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LABORATORY FURNITURE AND FITTINGS 1/

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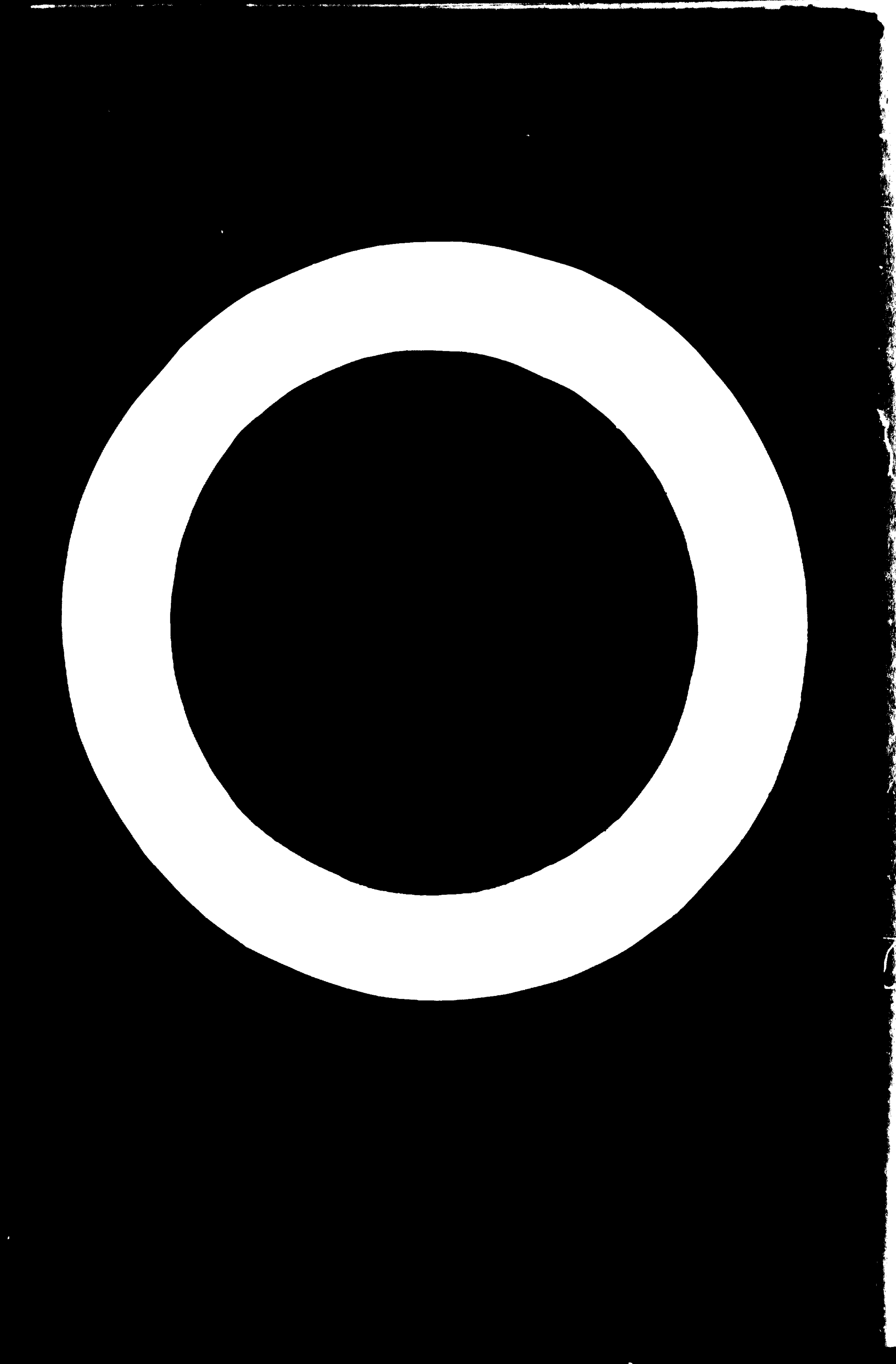


LABORATORY FURNITURE AND FITTINGS

1. GENERAL REMARKS ON DESIGN AND CONSTRUCTION OF LABORATORY FURNITURE

Numerous publications on laboratory furniture exist in all industrialized countries.
The main criteria are laid down in standards and other specifications. In this context, the British Standard 3202'Laboratory Furniture and Fittings' (1) may be mentioned together with some publications of the United States Department of Health, Education and Welfare (2). At the present time, Germany has nine DIN standards and the directives for laboratory work published by the Berufsgenossenschaft for the Chemical Industry and the Berufsgenossenschaft for Public Health which have influenced the construction of laboratory furniture (8, 9). Furthermore, several general guidelines must be taken into consideration; e.g. some specifications relating to ventilation systems, gas and water supplies, lighting, fire protection, electrical installation, accident prevention etc (see reference list).
Laboratory furniture for chemical and similar work consists of a few repetitive units varying in shape and style but uniform in their arrangement and their basic design, such as

island benches	(fig. I)
wall benches	(fig. I)
fume cupboards	(fig. I)
cupboards	(fig. II)
sink units	(fig. III)

Depending on the field of work, there are some additional units: e.g. balance desks (fig. IV), titration desks, microscope desks (fig. V), etc.

One can distinguish between two types of laboratory furniture and fume cupboards: The supporting elements for the bench tops may be

a) steel or wooden framework in which the underbench components can be mounted (fig. I, XII)

or

b) fixed carcass units of different types (fig. VI).

It is recommendable to utilize only type a), and to provide a foot space of 20 cm height for comfortable standing and cleaning. All these units, in particular the benches with lengths of 3 m and more, and the fume cupboards with 1,2, 1,5 and 1,8 m front lengths and 2,8 m height are space-consuming items which must be shipped dismantled, then reassembled on site and joined to the piping system of the building by skilled craftsman.

Fig. 7 Island and wall benches, with service shelves, ceramic sink unit, steel framework for carrying the bench tops and the carcases made of plastic-laminated timbers. Standard and low-bench fume cupboards.

Table 1

B e n c h d i m e n s i o n s in mm

	DIN 12 922	BS 3202	American				British		French	German	
			Manufacturers								
			Fisher	N I I	Hamilton metal	Hamilton wood	Gallen-kamp	Grundy	Catlin	Kötter-mann	Waldner
height (standing)	900	910	914	940	940	915	914	900	900	900	915
(sitting)	750	760	760	710[1] 735[2] 790[3]	760	760	760	750	760	775[4]	745 765
clear depth	600	610	610	610	610	610					600
overall depth (service space included)	750 1500		785 1395	760 1370	760 1370	760 1370	760	750 1500	750 1500	750 1500	750 1500
length of units (see figure 12)	600 900 1200		465 620 890 1195	465 610 900 1195	465 610 900 1195	465 610 900 1195		500[5] 1000[5]	600[5] 1150[5]	600[5] 900[5] 1200[5]	600 900 1200

1) microscope desk
2) chemist's desks
3) titration and balance desks
4) former German Standard height = 780
5) bench top projecting not included see figure 12

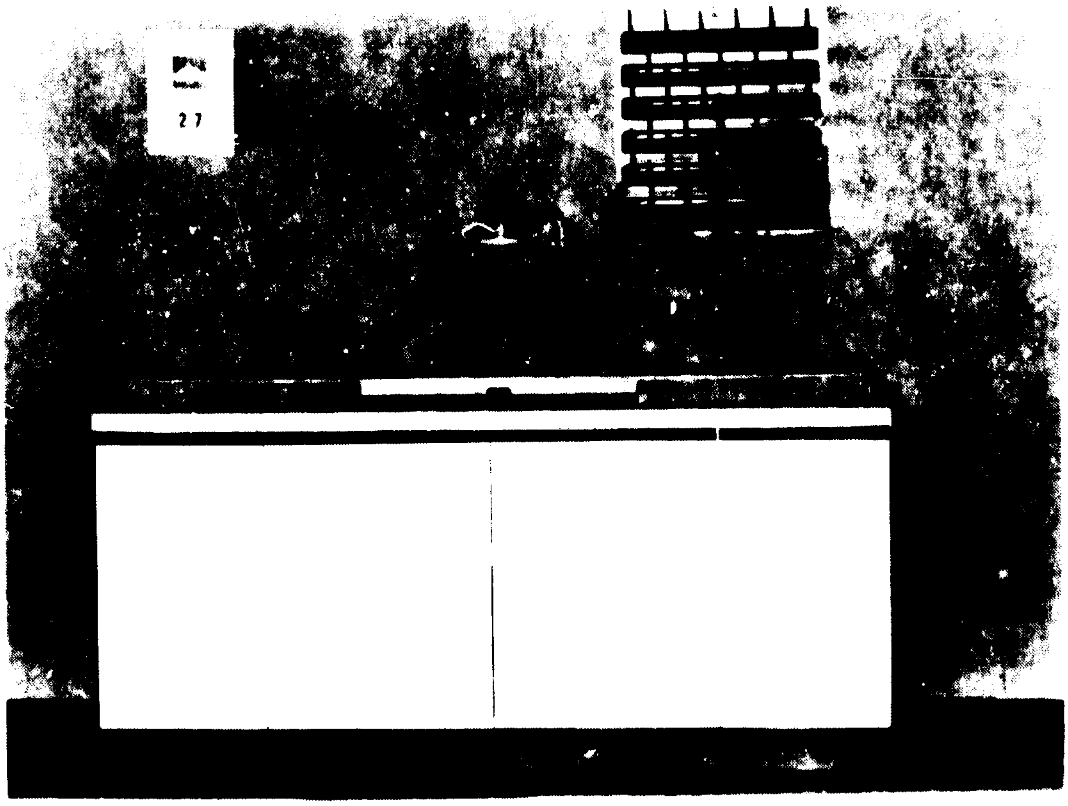


Fig. II Laboratory cupboards

Fig. III Laboratory sink unit
with draining boards

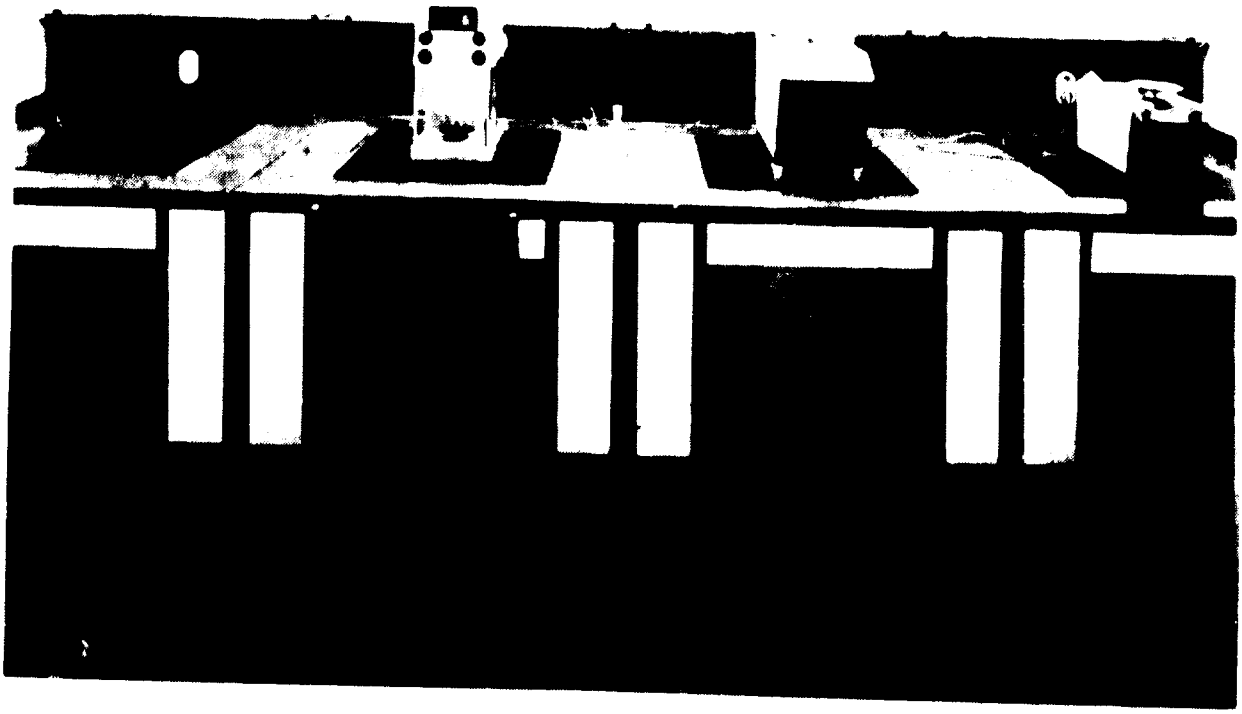


Fig. IV Balance desks with built-in anti-vibration mountings

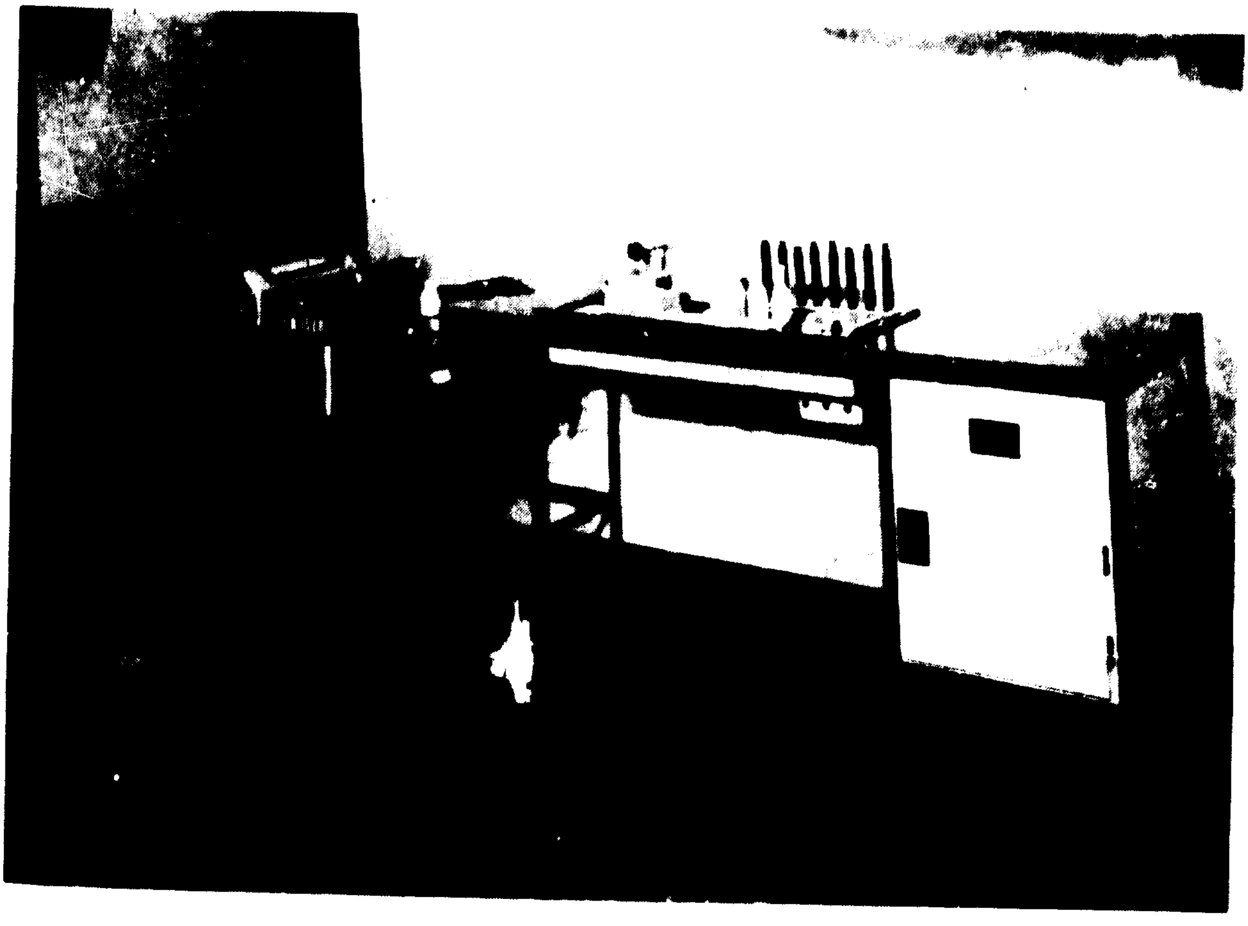
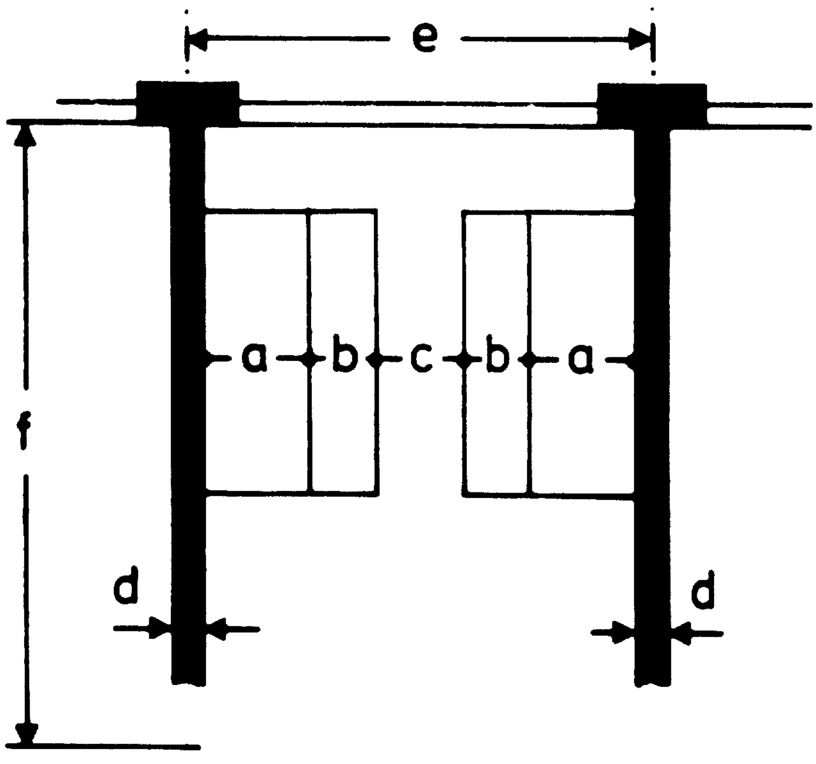


Fig. V Desk for sitting work

Fig.VI Island and wall benches, with service cell on the back, bench tops of large size acid-proof stoneware tiles mounted on fixed carcass units

Table 2

Width of working areas and space dimensioning



a) width of bench tops — 0,6m and 0,75m

b) width of operating area — 0,45m

c) width of passage way — 0,55m

d) thickness of partition — depending from its structure

e) optimal distances

f) for laboratories

for offices

	3m	3,3m	3,6m
f) for laboratories	6-7,0 m	6,6 - 8 m	7,2-9,0 m
for offices	3-4,5 m	3,3 - 5 m	3,6-5,5 m

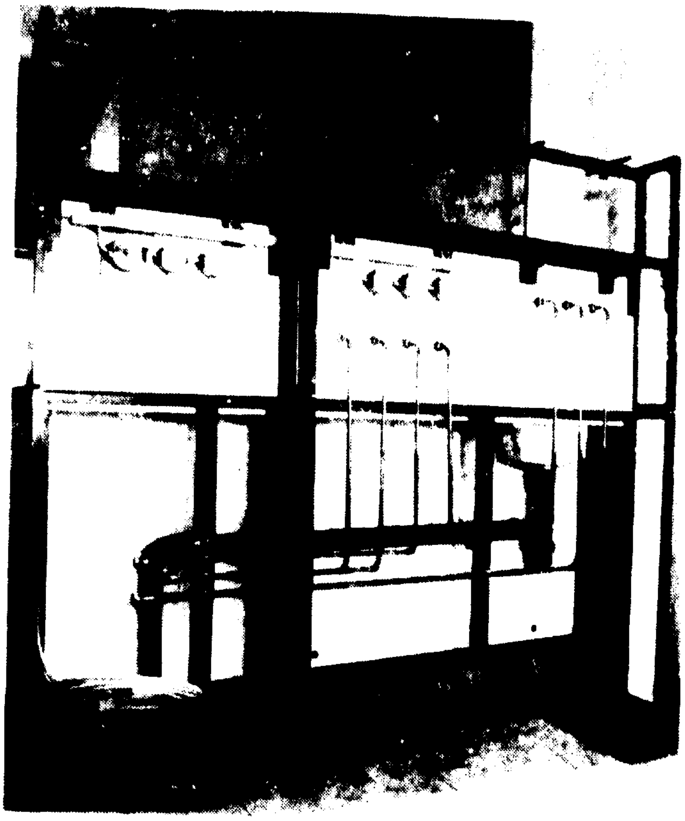


Fig. VII Prefabricated piping system made from copper tubing and plastic pipes

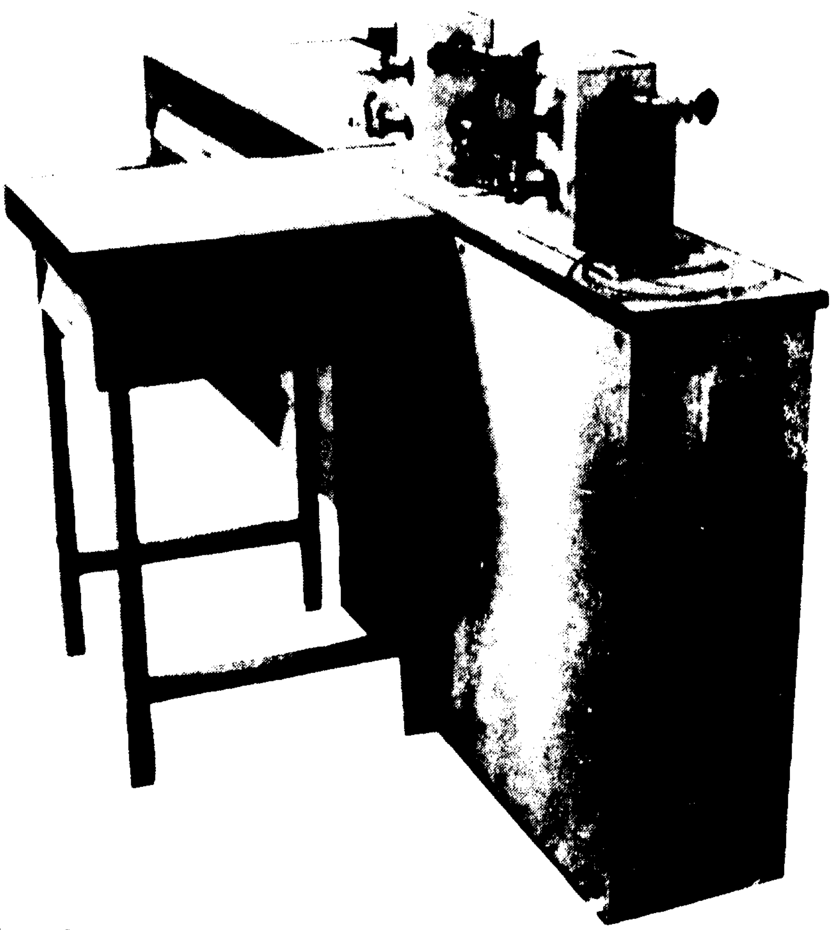


Fig. VIII Island plumbing cell with gas, water, compressed air taps, electrical sockets and cup sinks

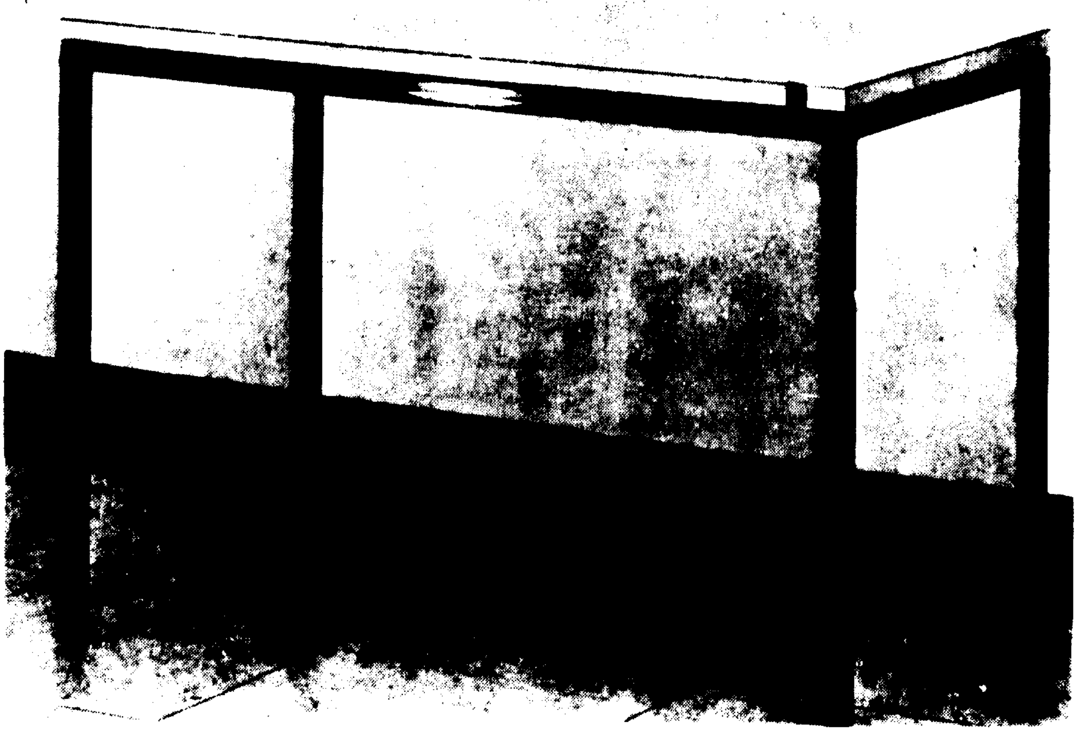


Fig. IX Instrumentation desk

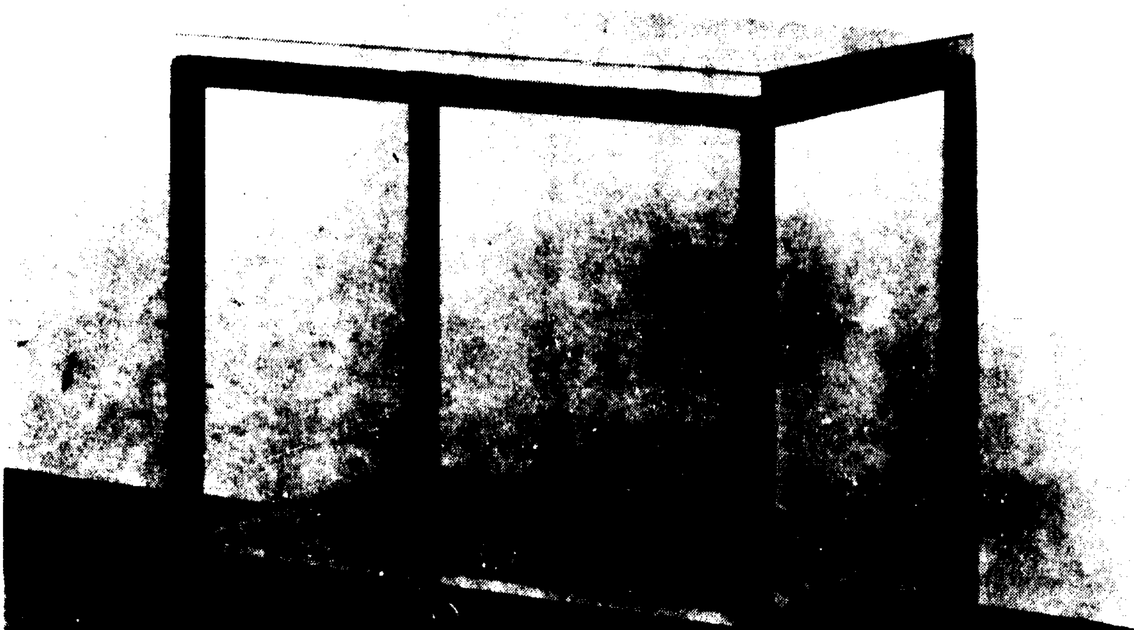


Fig. X Instrumentation desk on casters

At the earliest stage of planning, one should take into account that the design of the furniture and its essential dimensions of length, height and depth will largely govern space planning and the whole design of the building, plumbing and ventilation system, the choice of materials for floor and wall covering, etc.
During the past twenty years, additional laboratory furnishings such as

the plumbing cell (fig. VII, VIII and XI) and

the movable desk units (fig. IX and X)

which are better adapted to the actually predominant physico-chemical methods of analysis have been developed.
They can replace, if practical, the conventional complete bench designed as fitted furniture. The prefabricated plumbing cell mounted in the axis or on the wall of the laboratory includes all pipes and outlets for the various services and must be connected to the service piping system of the building. The easily dismountable, or, in some cases, independent and movable desks are placed adjacent to the plumbing cells. These instrumentation desks with different top coverings may be used as bases to carry special electrical equipment assemblies to be joined to the plumbing cell. Such flexible laboratory furniture will be preferred if the purpose of the laboratories could not be specified in detail at the planning stage.

In the industrialized countries, companies were founded for the manufacturing, supply and assembling of laboratory furniture. They also supply the plans, indicating location and sizes of the piping, exhaust and electrical terminals in the building. The increasing demands and the modulation and elementation of laboratory furniture has stimulated production in series, e.g. in the United States, in Germany, France and the United Kingdom, where a wide variety of carcasses made of timber, plastic-laminated wood and epoxy-resin coated steel is being produced (fig. XII).

For the equipment of industrial research centres in developing countries, one can not always start from the possibility of importing complete laboratory furnishings. The overseas transport would cause additional costs for e.g. dues, packing, delegation of specialists etc. Moreover, complete supply will not be necessary in all cases. - The production of complete laboratory furniture as an independent business branch has only been developed recently in the industrialized countries. In spite of this, the industrialized countries still utilize not only prefabricated furniture for the equipment of laboratories: laboratory benches are also mounted on site by the co-ordinated work of carpenters, tile-layers, plumbers and other craftsmen, their work being understood as secondary building work. In this case, fitters or carpenters build the supporting framework, on top of which tiles are embedded in acid proof putty on a concrete basis. The plumbers execute the necessary piping work. A furniture manufacturer subsequently supplies the carcasses to be fitted into the framework of the benches (fig. XIII and XIV). This method has proved

Fig. XI Island plumbing cells for laboratory servicing, housing additionally the vertical main lines, electrical distribution boards, waste and exhaust ducts for use with movable instrumentation desks

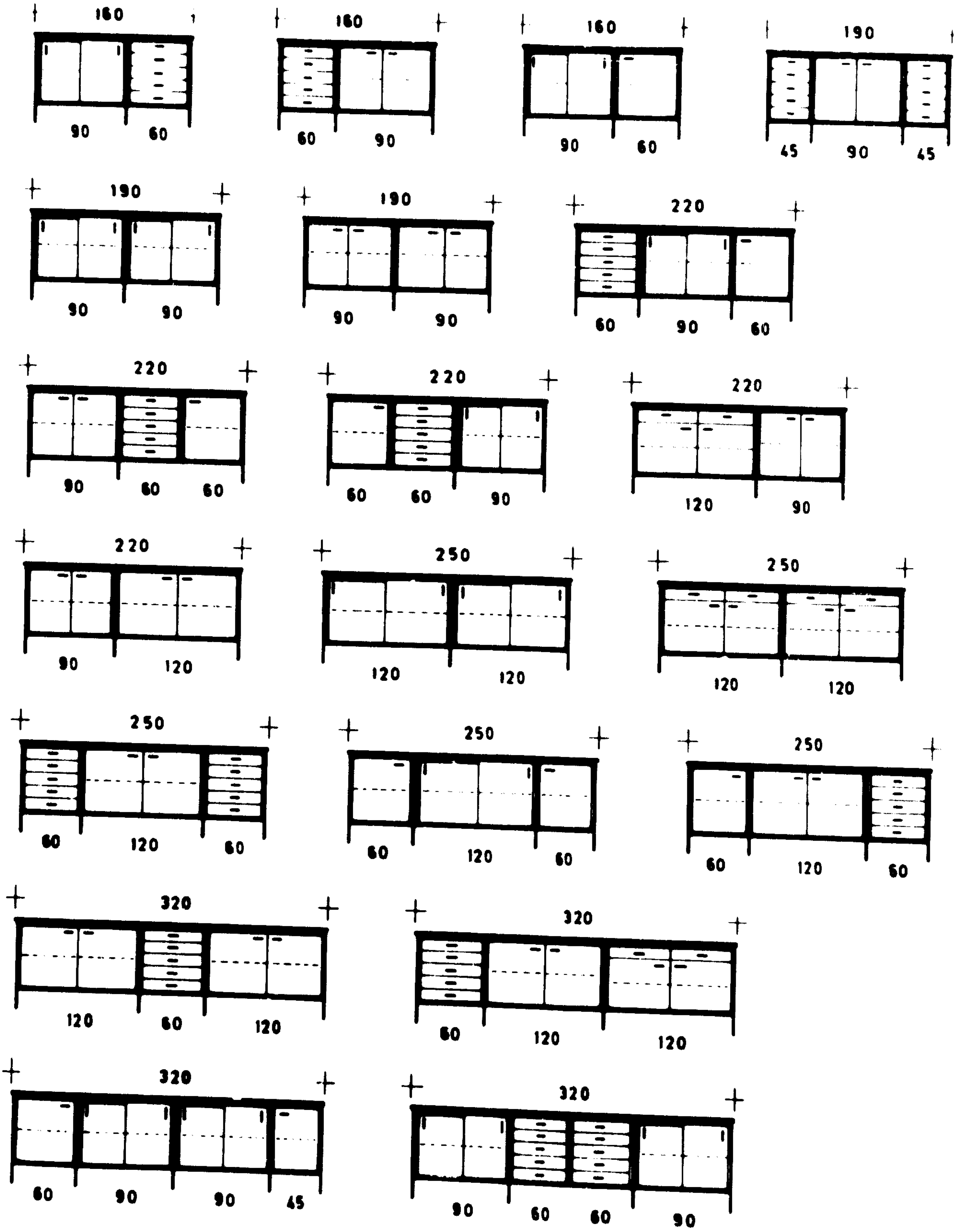


Fig.XII Bench assemblies of various modular carcasses satisfactory for many years and could also be applied to laboratory furniture of industrial research centres in developing countries if a skilled local industry exists. In this case, the contractor charged with construction and equipment of the building may also order and co-ordinate the subcontractor work for the laboratory furniture. The building contractor would have the necessary contacts to the specialized trademen. He could prepare the tender for supply and assembly and supervise the progress of work on site.

2. THE ESSENTIAL DIMENSIONS OF LABORATORY FURNITURE (Table 1)

2.1. Depth of working surface

The optimum working depth of benches for standing work was found to be 60 cm clear depth of the working surface plus 15 cm as space for the accomodation of above-bench fitments, such as gas stands, electrical sockets, shelves etc. The total depth of 75 cm is specified in DIN 12 922 'Laboratory benches; elements, essential dimensions'. The catalogues of important manufacturers for laboratory furniture in Germany, France, the UK and the United States as well as the British Standard 3202 also show an overall depth of $\approx$ 75 cm, corresponding to the sizes of most of the laboratory apparatus.
Table 2 shows the influence of the dimensions given in table 1 upon space planning.

2.2. Height of working surface above floor

The observation of the heights mentioned in table 1 has always caused some problems because of the various types of bench tops. Their thickness results from the different thickness of the coverings and their supporting bases: 6 cm for ceramic tiles, 4 cm for Pyroceram, 3,7 cm for acid-proof stoneware, 2,8 cm for plastics, etc. It is however inconvenient for the user if there are height differences between adjacent bench units.
Project and tender should therefore expressly prescribe that desks and benches with different coverings must have uniform heights, e.g. by underlining the bench tops.

2.3. Lengths of benches

Table 1 shows some modular lengths which have found general acceptance. The basic length of 1,2 m is frequently applied, but the series of lengths 60 - 90 - 120 cm and its multiples has been derived from this basic length in the practice of manufacturing laboratory furniture. This modulus of length in 30 cm steps (M 300) allows satisfying adaptation to local conditions and the utilization of elemented units (fig. XII).

Fig. XIII Laboratory bench assembling on site

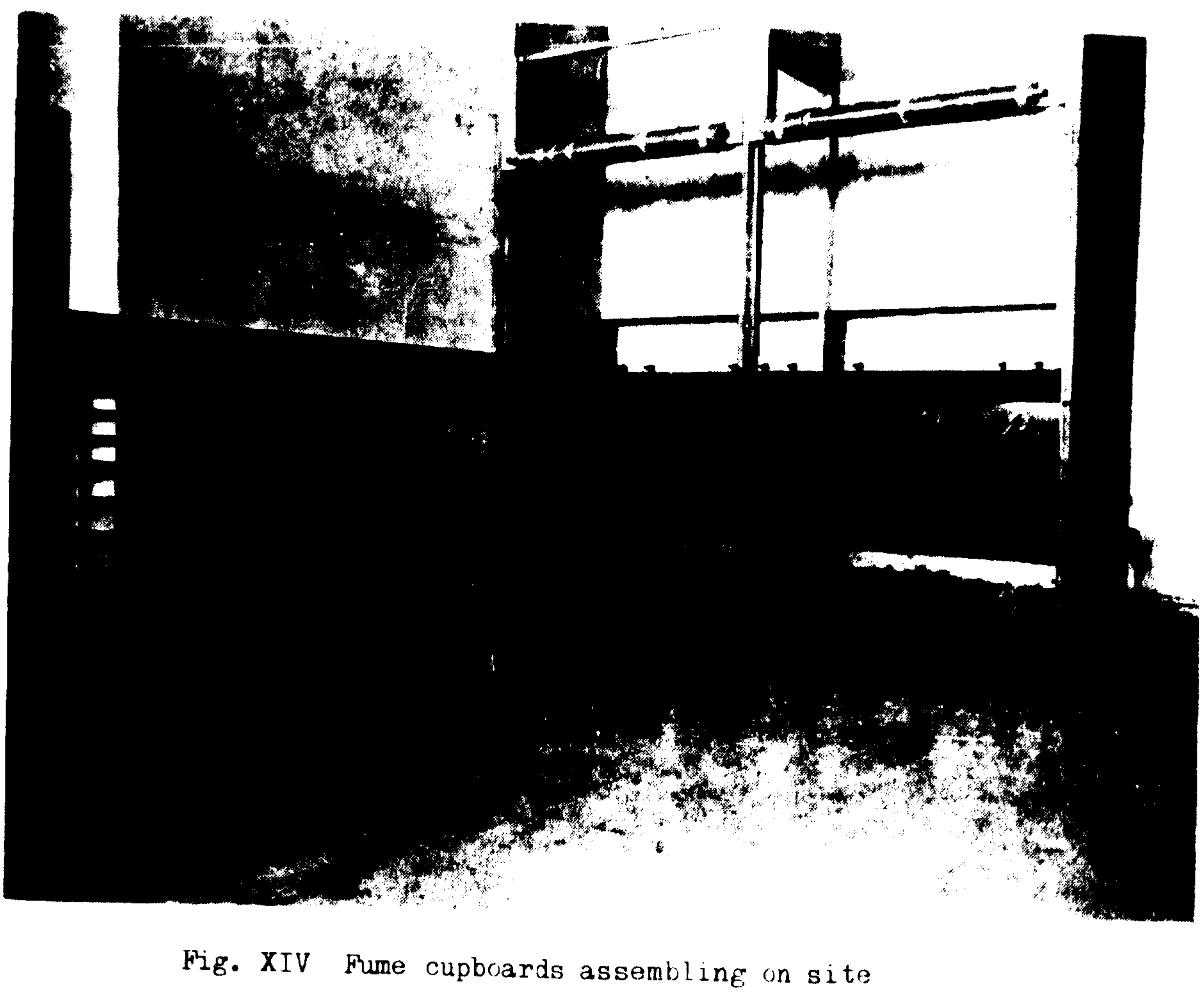


Fig. XIV Fume cupboards assembling on site

Fig. XV High pressure gas cylinder in exhaust cabinet

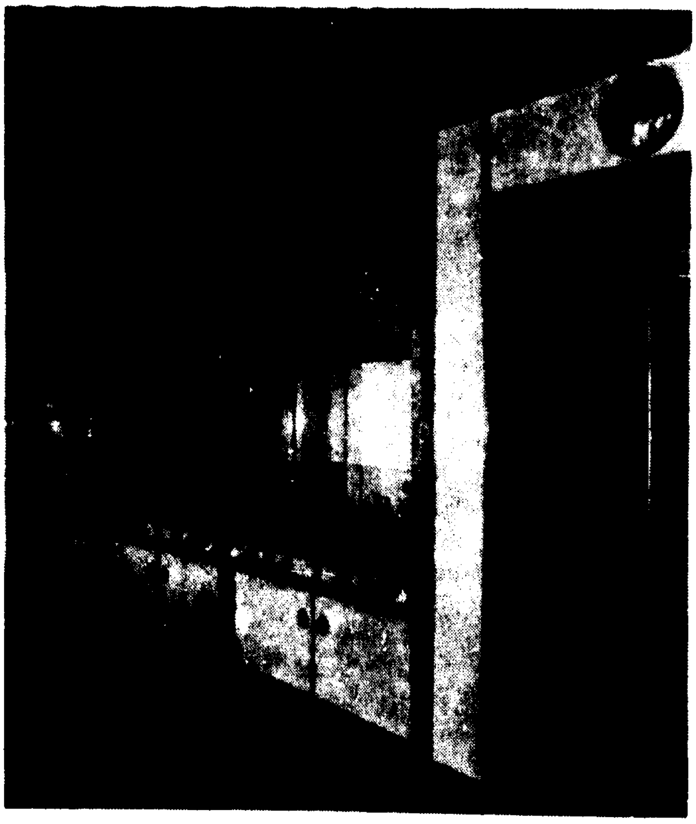


Fig. XVI Service terminals provided for the connection to the piping system of a bench

3. MATERIALS

The materials used for the construction of laboratory benches and fume cupboard are required to posess a variety of properties. This applies, in particular, to the bench top coverings; the various possibilities are scheduled in BS 3202 (1). In Germany and France, ceramic tiles, stainless steel, Pyroceram (a thermal shock resistant flat glass), large size stoneware plates as standardized in DIN 12 916 (5.07) and plastic-laminated wooden panels are used. Timber boards, natural stone, inlaid teak or similar hard timber, concrete covered with ceramic tiles are probably available in all countries. In any case, bench tops made of stainless steel, Pyroceram or large-size acid-proof stoneware (fig. I and VI) must be imported. The time for delivery, transport, clearance, damages etc can considerably delay the completion of the laboratory equipment work. Locally-available timbers should be used and manufactured as usual in the country for cupboards, under-bench units and carcasses.

The surface finish of wooden parts should meet the requirements of laboratory furniture. Chlorinated rubber paint coatings have yield satisfactory results. Steel carcasses spray-coated with powdered expoy-resin in an electrostatic field and subsequently stoved have proved to be resistant for many years. They are highly corrosion resistant, but must be imported if provided for research laboratories in developing countries.

4. SERVICE PIPING FOR LABORATORY BENCHES AND FUME CUPBOARDS

The planning of the plumbing system of a research centre with laboratories is governed by the outlets of the water, gas, compressed air, steam and electric lines on the laboratory benches and in the cupboards. The services and number of taps, cocks and valves to be provided for should therefore be specified at an early stage.

4.1. Laboratory bench fittings

The three types of bench fittings, i.e. stands, wall-fixing and front controlled patterns, are made of brass. In well air-conditioned rooms, chrome-plated surfaces are usually sufficiently resistant. Acid-proof coatings are however generally preferred in German laboratories for wet chemistry work.
Colour-coded lever handles and handwheels of cocks and valves could facilitate the identification of the fluids supplied. A suitable colour code is specified (5.08) in DIN 12 920.
BS 3202 recommends an alphabetical identification system. Changing positions of the letters depending on the position of the handle sometimes makes readings difficult and, besides, such letter symbols are not universally comprehensible.
Experience has frequently shown that more service piping have been installed than are really necessary for the activities of the laboratories.

Table 3 Recommended number of outlets, sinks and sockets

Services	for bench tops of 0,6/0,75 m width length: 3	3,6	4,2	4,5 m
Gas taps	2	2	3	3
Water taps	2	2	4	4
above cup sinks	1	1	2	2
compressed air valves	1	1	1	2
fused electrical circuits	2	2	2	3
with two-phased sockets	4	4	4 (6)*	6 (8)*
three-phased sockets	1	1	1	2
	for bench tops of ≈1,5 m width			
Gas taps	4	4	6	6
Water taps	4	4	8	8
above cup sinks	2	2	4	4
Water taps	3	3	6	6
hot water taps	1	1	2	2
above sinks with overflow	1	1	2	2
compressed air valves	2	2	2	4
fused electrical circuits	4	4	4	4
with two-phased sockets	8	8	8 (12)*	12
three-phased sockets	2	2	2 (4)*	4
	for fume hoods length 1,2	**1,5**	**1,8 m**	
Gas taps (front controlled)	2	2	3	
Water taps (front controlled)	2	3	4	
cup sinks	1	2	2	
compressed air valves (front controlled)	1	1	1	
fused electrical air valves	1	1	2	
with two-phased electrical sockets	2	3	4	
three-phased electrical sockets	1	1	1	

*) for physical or physico-chemical laboratories

4.1.1. Compressed air supply

Measurements carried out in some laboratory buildings of BAYER and SCHERING have proved that e.g. the compressed air service utilization rate was not even 6%. If compressed air must be provided on the benches, 3/8" valves will be sufficient for a gauge pressure of 1 bar and for a maximum supply of 0,15 standard m^3/min. (3).

4.1.2. Vacuum service

for suction of 0,15 m^3/min at a pressure below 400 Torr at each point could also be an expensive and uneconomical installation. Water-operated ejector pumps and even motor-operated small rotary pumps are more practical and more efficient, because they deliver a vacuum below 20 Torr and their pressure does not depend on the varying load of a piping system.

4.1.3. Steam supply

The necessity of supplying steam to benches and cupboards seems to be particularly doubtful.
Steam as a heat source could certainly be helpful in the evaporation of inflammable liquids, temperature-controlled electrical appliances, even explosion proof, are however on the market and are much more practical in use. Steam-heated laboratory apparatus is now rarely manufactured.

4.1.4. High pressure gas supply

Furthermore, the necessity of a general supply of high pressure gases, such as nitrogen, oxigen, hydrogen, helium, carbonic acid etc to the benches should be carefully examined at the stage of planning. The alternatives are

a) service piping running through the whole building from a central space for storage of the high pressure gas containers to needle valve panels on the reagent shelves of the benches
b) short tap pipes running from exhausted decentralized storage boxes for high pressure gas bottles on the floors to needle valve panels on a limited number of benches e.g. in chromatography laboratories (fig. XV)
c) clamps on laboratory benches and cupboards for fastening high pressure gas cylinders fitted with reducing valves; this is doubtless the most economical solution! (18)

However, one must take into consideration that alternative c) will increase fire load and explosion hazards in case of fire. German guidelines for accident prevention therefore prescribe the removal of high pressure gas bottles from the laboratory (8,11) during the night.

4.1.5. Water services

In industrial research plant, separate services for potable (town) water and industrial water should be provided for the laboratory work areas. The handwheels of valves for potable and non-potable water supply must be clearly distinguishable, e.g. by colour coding or by conspicuous and durable labels.
The supply of non-potable water to the benches can considerably diminish the consumption (water jet pumps 180 - 550 l/h) of potable water.
Moreover, the drinking water piping system must be protected against backflow (1, 2, 3, 4, 6.01) which could occur by hose connection of laboratory apparatus to water taps.
N I H therefore mentions (2) the use of an industrial water system to serve all laboratory work areas as an approved method. Such a distribution system must be independent of the potable domestic system. In this case, only the few water taps for potable water must be marked or labelled.
Hot water servicing does not seam to be indispensable everywhere. Local electric water heaters above the labcratory sink units could be more practical and more economical than hot water taps on benches which are fed from a central system.

4.1.6. Distilled and demineralized water

Plastic taps for distilled or demineralized water should not be provided for all benches (1, 2). Generally, it is sufficient to provide one tap fed by a central plant in each of a certain type of laboratories or in the storey, and this only if the activity of the institute, necessitates a permanent supply of distilled or demineralized water. In all other cases, it will be satisfactory to use distilled water form bottles stored on the reagent shelf of the bench.

4.1.7 Gas service

The number of gas taps on the benches and in the fume cupboards cannot be taken as a basis for the evaluation of the gas consumption. A gas tap 3/8" delivers 1200 l/h at the usual pressure of 90 mm w.c. A Bunsen burner consumes about 100 l/h (1,2,3, 6.02, 6.03).
The diversity factor of 0,4 or 0,5 mentioned in BS 3202 should only be based on 100 l/h gas consumption and not on the maximum possible supply of the tap. Gas stands or other types of gas fittings are installed on all benches and cupboards, although the utilization of gas-heated laboratory apparatus is steadily decreasing in favour of electrically-driven appliances.
Instead of the common town gas (90 mm w.c.), natural gas (200 mm w.c.) is now being used in many service systems of laboratories. The higher pressure requires adequately designed burners and bench fittings with greaseless stuffing box valves. For saftey reason, out-door location is required if high pressure gas bottles for propane/butane supply are utilized.

4.2. Pipeline terminals

The terminals of the piping system to which the installation of benches, cupboards and prefabricated plumbing cells are to be connected (fig XVI) should not exceed the following sizes:

water	1"
gas (town)	3/4"
gas (propane/butane)	1/2"
compressed air	1/2"
vacuum	1/2"
waste	50 mm NB

Copper tubing and welded or soldered connections are used for prefabricated piping in benches and plumbing cells. Gas, vacuum and compressed air bench piping mounted on site are usually made from black steel with malleable iron banded fittings, and water piping from galvanized steel tubing and galvanized iron fittings. The supplyline terminals should have shut-off valves.

4.3. Sinks and drainage

Cup sinks and sinks with overflow are made of acid-proof stoneware, fire clay, stainless steel and plastics. In Germany, their dimensions are standardized (5.05 and 5.06) in DIN 12 914 and DIN 12 915. The glazed ceramic sinks of brown, white and grey colour and the ceramic S-traps for laboratory use are highly corrosion-resistant and therefore preferred for laboratory furniture.

In comparison with ceramic sinks, stainless steel sinks are less resistant e.g. against air containing small amounts of halogen, particularly chlorine, which frequently occur in chemical laboratories. For the waste lines, iron pipes with spigot and socket connections made from fine grain spun cast iron can be used (1), or PVC and PE waste lines with welded connections, which experience has shown to be sufficiently corrosion-resistant and shockproof.
Bench waste lines made from acid-proof stoneware and - particularly in the United States - of glass are of highly corrosion resistance but have low impact strength.
For research centres in developing countries, the use of cast iron pipes which are available anywhere, should be recommended for the main ducts as well as for the piping in benches mounted on site.

5. CONSUMPTION OF FLUIDS

Croissant (3 p.49) carried out continuous measurements of steam, water, gas and compressed air consumption (table 4) - at 5 minutes smallest interval of recording - in 12 laboratories of an industrial research centre(two analytical, three research, two application engineering, three routine, one agriculture and one teaching).He recorded the consumption peaks and the mean values for 24 h, covering also the maximum values when multiplied by 1,5. He came to the conclusion that exact values guaranteeing a

Table 4 Consumption per m bench length

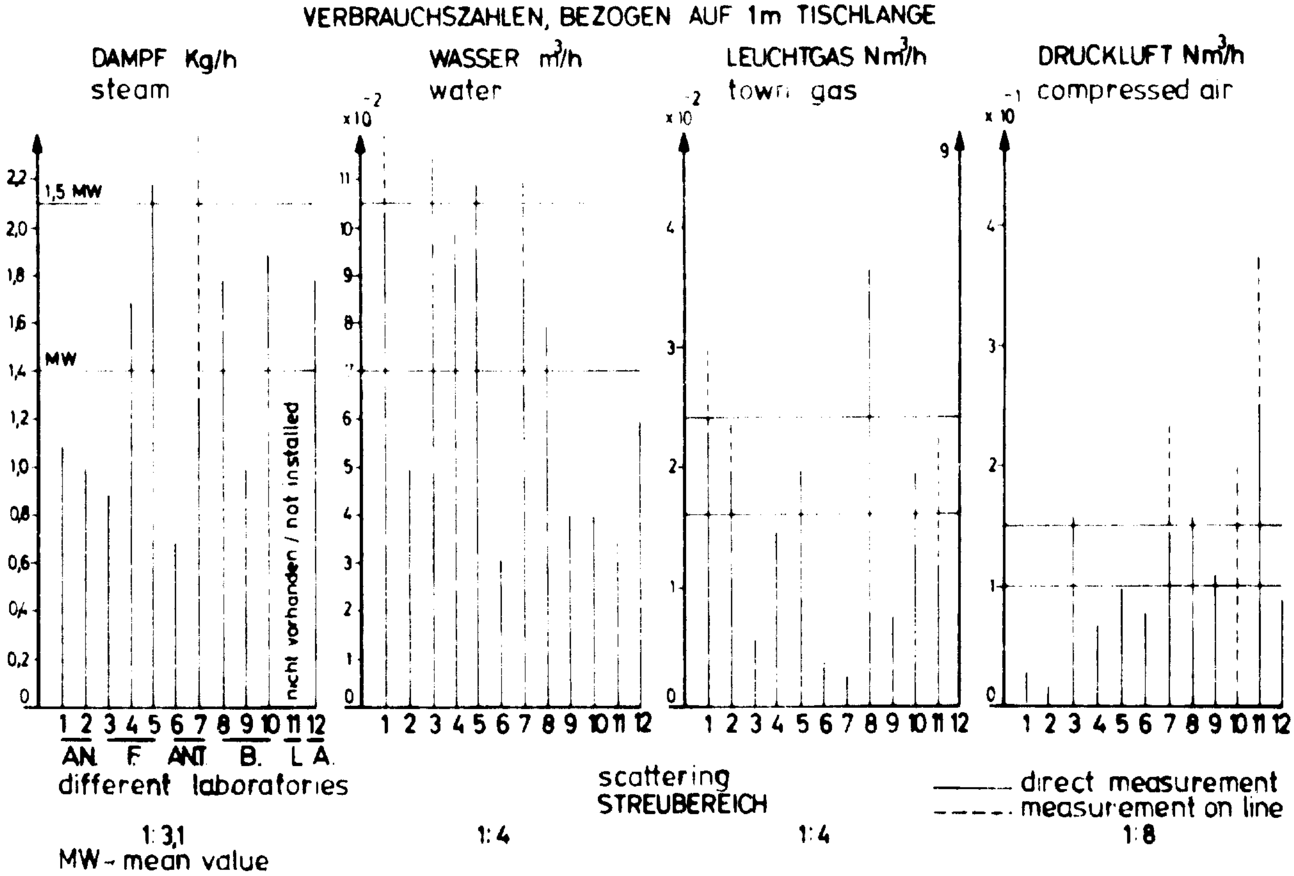
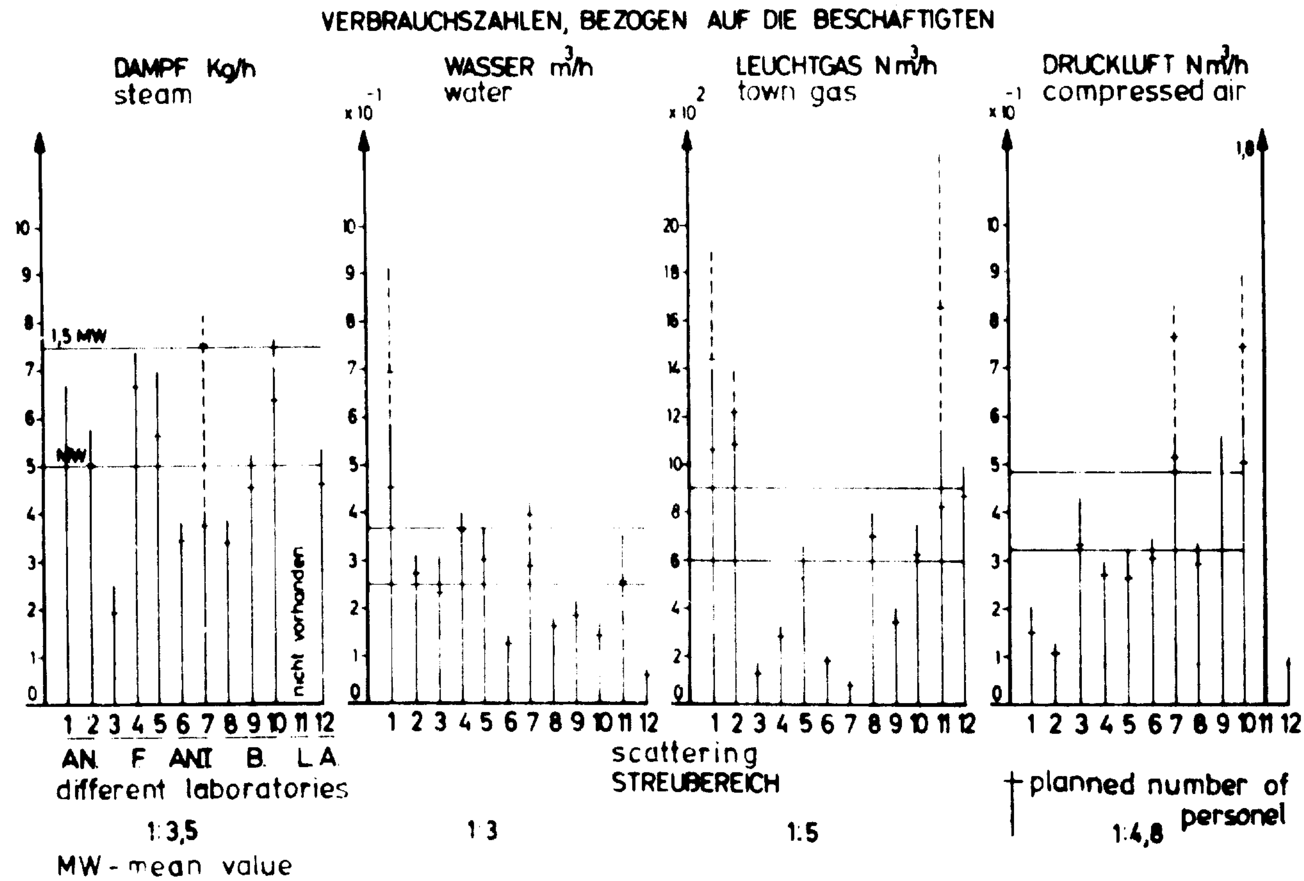


Table 5 Consumption referred to the number of personal



solid basis for planning in all types of institutes could not be stated, but that the results of the measurements gave a realistic impression of the order of magnitude to be expected for most of the cases.
The measurements yielded the results shown in table 4.

Consumption				
per m bench length		scatter range	per worker	scatter range
Steam	0,07-2,2 kg/h	1:3,1	1,9 -6,6 kg/h	1:3,5
Water	0,03-0,12 m^3/h	1:4	0,12-0,36 m^3/h	1:3
Town gas	0,01-0,04 m^3/h *	1:4	0,02-0,11 m^3/h*	1:5,5
Compressed air	0,02-0,1 m^3/h *	1:4	0,11-0,52 m^3/h*	1:4,8

* standard m^3

6. CONCLUSIONS

When planning an industrial research centre, the laboratory furniture should be considered as an integral part of the building and its details should be specified in the project.

In the past, experience showed that planning, tender and supply of laboratory furniture and its assembly on the site started after completion of the building would cause considerableadditional costs and much loss of time. If however, assembling of laboratory furniture could be coordinated with the advance of constructional work, the necessary labour would be available at all stages to carry out additional work caused by the erection of benches and fume cupboards and their connection to the main lines.

If it is decided at an early stage of planning that the engineers of the contractor are unable to design the laboratory furniture and that local subcontractors cannot execute such work, an experienced manufacturer for laboratory furniture should be engaged to submit information on the supply and assembly on site of prefabricated laboratory furniture.
Because of the difficulties of overseas supply, there are only a few specialized companies interested in such business. The majority of manufacturers do not have the necessary experience.

ANNEX - Reference list

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