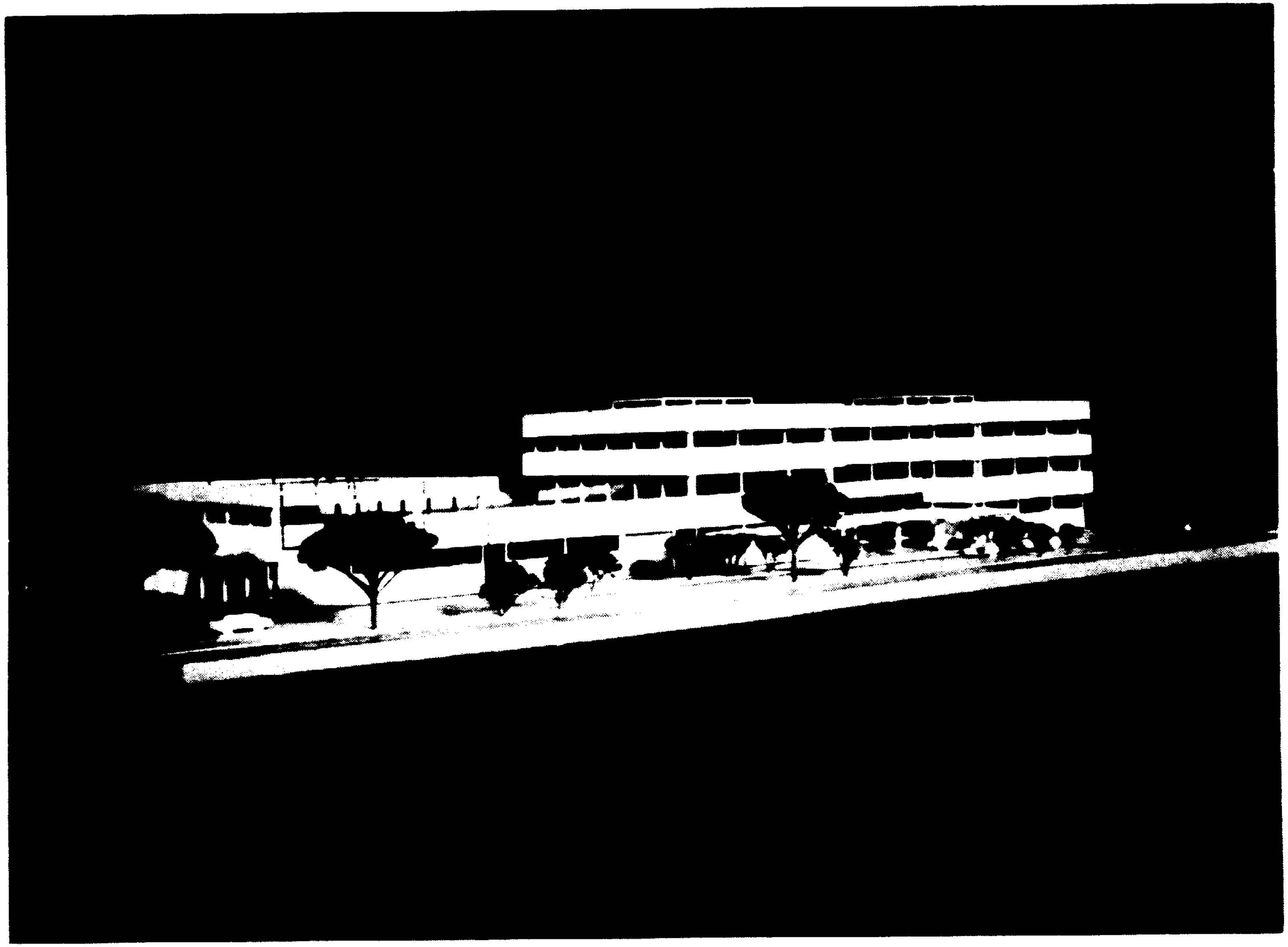


FIGURE II : REAR VIEW

S. Barthelmess, "Industrial Research and Development Centres"

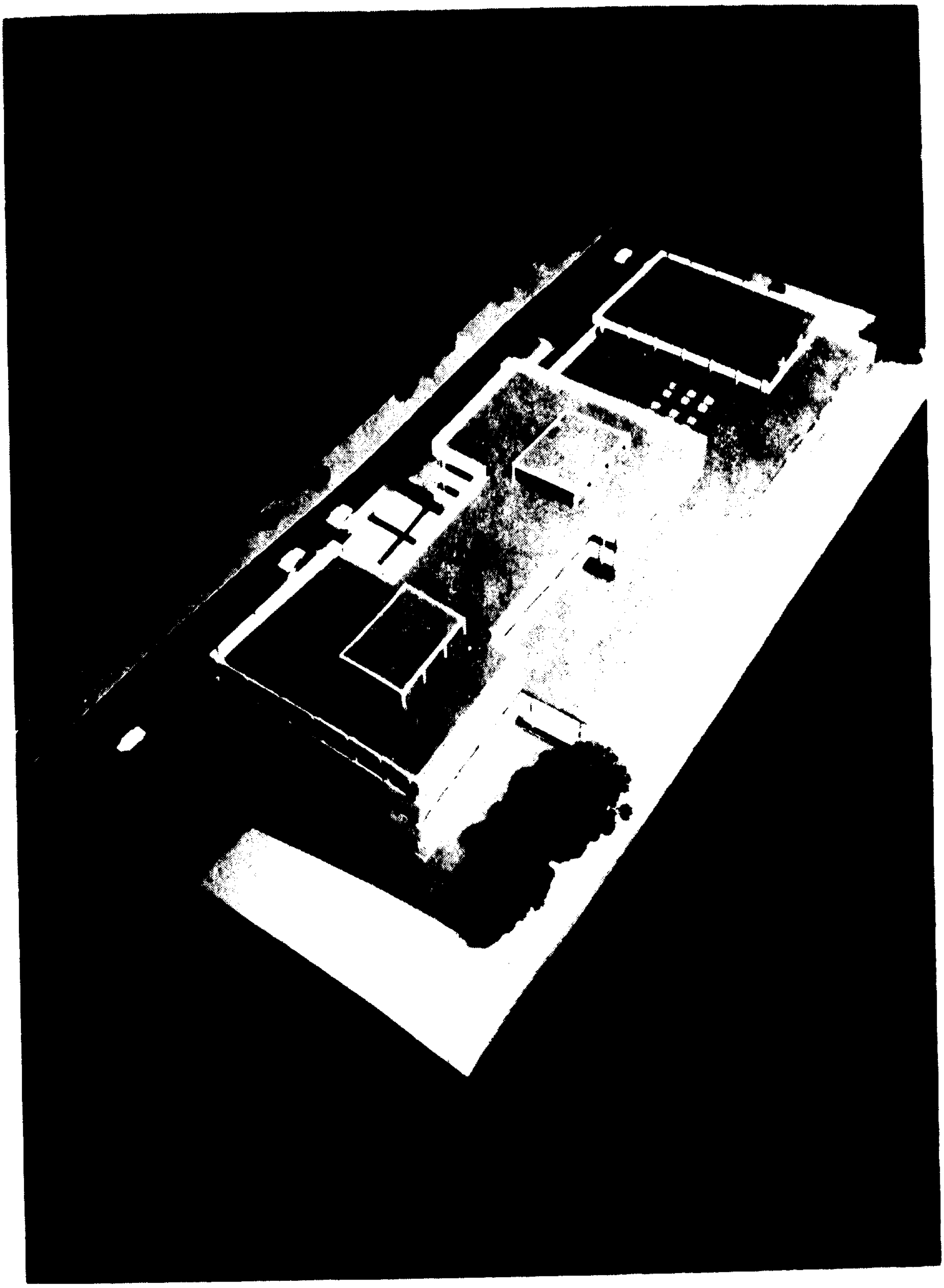


FIGURE III : PLAN VIEW

S. Barthelmess, "Industrial Research and Development Centres"

FIGURE IV: CASE STUDY " RESEARCH INSTITUTE ", GROUND PLAN S 1 : 500
GROUND FLOOR

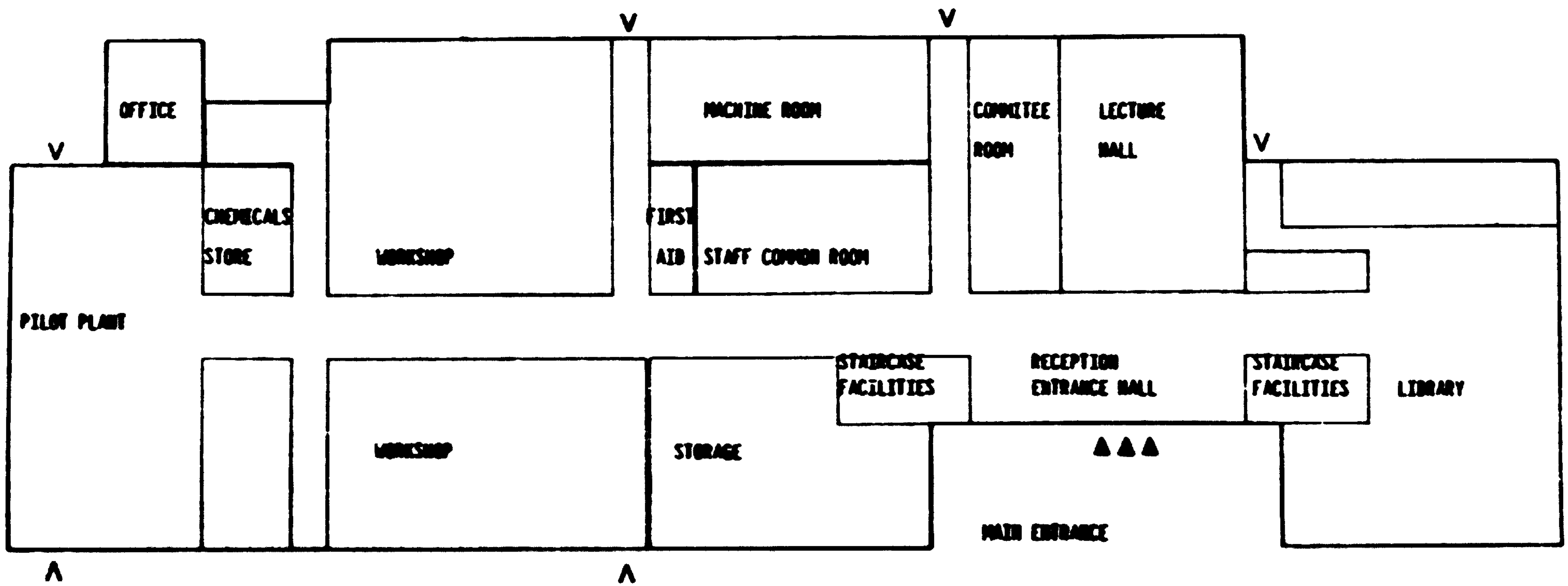


FIGURE V : CASE STUDY " RESEARCH INSTITUTE ", GROUND PLAN S 1 : 500

FIRST FLOOR

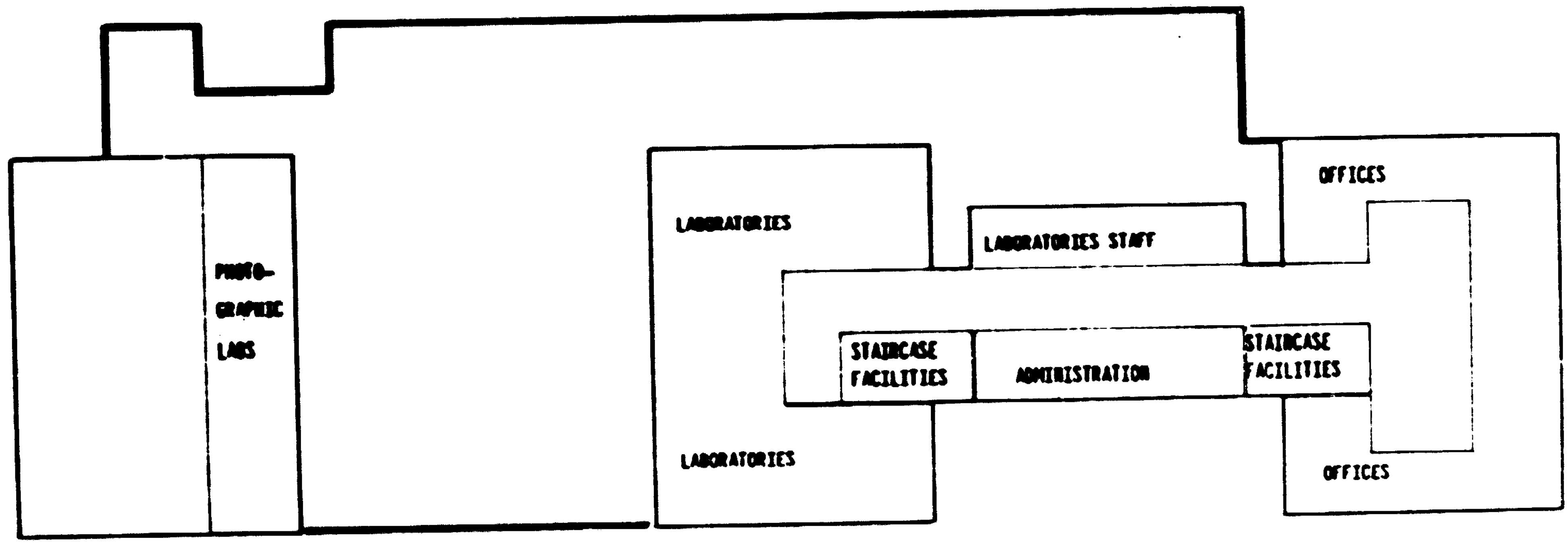


FIGURE VI: CASE STUDY " RESEARCH INSTITUTE ", GROUND PLAN S 1 : 500

SECOND FLOOR

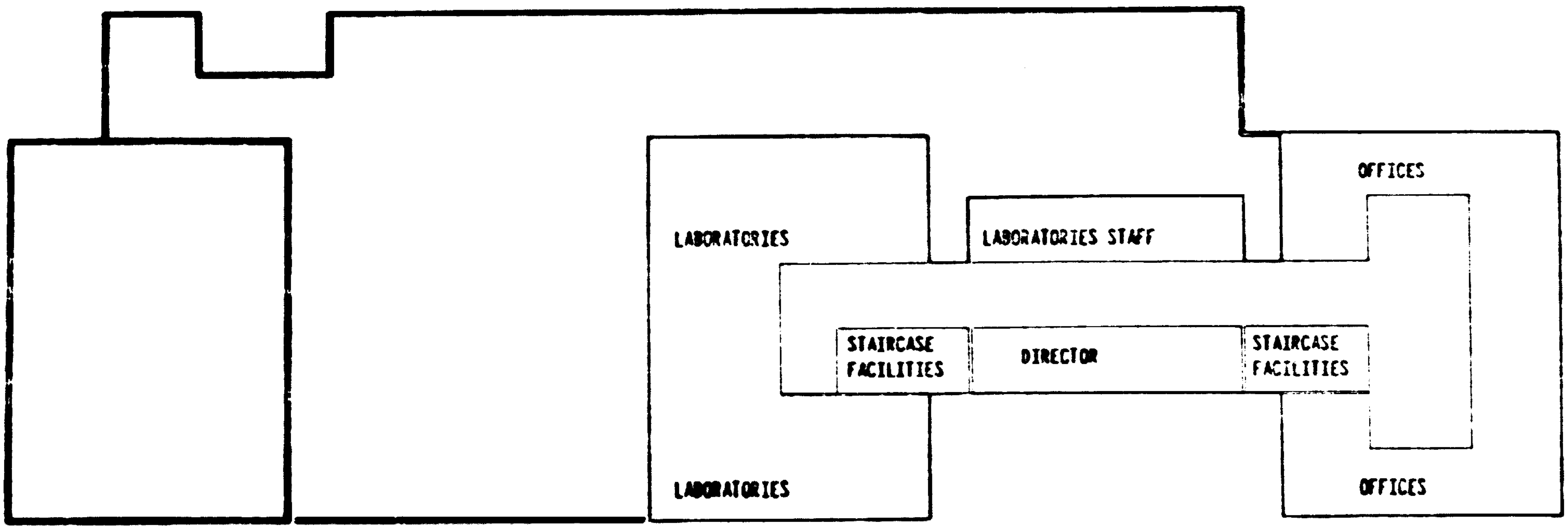


TABLE 1

CLIMATIC DATA PROJECT SUDAN

MAXIMUM AND MINIMUM TEMPERATURES

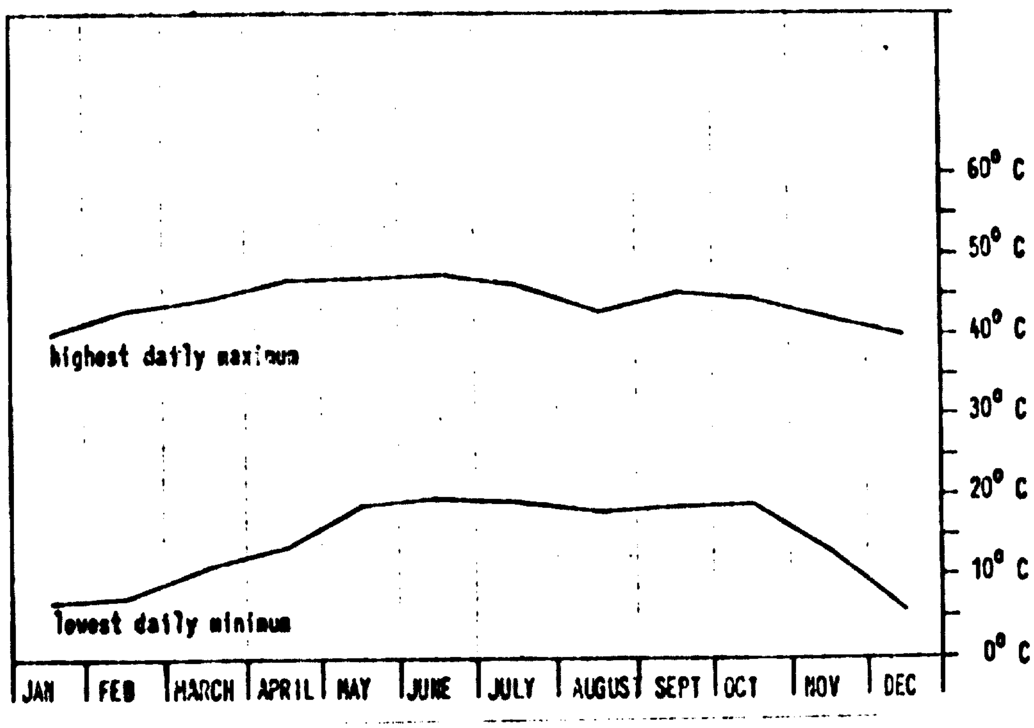


TABLE 2 Air-Conditioning

PROJECT SUDAN

Decentralized air-condition (single units)	Central air-conditioning	fully conditioned	ventilated	not treated
	+ + + + +	0 % ... 50 %	100 % ... 50 %	
	+ + + + +	50 % ... 100 %	50 % ... 0 %	
	+ + + + +	75 % ... 100 %		25 % ... 0 %
+		50 %		50 %
+ +		60 %		40 %
+ +		75 %		25 %
+ + + + +		50 % ... 0 %		50 % ... 100 %

Sample calculation:

1) Supposing full air-conditioning of 60 percent of building volume and ventilation of 40 percent a central air-conditioning plant is preferable

2) Supposing full air-conditioning of 60 percent of building volume and 40 percent of non-treated volume single air-conditioning apparatus are preferable

TABLE 3 "Advantages and Disadvantages of Decentralized Air-Conditioning Plants"

Advantages

1) Comparatively simple design
2) No cold water network necessary
3) For rooms situated at the outside, no network of supply air ducts necessary
4) High flexibility of the system
5) Favorable price
6) Many small and identical units, thus small stock of spare parts
7) Good contrallability of the temperature in the inside rooms

Disadvantages

1) No automatic humidity control
2) High noise level due to built-in refrigerating machines
3) Large openings in the facades for condenser cooling air
4) During a dust storm all outside air openings must be closed; then, cooling of the boundary zone not possible
5) Central air processing unit and air duct network for inside rooms very expensive
6) High maintenance cost for exchange of filters
7) Maintenance only possible by skilled labour

FIGURE VII:

SINGLE AIR-CONDITIONING PLANT FOR THREE OFFICES - PROJECT SUDAN

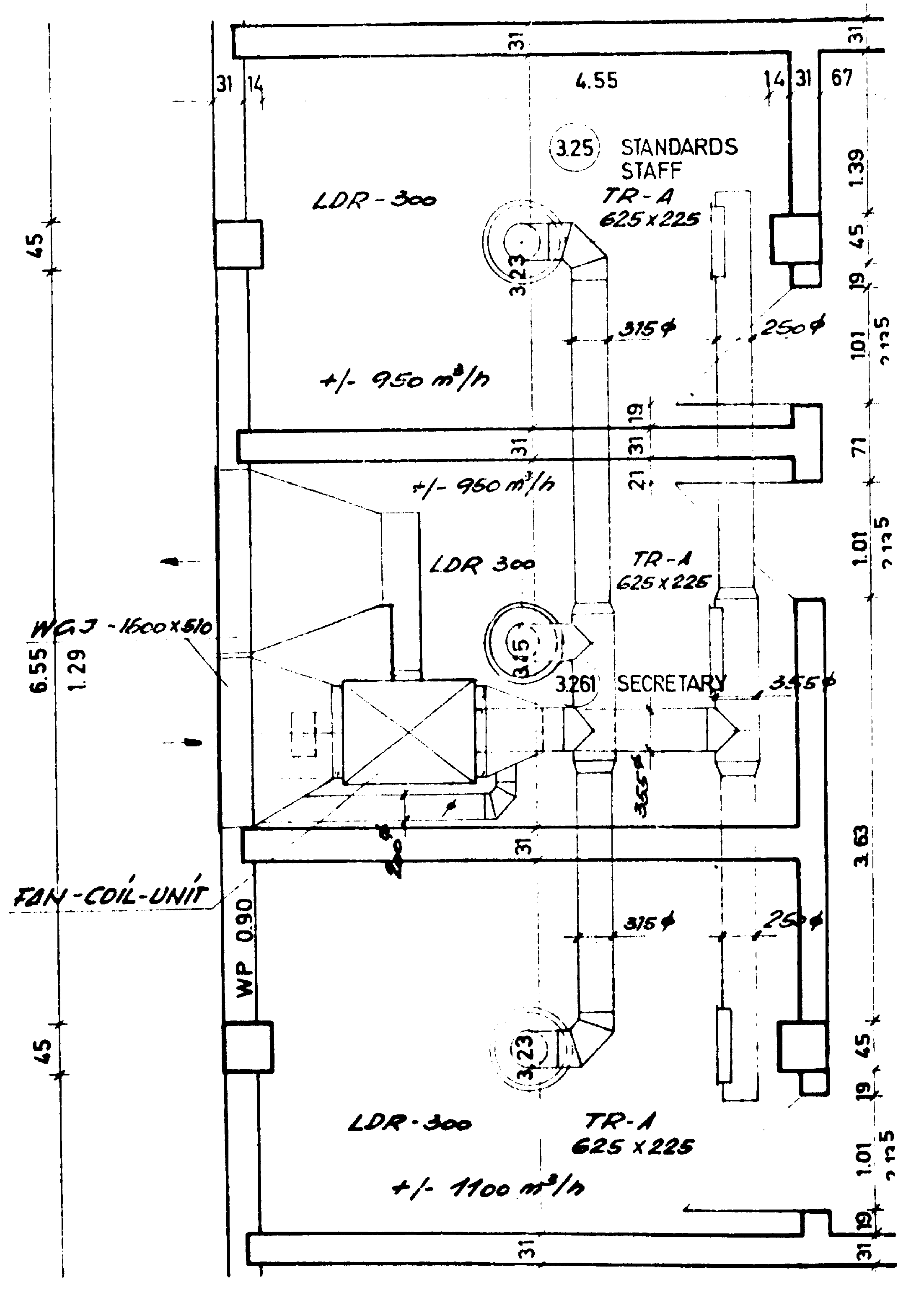
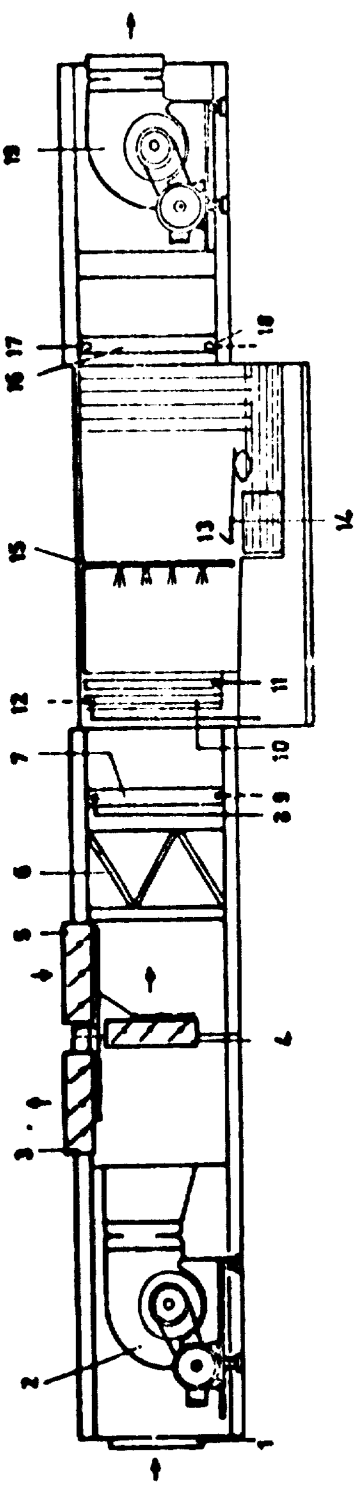


FIGURE VIII AIR-CONDITIONING UNIT ON THE ROOF - PROJECT SUDAN



Prefabricated air treatment plant with exhaust air and circulating air units

1 Exhaust air
2 Air exhauster
3 Outgoing air
4 Circulating air
5 Outside air
6 Air filter
7 Preheater
8 Heating medium supply
9 Heating medium discharge
10 Air cooler
11 Cooling water feed
12 Cooling water drain
13 Humidifying water feed
14 Float valve
15 Nozzle connection humidifier
16 Air heater for reheating
17 Heating medium supply
18 Heating medium discharge
19 Air supply (fan)

FIGURE IX AIR-CONDITIONING OF THE LABORATORIES AND ANNEXES

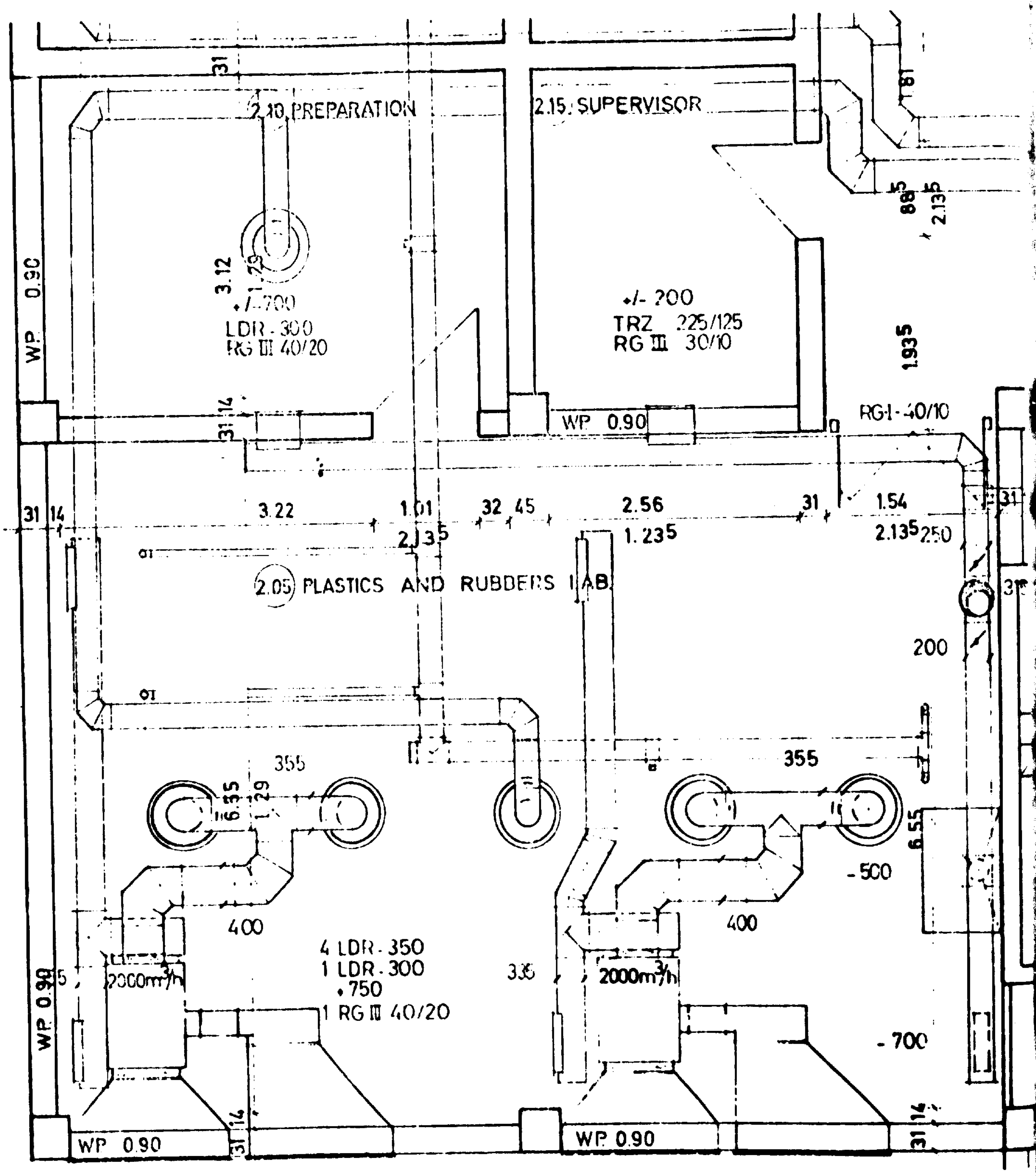
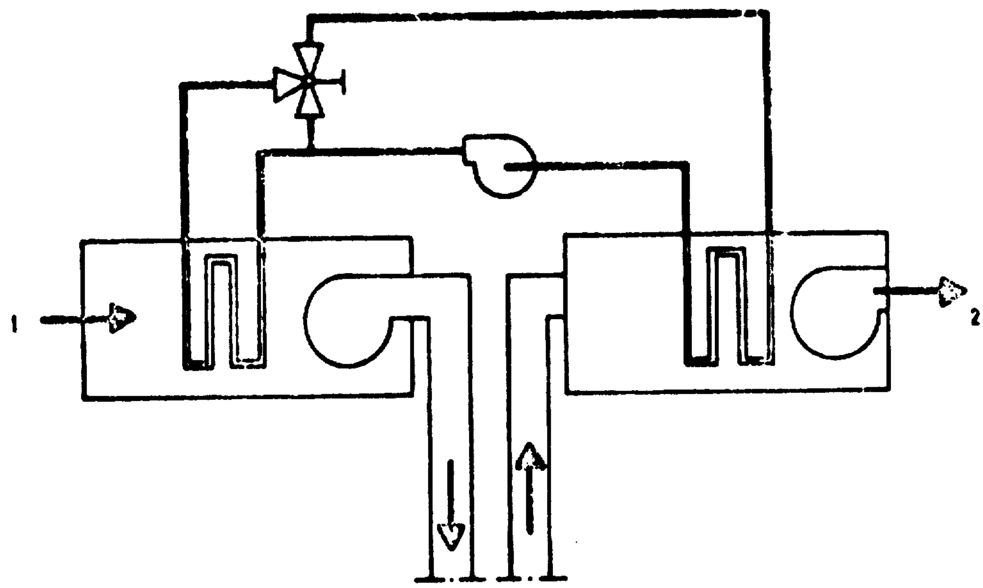


FIGURE X HEAT EXCHANGER



Heat recovery via air-to-water heat exchangers

1 Outside air

2 Exhaust air

TABLE 4

Basic Technical Data - Project Sudan

1) Outside air conditions: max. + 45°C/25 % relative humidity

2) Conditions for "Controlled Atmosphere" (room No 1.35):

from 20°C/30 % r.h. - 80 % r.H.
to 27°C/30 % r.h. - 80 % r.H.

3) Conditions for laboratories and offices:

Temperature : max. 29°C
Relative humidity : not controlled

4) Noise level requirements:

Workshops and store : 60 dB(A)
Laboratories and offices : 50 dB(A)

5) Air speed in the rooms: max. 0.4 - 0.6 m/s

6) Overall heat transfer (k-values):

External wall	1.17	kcal/h . m^2 . °C
Roof	0.5	kcal/h . m^2 . °C
Windows	2.8	kcal/h . m^2 . °C

7) Internal charge:

Personnel : as stated in description of rooms
Lighting heat : 700 Lux, taken into account by 50 %
Heat by machines : as stated in description of rooms. Diversity factor 0.5

8) Standards, directives, regulations:

VDI Ventilation regulations DIN 1946, sheets 1 and 2

VDI 2051	Ventilation of laboratories
VDI 2052	Ventilation of kitchens
DIN 18610	Ventilation shafts, ventilation ducts and units
DIN 1944	Ventilators
DIN 8975	Refrigeration equipment
VDI 2081	Noise suppression in ventilation units

FIGURE XI SUPPLY-AIR DEVICE
CHEMICALS STORE - PROJECT SUDAN

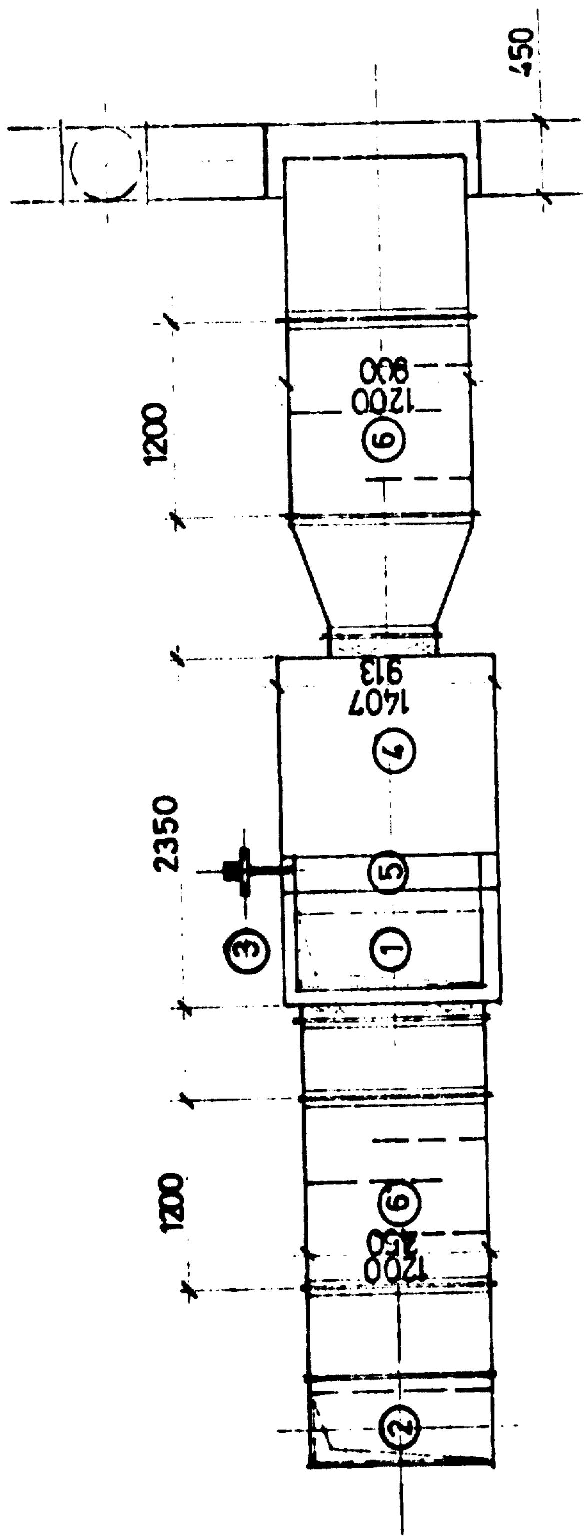


FIGURE XII

CHEMICALS STORE, EXHAUST

1 : 20

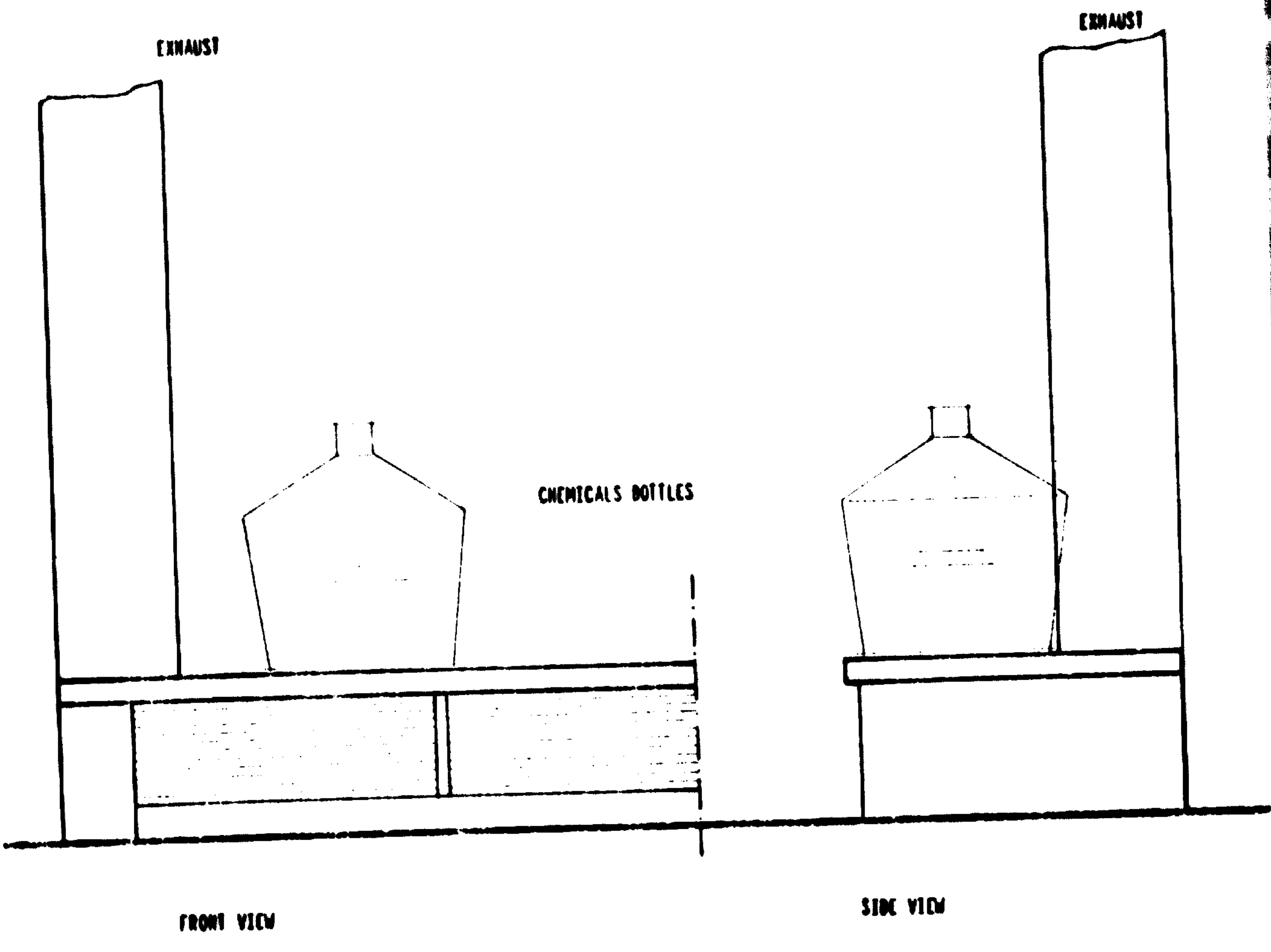


FIGURE XIII

FUME HOOD

S 1 : 20

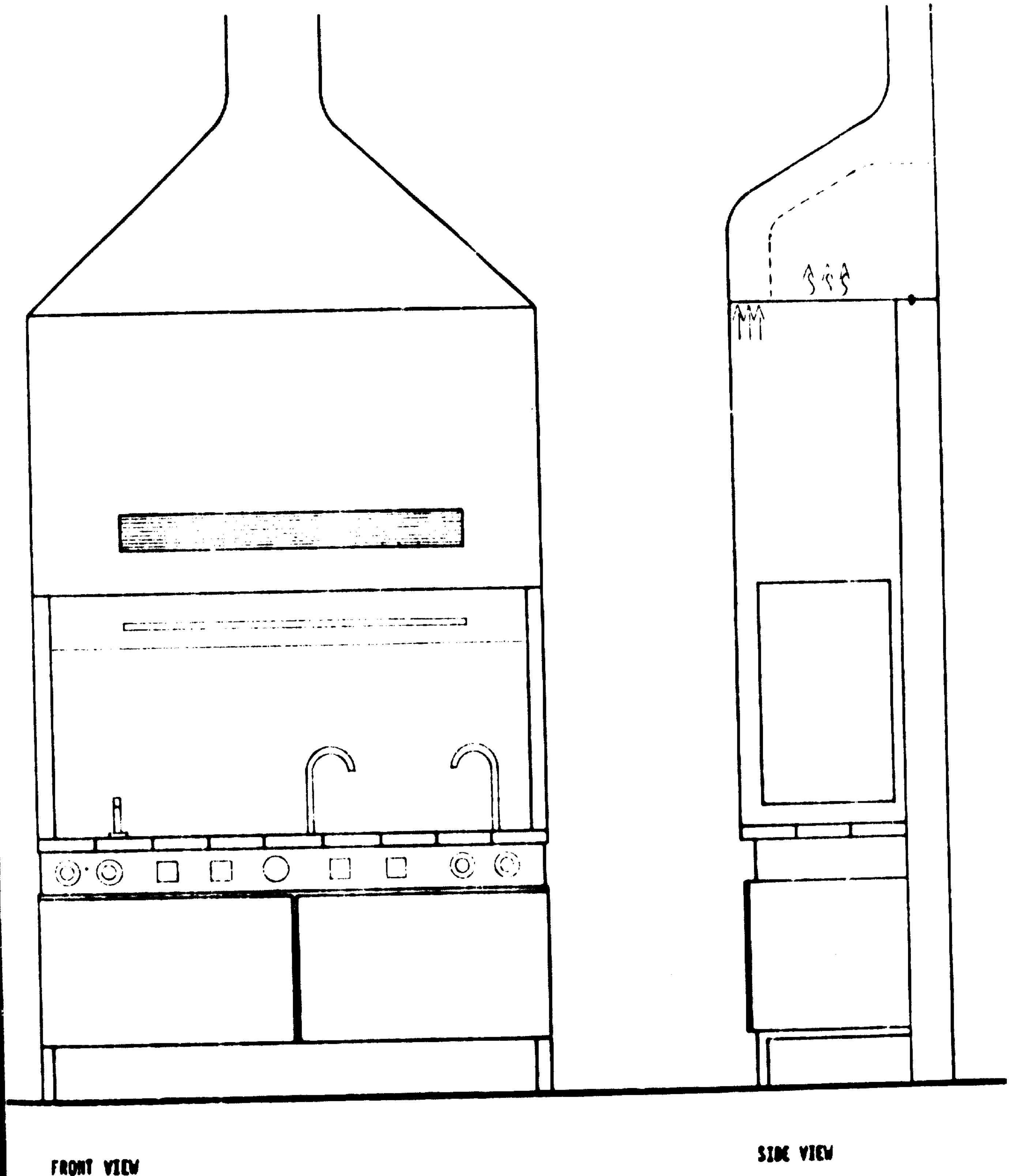


FIGURE XIV

EXHAUST AIR DEVICE " FUME HOODS " - LABORATORY I PROJECT SUDAN

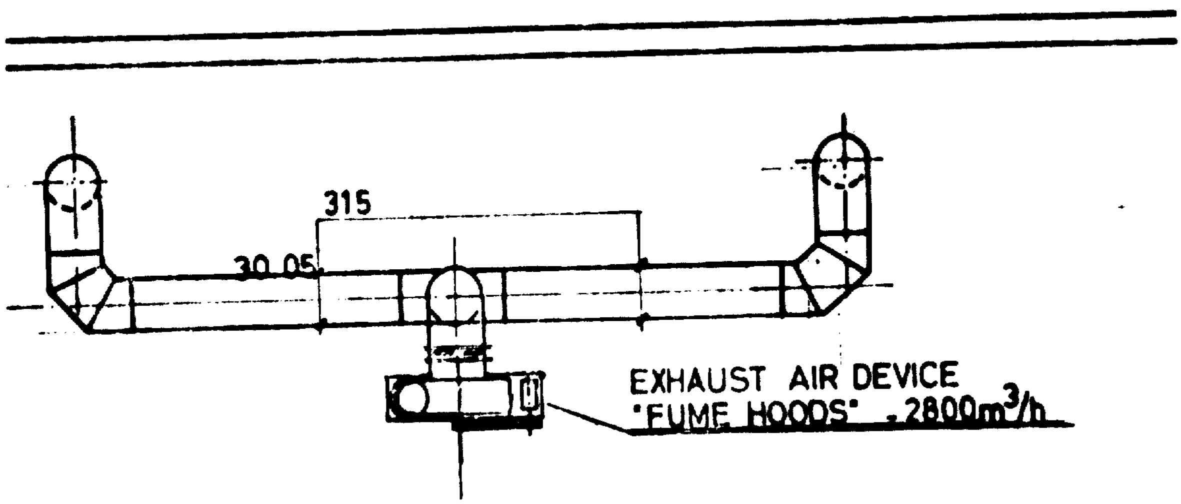


FIGURE XV SNIFFLE DUCTS LABORATORY II PROJECT SUDAN

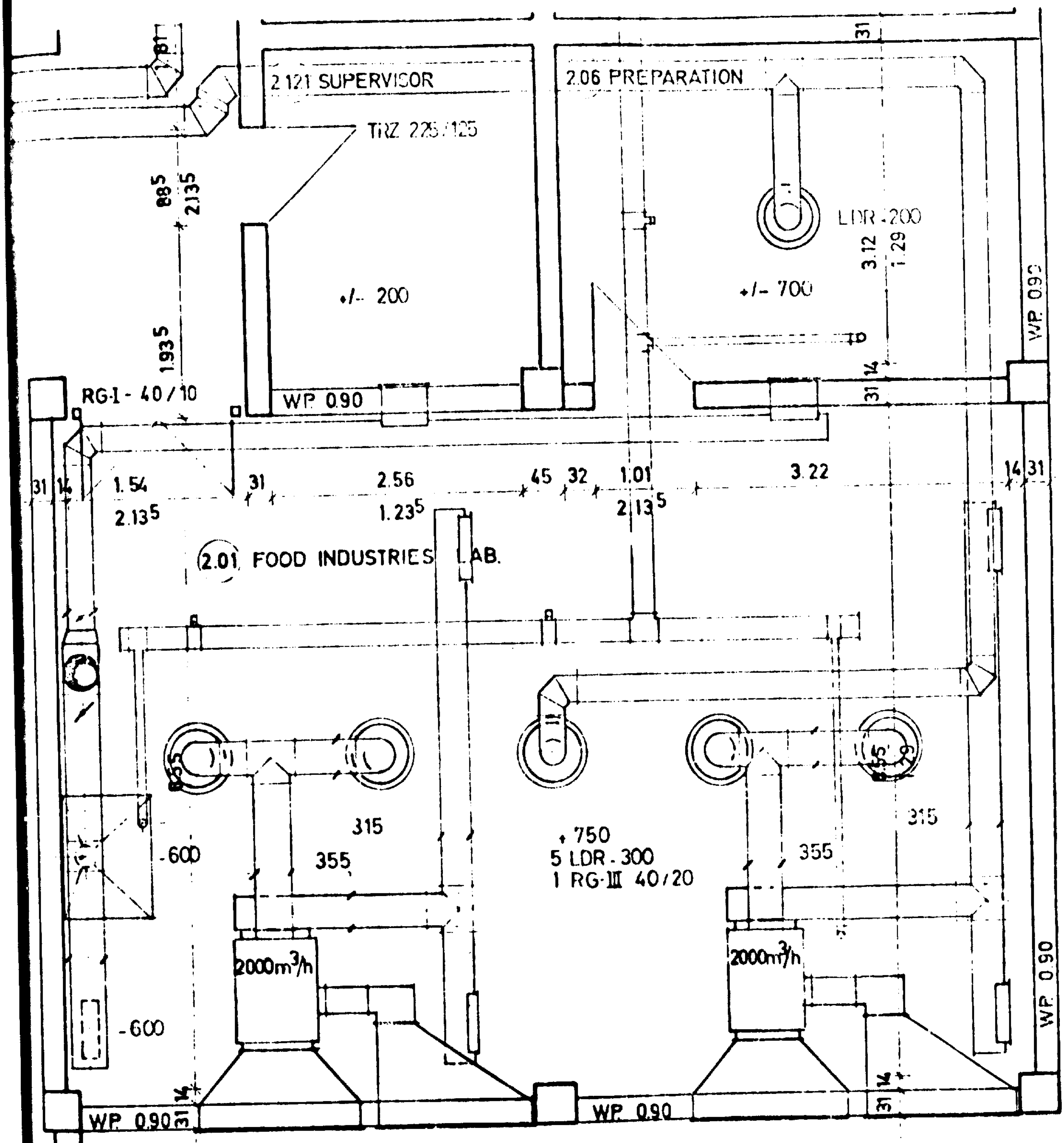


TABLE 5 RESULTS OF EXAMINATION OF SAMPLES OF WATER, LOCATION KH. NORTH TAP WATER 1969-1970

DATE :	23/8/69	15/11/69	20/1/70	25/5/70	24/6/70
Appearance	Clear	Clear	Clear	Clear	Clear
Turbidity	4.3	3.0	2.5	1.2	2.8
Colour Hazen Units	-5	-5	-5	-5	-5
Odour	Nil	Nil	Nil	Nil	Nil
Temperature when tested	31 °C	29 °C	25 °C	36 °C	36 °C
pH	6.5	7.1	7.5	7.5	7.5
Dionic reading	220	150	175	215	160
Total Hardness as CaCo3	100	65	90	125	95
Temporary Hardness as CaCo3	40	75	80	120	95
Permanent Hardness	60	Nil	10	5	Nil
Excess Alkalinity as CaCo3	Nil	10	Nil	Nil	Nil
Calcium as Ca	30	22	-	28	24
Magnesium as Mg	6.0	3.4	-	13.20	8.4
Silicate as Sio 2	12	14	10	7	8
Sulphate as So4	48	14.4	20.16	38.4	24.0
Chloride as Cl	11	10	11	18	18
Iron as Fe	Nil	Nil	Nil	Nil	Nil
Nitrite as N	0.0001	Nil	Nil	Nil	0.00015
Ammonical Ammonia as NH3	0.072	0.016	0.022	0.132	0.144
Albuminoid Ammonia as NH3	0.116	0.056	0.058	0.160	0.176
Fluoride as F	- 0.4	- 0.4	- 0.4	- 0.4	0.35
Total solid in suspension	-	-	-	-	-
Total dissolved solids at 180°C	-	-	-	-	-

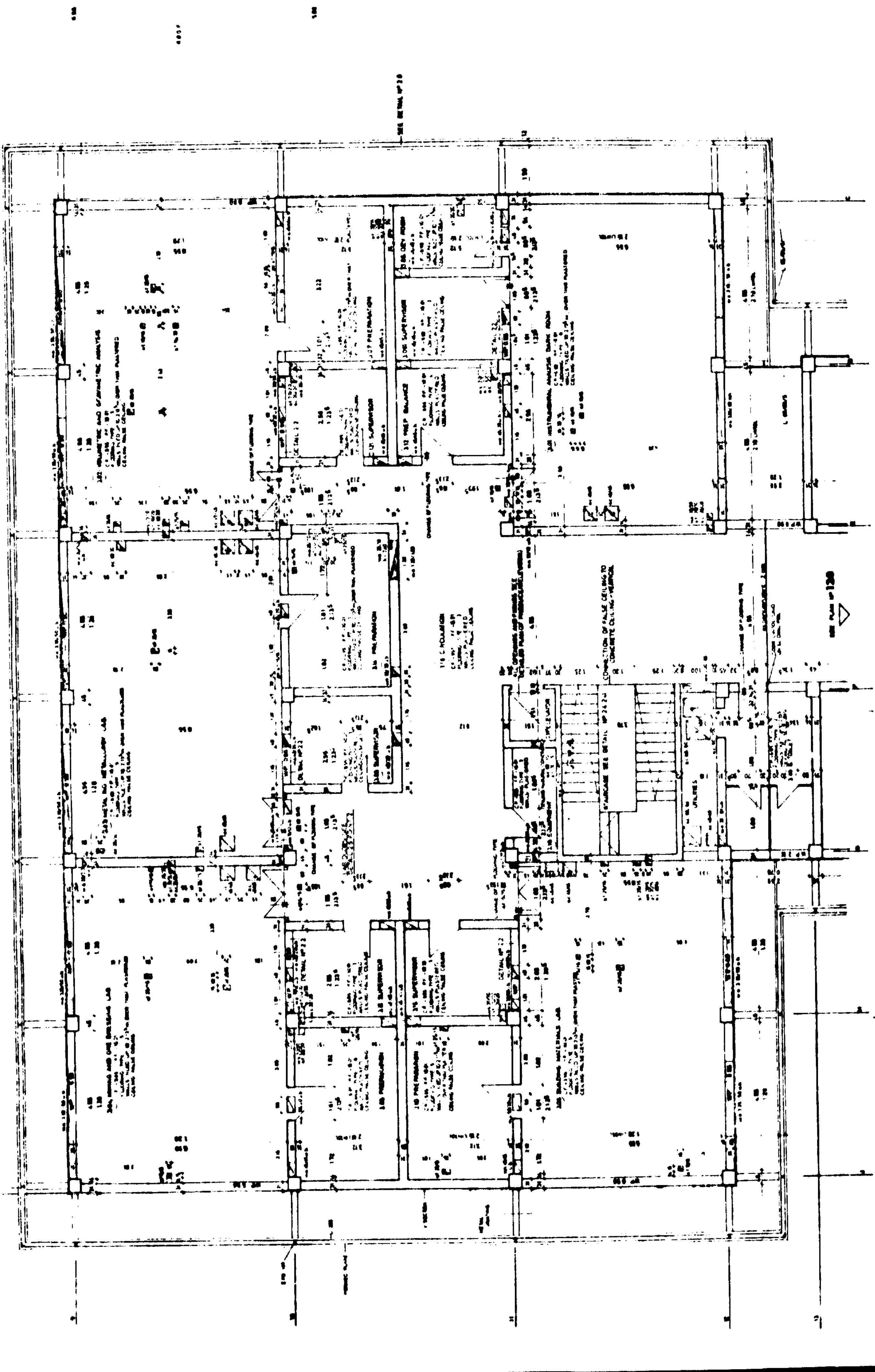


FIGURE XVI LABORATORY AREA

FIGURE XVII

FACILITIES - LABORATORY PROJECT SUDAN

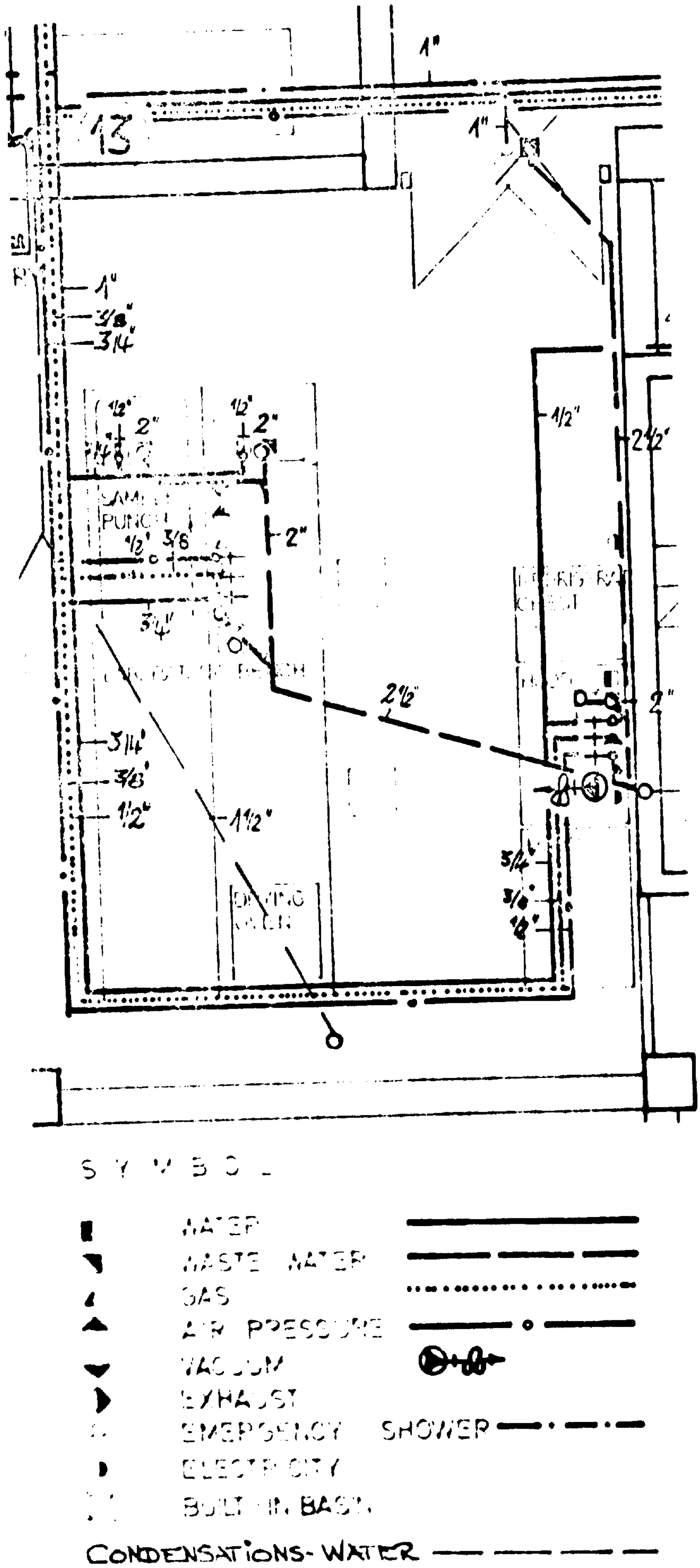


FIGURE XVIII

FACILITIES - WATER SUPPLY TOILETS PROJECT SUDAN

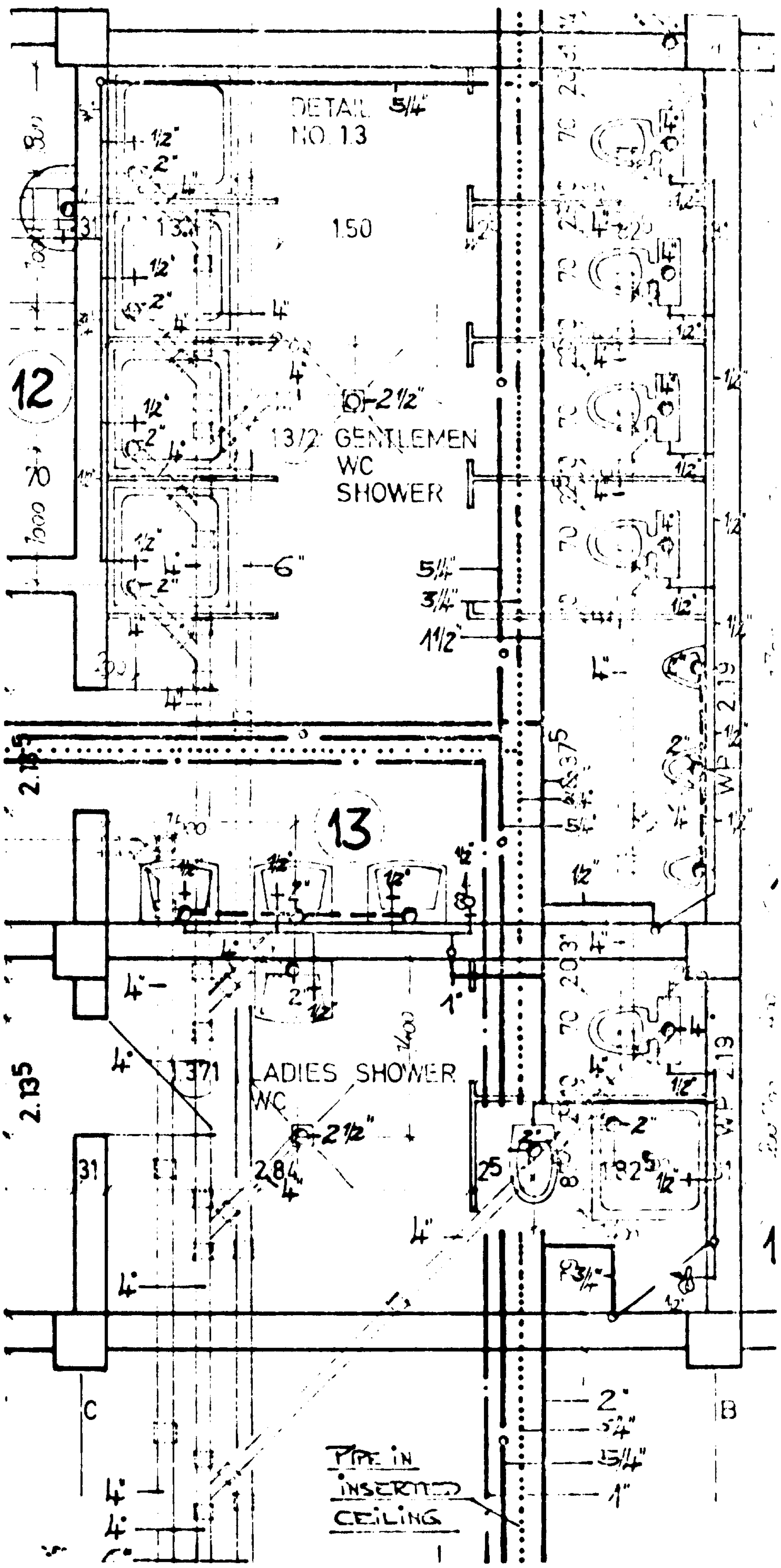


FIGURE XIX TRANSFORMER STATION

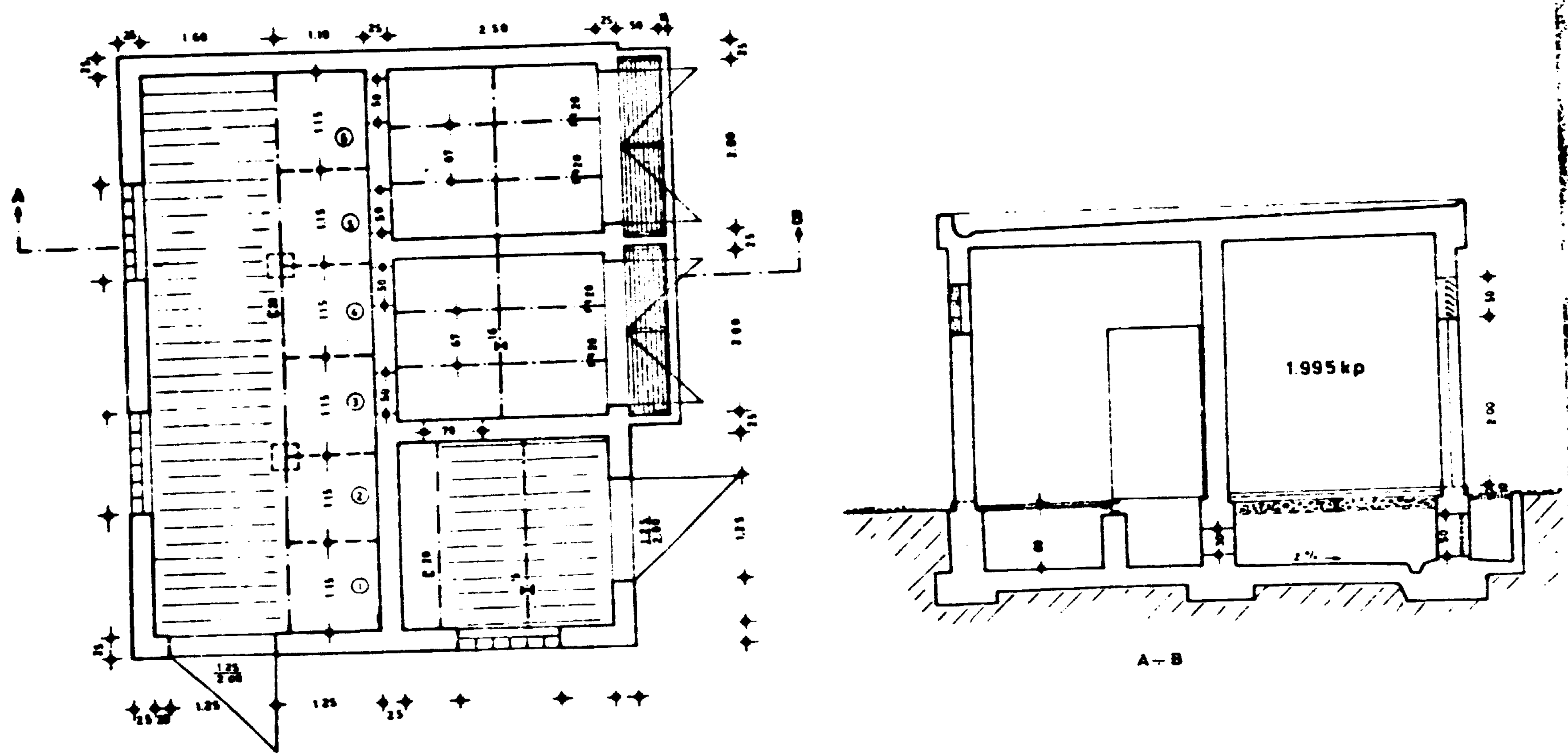


TABLE 6 POWER DISTRIBUTION IN THE AXIS AREAS OF THE BUILDING PROJECT SUDAN

Distribution	Location	Power Installed kW	Power for Lighting kW
s.d. 1 + 1a	axis 1 - 5, ground floor	158.7	20.2
s.d. 2	axis 1 - 5, upper floor	30.7	7.6
s.d. 3	axis 5 - 8, ground fl.	218.6	26.6
s.d. 4	axis 8 - 12, ground fl.	121.7	18.3
s.d. 5+(a - e)	axis 8 - 12, first fl.	278.9	27.0
s.d. 6+(a - d)	axis 8 - 12, second fl.	353.5	27.6
s.d. 6A	axis 8 - 12, second fl.	const. 19.7	
s.d. 7	axis 12 - 16, ground fl.	65.2	14.6
s.d. 8	axis 12 - 16, first fl.	47.6	10.6
s.d. 9	axis 12 - 16, second fl.	51.7	11
s.d. 10	axis 16 - 20, ground fl.	124.4	16.5
s.d. 11	axis 16 - 20, first fl.	137.8	20.6
s.d. 12	axis 16 - 20, second fl.	88.9	19.8

FIGURE XX   EMPLACEMENTS OF THE HYDRANTS

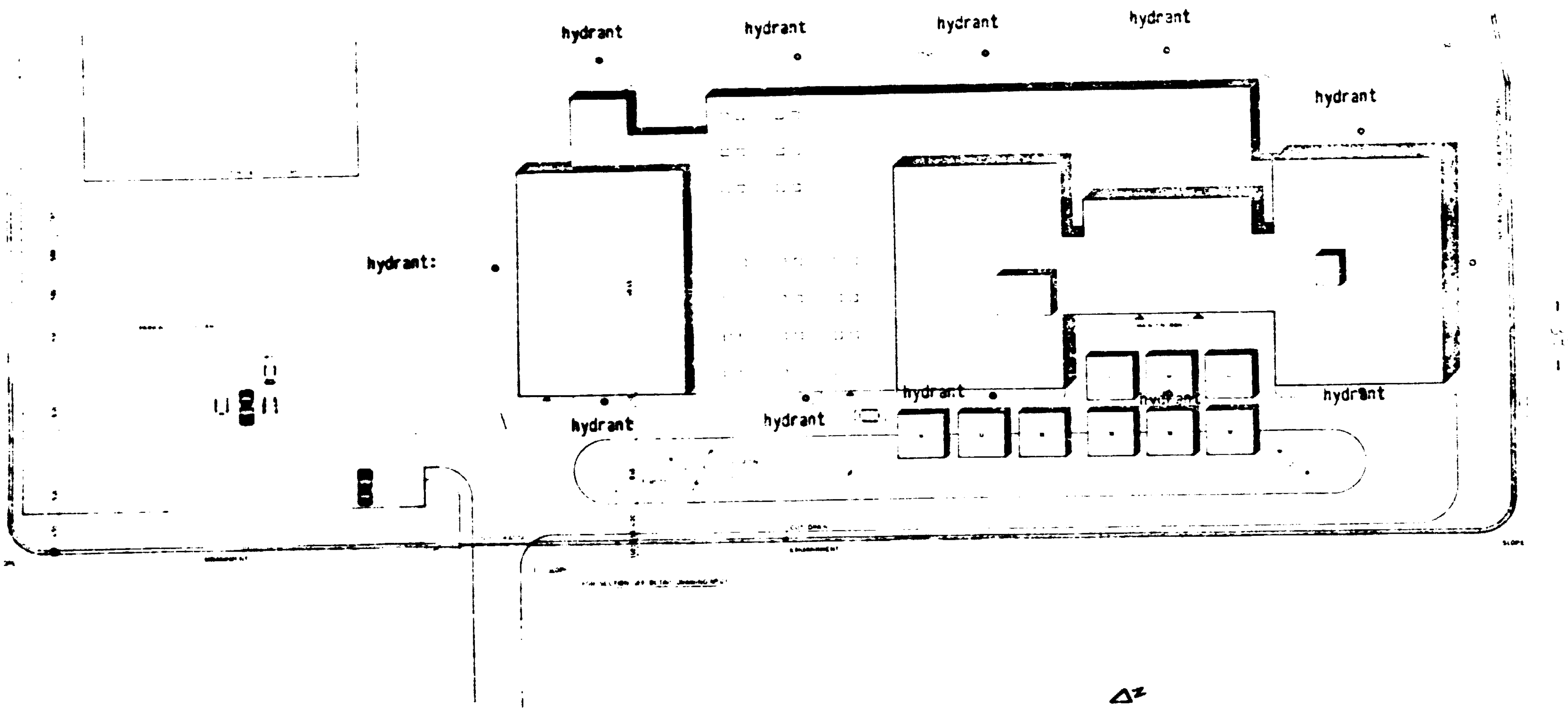


TABLE 7 SOLAR RADIATION AS RECEIVED ON HORIZONTAL

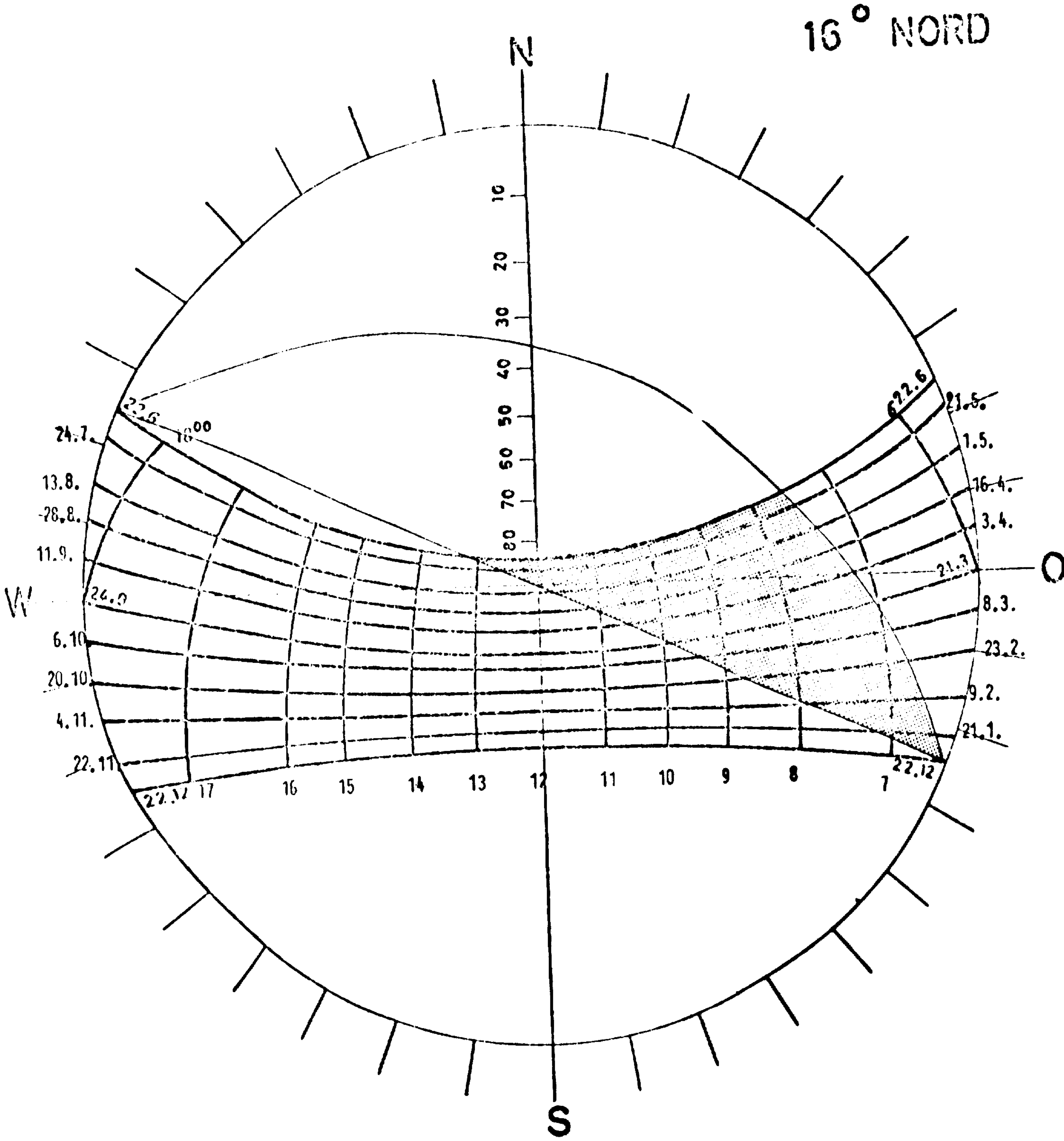
Surface (gm. cal / cm^2)

SHAMBAT OBSERVATORY 1963 - 1969

JANUARY	483.2
FEBRUARY	563.1
MARCH	596.7
APRIL	633.7
MAY	618.1
JUNE	578.2
JULY	554.4
AUGUST	541.5
SEPTEMBER	553.2
OCTOBER	527.1
NOVEMBER	498.5
DECEMBER	479.6

FIGURE XXI

SHADED TIME FOR THE NORTH FACADE
WINDOWS ONLY



shaded time

FIGURE XXII

SHADED TIME FOR THE SOUTH FACADE
WINDOWS ONLY

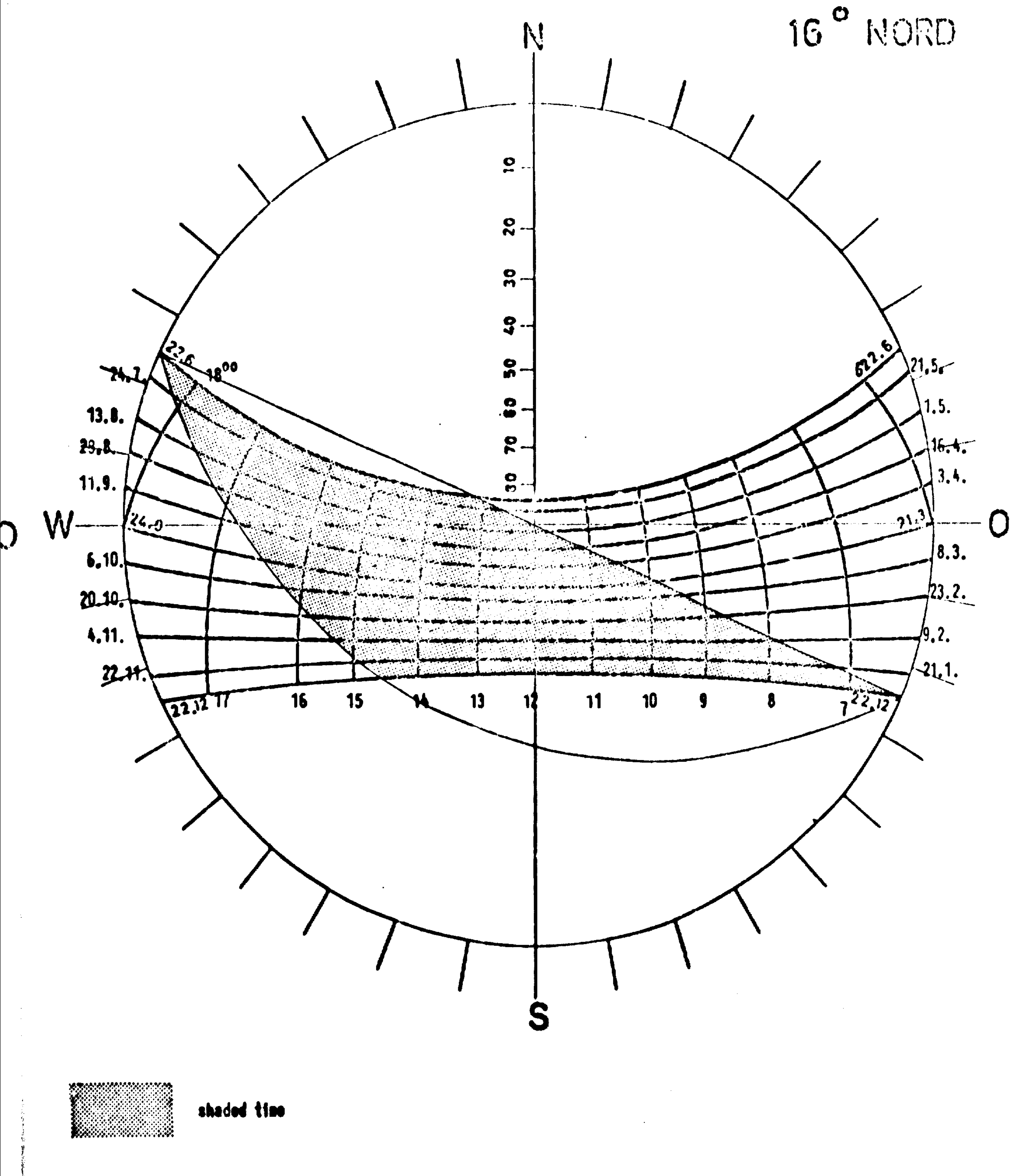
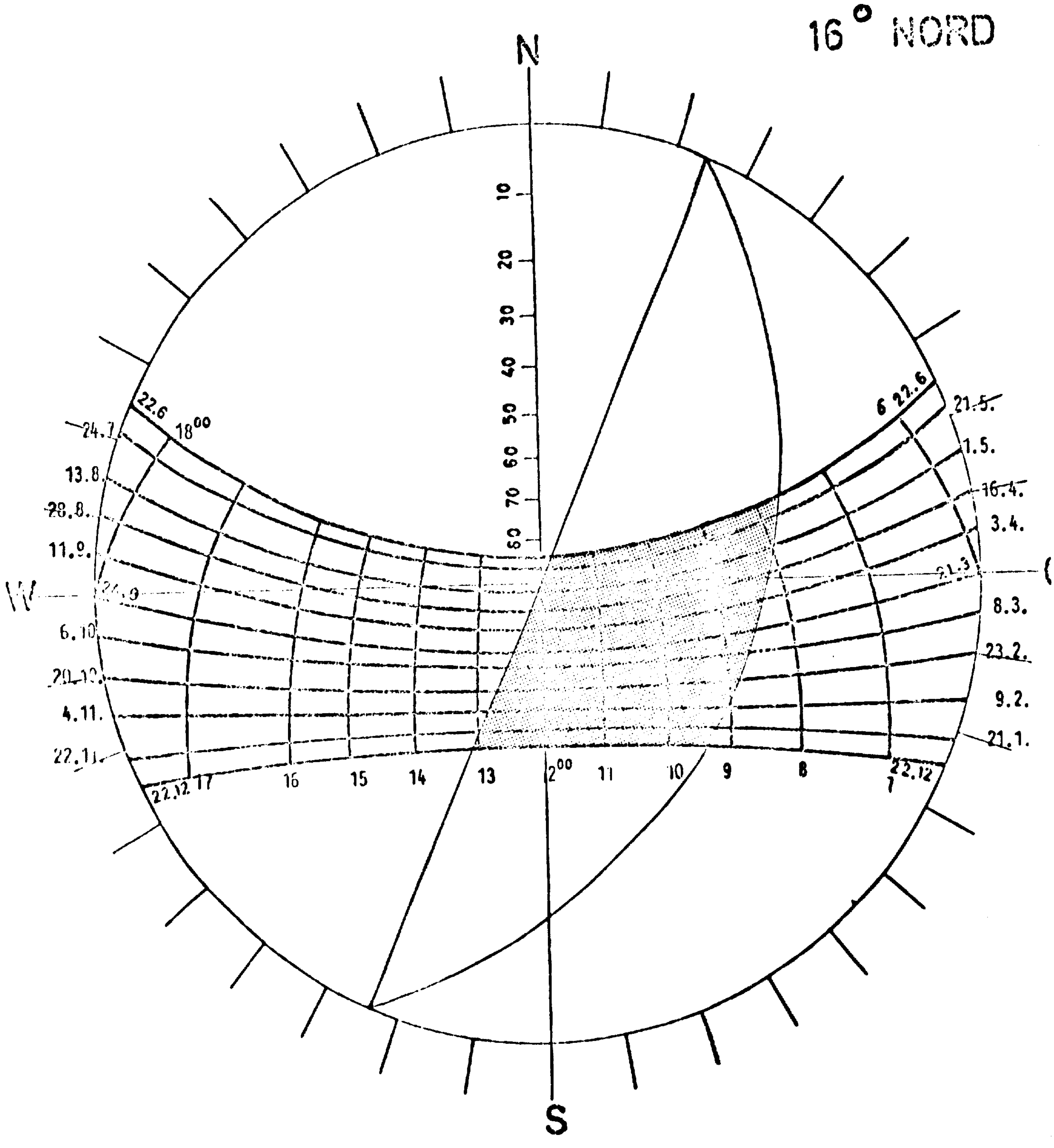


FIGURE XXIII

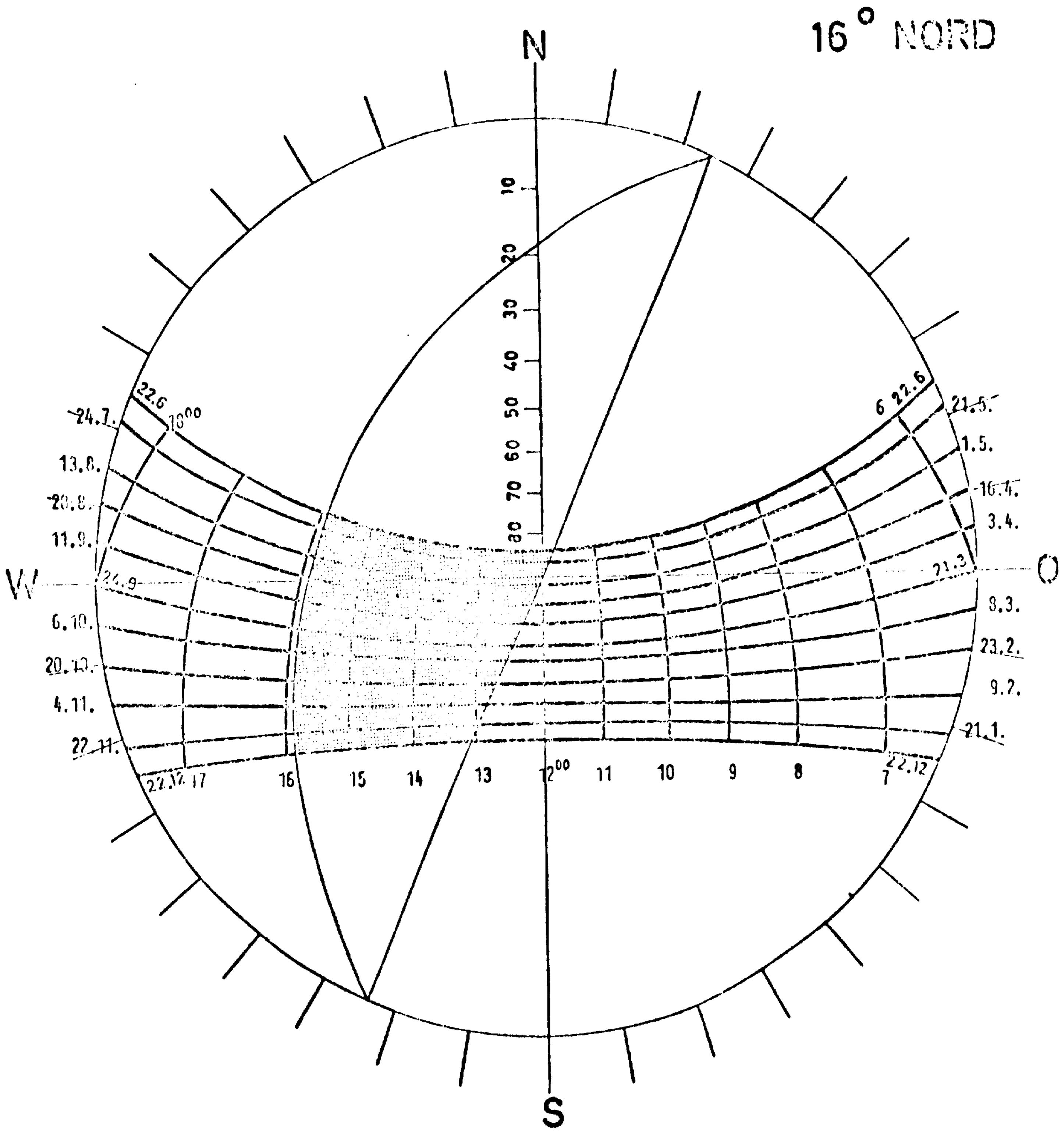
SHADED TIME FOR THE EAST FACADE
WINDOWS ONLY



shaded line

FIGURE XXIV

SHADED TIME FOR THE WEST FACADE
WINDOWS ONLY



shaded time

74. 10. 11