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05864

Distr.
LIMITED
ID/WG.181/5/Add.1
23 September 1974
ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting on Building and Facilities, Design and Lay-out for Industrial Research and Development Centres

Innsbruck, Austria, 23 - 27 September 1974

/research centre/

LABORATORY FURNITURE AND FITTINGS

Addendum

Equipping of Laboratories 1/

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id.74-6523

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1. INTRODUCTION

1.1 Historical Development:

The building of laboratories developed parallel to the boom of the chemical industry in the 20th century. Any of the laboratories built around the beginning of this century could still be compared with the alchemists' kitchens of medieval ages. But soon it was realized that works in a laboratory should they be purposeful and successful were asking for facilities meeting all technical and hygenic requests. In the early thirties already quite a progress could be seen. The rooms became higher and lighter, the working spaces were installed more to purpose.

Now it was tried to bring more system into the development of the design of laboratories. Due to the variety of fields of work most of the laboratories up to now were sort of measured according to request. In Europe in the early nineteenfifties the development of flexible furnishing was undertaken. This became necessary to meet the erratic progress of sciences. The further and consequent development led into the unit and modular system of today.

In the future a further standardization will help the laboratory to meet as much requests and trends as possible.

1.2 The discussion of the theme laboratory is difficile because it is impossible to find one denominator for all kinds of laboratories. With the themes in question it makes it a gigantic task to meet requests which vary highly, often diverge and partly exclude each other. This goes for the design as well as the supply of the different media.

These requests ... in rise from the diversificated working conditions and activities necessary for the working in different fields.

For some tasks it is sufficient to provide laboratories with normal dimensions and simple furniture. More tasks make it necessary for the rooms and buildings to meet special requirements as there are:

- constant temperature and clima
- free of vibrations
- free of disturbing magnetic fields
- special media outlets

There can be:

- small rooms
- large laboratories and laboratory halls
- special experimental facilities
- open air facilities

Eventually the question of design and construction of buildings may be thrust into the back ground when functional and technological problems prevail.

From the above-mentioned it can be drawn that there are no principals the variety of tasks has in common, neither in the field of construction nor functionally or technologically.

The formally used distinction between research analysis and theory does not suffice any more. The variety of tasks and by those the laboratories asks for further articulation, as there are

- research
- development
- technique of application
- production
- control
- theory with practical courses.

The further articulation into

- chemistry
- biology
- medicine
- physics, etc.

is much too rough to suffice. In chemistry for example the following disciplines could be sorted out:

- inorganic chemistry
- organic chemistry
- analytical chemistry
- bio chemistry
- physical chemistry
- colloid chemistry
- plastics
- pharmacy
- food chemistry
- chemical technology
- radio chemistry.

On the other hand medicine could be divided into:

- anatomy
- physiology
- physological chemistry
- phathalogy
- hystology
- hygenie
- medical micro biology
- pharmacology
- radiation research.

This summary is not complete. Further articulations can be imagined and new disciples may be added in the near future.

All this points at the enormous problems to be solved on the way to further standardization. It follows that all the efforts to standardize laboratory buildings and furniture can only be successful when they are limited to equal or similar fields and mainly concentrate on standard laboratories.

2. DESIGN

In consequence of the complexity of the task it will be understood that we can only pick out one single field as an example, namely the chemical research laboratory. Of course the worked-out principles are valid in other fields as well when adapted to the given facts.

2.1 Design Basis:

The most specific articulation of his aims by the client is the first basis. The independency of building and installation suggests the utmost co-operation of experts from the beginning (architect and engineers). To enable the experts involved to overlook and consider the bundle of problems the planning phase must be sufficiently long. Otherwise mistakes and errors show up at the latest when work goes into operation. Seldom they can be extinguished without remaining disadvantages and high costs.

2.2 Flexibility:

The versatility of research tasks dictates the flexibility required from laboratory design. The first step is to make units of equal size exchangeable.

Depending on the tendency in the field from the opinion of the beneficiary the flexibility is to be carried further. Are persons or groups of persons following a certain program changing their place of activity while using their special equipment units oncasters may do the job as well as removable work benches, fume walls or even partitions. As much it should be possible to supplement different media or change them.
A rise in flexibility naturally raises costs. Therefore the degree of flexibility necessary to solve the given problems with most advantages must be fixed at an early stage.

2.3 Pre-Fabrication:

Whether the building is pre-fabricated or annected conventionally is not primarily connected to the given task. A pre-fabricated construction can shorten the erection period but makes a much more thorough pre-planning on behalf of the distribution of services necessary.
But in the field of furnishing the pre-fabrication gains more and more. For some years now various firms offer complete laboratory programs.

2.4 Detailed Planning:

For successful detailed planning the following questions are to be answered:

2.4.1 Tasks and functional program:

- function of the building
- number of working places and rooms
- number of auxiliary rooms and their relation to the working rooms
- traffic development
- availability of services

The answer on all these questions may give us the plan of the building:

- one-sided concept (figure 1)
- two-sided concept (figure 2)
- radial concept (figure 3)
- sample of disadvantageous layout (figure 4): the placing of laboratories, offices and auxiliary rooms adjacent to each other makes services distribution inefficient (a = not utilized services distribution)

2.4.2 <u>Statics</u>

-Choice of economic construction

-loads

-system of outlets

2.4.3 <u>Criteria of Construction and Finishing</u>

- Choice of different materials for façade with glasing and blinds
- wall and floor covers
- ceilings
- insulations
- safety facilities

2.4.4 <u>Services</u>

- Choice of ventilation and air-condition system or combinations of them
- heating
- media
- potable water, industrial water, cooling water, deionised water

  cold and warm water

  drainage

  different systems for drain water, sewage, chemical waste water, again divided into: stronger or less organically poluted waters,

  gas

  steam

and further media, as there are:

nitrogene

oxygene

hydrogene

helium, etc.

- electrical supplies

power supplies (kind and voltage)

emergency supply

lighting

internal communications and clocks

2.4.5 Laboratory furnishing

- benches
- fume cupboards
- sinks
- service racks
- furniture
- equipment to be connected as

washing machines

drying cabinets

vacuum drying cabinets

transmissions and single motors

various laboratory equipment with all necessary information on connections

3. Modular Systems

3.1 The modul multiplied makes the length of the building. It is the addition of the chosen dimensions for wall thickness, working areas as well as traffic and utility areas.

For industrial buildings 300 cms are well tried, for schools 360 cms proved valuable. Normally in an industrial chemical lab the traffic area can be neglected as seldom all working length is being worked on. But even in this case the dimension should not fall short of 120 cms (figure 5).

3.2 **Depth and Height of Rooms:**

Dimensions for depth and height of rooms are directly related to each other. As a rule the depth of a chemical laboratory differs between 600 and 1000 cms. The height normally is 300 cms in rooms of 1000 cms depth. This should be increased to achieve a better lighting. The height overall of one story exceeds 400 cms approximately.

3.3 **Raster:**

The raster important for the depth of the room nowadays is mostly chosen from the metric system. Most of the laboratory programs use 100 cms as basic units (50 cms, 75 cms).

3.4 **Standards for Furnishing:**

The following dimensions are meant as approximate guides. They vary in practical use in accordance with the chosen program and the specific requirements.

3.4.1 **Depth**

- wall benches		80 cms
- fume cupboards	up to	100 cms
- cupboards		35 cms
	to	50 cms
- sinks		60 cms
	to	80 cms
- middle benches		140 cms
	to	175 cms

3.4.2 **Height**

- wall benches, middle benches:	
"sitting" work	80 cms
"standing" work	90 cms
- fume cupboards:	
standard	90 cms
walk-in type	40 cms
special type	height of room
- sinks	~ 90 cms

3.5 Area Requirement:

In a chemical lab the requirement of working area/ chemist varies between 25 and 30 squm. In single-room laboratories slightly higher requirements are to be considered.
Depending on the field 2 to 3 laboratory hands and aids may be reckoned per chemist. Another way of calculating is by metres of work bench. Approximately 20 metres of work-bench length per chemist are the appropriate number.

3.6 Gross Area, Net Area:

Under gross area the complete building area is understood. Deducting from this all constructions, auxiliary and traffic areas and distributional areas we get the next area. As an average the relation between these two areas is about 50 : 50.

4. Technical Installations:

4.1 General Possibilities:

As there is no one and only way of distribution we want to mention the generally used kinds:

4.1.1 Vertical Distribution:

All the media are supplied and distributed horizontally in the basement (main distribution). From this main distribution the further transport is achieved in vertical transport zones, mostly between laboratory and corridor. The media are transported either alongside the laboratory walls or through floor channels to the pick-up points. "Utility pots", which contain all necessary media in form of floor pick-up points have proved very useful. The service cells of the furniture are connected to them by very simple and safe couplings.

4.1.2 Horizontal Distribution:

The various media are transported by one or more means to the different stories. There the horizontal distribution takes place within the suspended ceiling and the floor can be penetrated whereever the pick-up points may be located. From here onward it is the same as with the vertical distribution.
Another kind of horizontal distribution is the piping alongside the outer walls below the window sill but this solution restricts to a chamber-like arrangement of the furniture.

4.2 Ventilation and Air-Conditioning:

A main requirement for proper laboratory work is a first-class ventilation. Only the most important criteria shall be named for the dimensioning of a ventilation system:

- normally the ventilation of a chemical laboratory will be a fresh-air system;
- therefore an air-condition will be the exception (more economical as special rooms with clima-boxes can be air-conditioned). Of course the geographic location is important. In hot countries a complete air-conditioning will be necessary.

4.2.1 Data on Air-Change:

- chemical laboratory 10 to 25 times p.h.
- auxiliary rooms 5 to 10 times p.h.
- fume cupboards depending on volume 200 to 400 times p.h.

These numbers indicate that a natural ventilation only is out of question.

4.2.2 Location of Ventilation Centres:

Normally the fresh air will be processed in the basement and the wasted air will be delivered over the roof. Under particular circumstances the fresh-air processing as well as the waste-air delivery will be located on the roof.

The disadvantage is a necessary vertical double-ducting.

4.2.3 Fresh-Air Processing:

The fresh air is sucked above floor-level, filtered, warmed-up or cooled and moistened. Shadowy and polution-free zones should be chosen for the air in-take, if possible. The processed fresh air normally is distributed in ducts of galvanized steel, aluminium or plastic.

4.2.4 Fresh-Air Distribution in the Room:

The following possibilities are known:
- supply through adjustable grids directly into the room
- supply through anemostat
- supply through perforated ceiling

The last way is used where draught is to be feared caused by a high change of air (many fume cupboards).

4.2.5 Exhaust System:

Normally the exhaust air is sucked out through fume cupboards by fans and transported through ducts over the roof. Depending on the kind of vapours transported heavily inflamable plastic ducts (polypropylen) or glazed stone-ware ducts are used (the minor disadvantages of both are known). The anti-corrosive protection of the exhaust fan is also important, which very often leads to those of plastic (P.V.C.). Very often each fume cupboard has its own ducting and fan to avoid the danger of explosions in the ducting systems due to the mixture of different vapours from different rooms or fume cupboards.
The laws on the prevention of polution of air are to be obeyed.In some cases the exhaust air has to be washed or filtered.

4.3 Heating:

Normally the heating will be a warm-water central heating. Mostly steam or hot water is transformed in the terminal and rooms are heated by radiators or convectors, preferrably located below the windows. It is very important to secure the necessary free diameters for the circulation of air when furnishing the rooms, especially with window benches.

4.4 Sanitary Services:

Besides the usual services for toilets and showers as well as the rain water drainage, it is the duty of the sanitary engineer to provide the building with the necessary facilities. This generally happens in the basement. The media normally used in a chemical laboratory are summed up under point 2.4.4. More and more frequently now only the various waters as well as gas and vacuum are distributed from the terminal. Steam and compressed air are produced locally by mobile apparatus. The various inert gases as nitrogene, oxygene, hydrogene, etc. are provided in bottles.
The installation of fire extinguishing systems and emergency showers according to local by-laws must not be forgotten.
An important part of the sanitary installation is the design and provision of the sewage system. It again is subject to strict local regulations and frequently made of polyathylen.

4.5 Electrical Supplies:

The dimensioning and provision of electrical facilities are subject to strict regulations.

4.5.1 Installed Power:

For the dimensioning of the installed power and the simultaneousness there are no standards. It is relatively easy to fix the needs of lighting, fans, pumps, elevator motors, etc. More difficult it is to fix the needs for laboratory use. As an average one reckons with a need of 10 to 15 KW per chemist working area with a simultaneousness of 0.3.

4.5.2 Voltage:

Generally 220 Volt A.C. and 380 Volt A.C. are used but this differs from country to country. The named voltages should be preferred as the most modern and usual laboratories and apparatus are designed for them.

4.5.3 Distribution:

The distribution is carried through preferrably with the sanitary installation.

4.5.4 Emergency Power:

To bridge possible break-downs of the public net and to insure a continuity of experiments mostly an emergency power group is installed preferrably based on Diesel aggregates.

4.5.5 Depending on the work to be done, the lighting intensity varies between 400 and 100 lux. Generally used in laboratories are fluorescence tubes with day-light white. The lamps are mounted either in or below the ceiling.

The emergency lighting of flight routes and rooms without day-light as a rule is fed by batteries, which come into action automatically with the break-down.

4.5.6 Communications:

In a chemical laboratory can be found: telephones, clocks, loud-speakers and fire-alarms.

5. Furnishing of Laboratories:

5.1 Basics:

The variety of tasks in planning and construction of laboratory buildings also affects the furnishing. Today as in the whole construction business flexibility is the word of the hour. It took years, even decades, to bring a certain standardization to the construction of laboratories. Therefore we are sure to be right when we concentrate on systems using multiple units and cut out the laboratory produced according to special request in the older days.

5.2. Dimensions:

For many years 15 cms originating from laboratory tiles were the basis for dimensioning cabinets. Nowadays 120 cms as basic dimension seems to have surpassed all other numbers. This dimension is easily to be divided into following fractional dimenions: 30 cms, 60 cms, 90 cms. Bigger units can easily be composed as 150 cms and 180 cms.
Depth and height of the furniture vary in accordance with requirements and the working program. Guides are mentioned under 5.4.

5.3 Systems:

Two main systems are used:

5.3.1 Carcass System:

With this system cabinets do not only contain equipment but also support the table-top resting themselves on a closed base or pedestal structure. The advantage of this system is a maximum capacity of room available.

The main disadvantage is the lacking flexibility. It is not always simple to exchange some of the units and sometimes one has to get access to the media distribution to remove the back walls of the cabinets.

5.3.2 Structural System:

Steel tubes or aluminium profiles generally support the table-tops with this system. The exchange of underbench units is easy. The cabinets are either suspended or fixed to the frames or independent from the structure and can be moved easily on casters. The service cells in any case are easily accessible.

5.4. Laboratory Benches:

5.4.1 Supporting Structure:

Frames are placed vertically in certain (modular) distances. Uneven flooring is leveled with adjustable foot caps. The frames again are connected with horizontal bars to guarantee a rigid structure. Most of the firms are using tubular steel of rectangular section for these structures. Special aluminium profiles with patent couplings gaining on the market have the advantage of easy exchange of even the smallest single part.

5.4.2 Table Tops:

They can be chosen from the following possibilities according to requirements:

- laboratory tiles on concrete slab
- laboratory tiles on wood-chip board or block board (new tile 145 mms; 8 x 14,5 cms + 5 mms joint = raster 120 cms).

- Plastic top on wood-chip board or block board (polopropylen or P.V.C.)
- Plastic laminates on wood-chip or block board
- large-sized jointless stone-ware tops
- highly heat-resistant, securized materials on wood-chip boards (Prukeram)
- special glass in rubber bedding on wood-chip board (Prusekur)
- slate or other stone tops
- hard-wood tops
- asbestus cement tops with or without special surface (Glasal, Colorceran-Eternit, Colorlith)
- stainless steel (V4A)

Other materials are being tested or under development. Excellent results are to be expected shortly.
The following requirements direct the choice of table-top:

- chemical resistance
- thermal resistance
- resistance again abrasion
- top as jointless as possible
- smooth surface (cleaning)
- non-porous materials

The formally used table top of led has rightly disappeared. Gutters, single-cups and sinks as well as penetration by media-distribution are to be built-in and considered.

5.4.3 Service Shelves:

On the table tops normally of lighter construction than the supporting structure shelves are mounted. Most of them are combined with service-channels and hold special cups for the erection of racks.

The shelves themselves very often are from wired glass.

5.4.4 Service Systems:

Another important field is the proper choice of the service system for the various media and electrical distribution.

Here again we have two basically different possibilities:

- fittings and media are connected to the bench (figure 6)
- fittings and sockets are installed in a separate unit and the benches are placed adjacent to them (figure 7).

For the usual installations below work tops for the most media galvanized steel pipes, copper tubings, P.V.C.-tubing as well as polyathelyn for the drainage are used. Lately the installation using copper tubings from the roll with standardised dimensions has been successful. Also long-time experiments with special tubing has been a success and they are being used widely by the industry for the last couple of years.

For this kind of installation a special "distribution terminal" is being used. Every fitting is being connected separately to guarantee steady pressure everywhere. Additionally every media can be turned off at this distribution terminal. By this, repairs are made easy and additional supplements possible without closing down the whole laboratory.

5.4.5 Fittings:

Most of the laboratory fittings are from brass;for surface protection they are either ofen-enamled or spray-coated with synthetic in an electro-static field and subsequently stoved. For particular media, special fittings are necessary, e.g. silver-coated brass fittings or plastic for demineralized water.

A variety of fittings is composed of relatively little single parts. Delivery periods, storage and costs benefit from that. Depending on the field they are used we know the following types of fittings:

- stands
- wall fittings
- remote controls.

The well-known and high-quality fitting programs use a specislly shaped and colour-coded handle for every media to avoid confusion and mistakes. The following systems are in use:

- stands are directly installed into the table-tops
- fittings are gathered in so-called energy columns. This possibility is specially fit for benches, where it is neccessary to have a table-top undisturbed and as huge as possible.
- The remote controls are used for fume-cupboards having the outlets inside it (safety regulations).

With all these systems the media distribution is normally below bench-top.

- The horizontal distribution to the fittings is housed in a "media channel". Its support at the same time are the supports of the reagent shelf.

With this system of servicing a table-top is once penetrated and the horizontal distribution is within the channel.

5.4.6 Electrical Services:

Electrical power is distributed through fixed sockets or through a new system of flexible socket units. Sockets on cables of different length are connected to the terminal.

The great advantage of this type of installation is the possibility to use the sockets exactly where they are needed. In this way 220 V as well as 380 V can be supplied.

5.4.7 Under-Bench Units:

These units nowadays are mostly of laminated chip-boards, sometimes of wood, laquered or painted. Complete plastic cabinets are the excellent result of a series of experiments, now gaining a strong position in the building of laboratories. At the same rate steel furniture is losing ground. Generally we know the following basic types:

- units with adjustable shelves
- units with drawers.

All these types are produced in different rasters.
The different programs either have units with hinged or sliding doors or both of them. As any sliding door, which is produced in the lightest connection with wooden parts, is subject to changes of humidity in the air and can cause considerable difficulties in servicing. Hinged doors are to be preferred. Good furniture systems can replace the sometimes seemably necessary sliding doors because they can provide hinges, which allow the doors the be opened by 180 degrees and do not project into the room.
In addition to this, we know a number of special units, as there are:

- cabinets for chemicals, like acids and solvence, ventilated
- units to house special equipment, like drying cabinets
- units with drain
- units with ice-containers

Naturally this summary is not complete.

5.4.8 Balance Tables:

Balance tables are used to protect the highly sophisticated balances from vibrations of the building. In common use are constructions of concrete or steel with special shock absorbers. These constructions are protected by a cover on all sides against direct contact. For simple balances sometimes ordinary laboratory benches suffice. On the other hand highly sophisticated balances for most accurate results ask necessarily for special balance tables, which is case have a double-frame for additional shock-absorption.

5.5 Fume Cupboards:

Fume cupboards or hoods gain importance in the chemical laboratory. They are working area secluded from the laboratory. In these hoods are kinds of works involving gases or vapours of poisonesa or only unpleasant character are involved. The majority of the exhaust air from the laboratory is sucked through the fume cabinet, which makes an first class ventilating construction a necessity. Depending on the kind of work to be done, as an accessory apparatus for this, we know the following types differing in size:

5.5.1 Fume Cabinets:

These cabinets are the most common type, used for work at normal working height. They can be single but mostly are located in complete rows. Of course every section can be operated separately as well as the single sections may be combined to one unit, if the size of the apparatus involved requires it.

5.5.2 Step-in Fume Cabinets:

They become necessary as soon as the equipment involved for experiments cannot be placed in normal fume cupboards. In principal it does not differ from the fume cupboard only the height of work is 40 to 50 cms.

This fume cupboard has necessarily two front slides.

5.5.3 Special Type:

In various cases this type is being preferred to other fume cupboards. Here it is possible to step into it, which makes handling of heavy equipment easier, which on charts can even be given directly into the fume cupboard. In many cases an additional table-top can be mounted at normal working height or a part of the back wall can be re-arranged to allow the use as a normal fume cupboard. Here also two front saches are necessary.

5.5.4 Construction:

- Lower part: Generally the construction of the fume cupboard is divided into lower and upper part. In principal the lower part (with fume cupboards and step-in cupboards) can be compared with the normal work bench. The more modern laboratory programs dispense with a special lower part. Here the upper part can be directly mounted on any wall bench. This only under the assumption that exhaust facilities are available.
- Upper part: This upper part is the supporting structure for the saches and the back wall.
- Saches: To operate the fume cupboard one or more front saches are necessary. They are necessarily of securised glass with or without frame. They are led in the sides of the upper part and balanced by counter-weights. Saches and couter-weights are connected by chains or steel ropes (eventually plastic-covered).

With some constructions the sache can be brought down to the work top. To avoid the hindrance of the jams at least with the bench-type of fume-cupboards other varieties have been developed, as the new-shaped sache with guidance in the back wall. But this solutation excludes the combination of severel units. Other constructions also avoid horisontal jams, the side-sache can be unhinged. The great advantage of this construction is providing us with a normal, undisturbed wall bench when the saches are moved upwards.

- Back wall: The back wall of the fume-cabinets has two functions. For one it houses the counter-weights and auxiliary facilities for the construction of racks and on the other hand guarantees the proper ventilation of the fume cupboards.

- Ceiling: The ceiling closes the fume cupboards on top. Mostly it incorporates a combustible panel, sometimes in connection with an outside lighting.

- Ventilation: The proper functioning of airation and exhaust is one of the main criterions for safe laboratory work. The choice of the right velocity of intake air prevents the return of gases and vapours into the room. As guide per metre fume-cupboard approximately 500 to 600 cubic metres per hour ought to be sucked out to fulfil these requirements. Dependent on the capacity of the fume cupboard this will lead to an air-change of 200 to 400 times per hour. Every modern construction provides a channel, which guarantees the suction of vapours on the highest point of the cabinet as well as above the table top along full width.

The exhaust ducts within the room are mentioned under point 4.2.5.

- Fittings: Safety regulations require remote controls. Normally the controls are mounted on a panel below the work top and inside the cabinet are only the outlets. With step-in type cabinets and special cabinets the fittings can be located in the posts. The outlets are either on their back side or penetrating the front wall.
- Electrical Distribution: The electrical sockets can either be in the horizontal panel mentioned before or inside the cupboard. This only depends on the safety regulations. The lighting of the fume cupboards can either be connected with the lighting of the rooms or switched separately.
- Additional Facilities: Further parts of a fume cupboard are cups to enable the erection of apparatus, racks, cantilevers, etc. Also in use are transmissions or single motors operated either electrically or by compressed air.

5.6 Racks, Lattice Partitions:

In a modern flexible laboratory more and more working areas are reserved for large apparatus and combined equipment. In connection with a work bench with low work top the installation of rails will suffice. In zones accessible from all sides racks will be installed; fixed between floor and ceiling by cantilevers, bars and connections also racks can be constructed. The media to be provided in all these cases will be found in energy columns.

5.7 Sink Units:

Sinks for cleaning of laboratory glass-ware are mainly installed in two places. Small sinks are located at the end of middle benches. In larger laboratory units all facilities for cleaning of glass-ware are combined to one unit. Quite frequently sinks and drip boards are produced either from polypropylen or stainless steel. Combined stone-ware sinks with wooden drip boards now more and more come out of use. Drip racks or peg boards are installed above the sinks. Under the sinks, when necessary, are built-in waste-baskets, dish-washers, drying cabinets, etc. In some cases sinks have to be connected with the exhaust system.

5.8 Cupboards:

Together with under-bench units quite an amount of cupboards is necessary to store chemicals and equipment. We distinguish normal cupboards of different height and depth and hanging wall cabinets. For sample collections for instance, special cabinets have to be designed.

5.9 Other Laboratory Equipment:

To complete the subject a great variety of special apparatus and equipment has to be considered with the design of laboratory buildings.

5.10 Installation:

Thanks to pre-fabrication of laboratory furniture, it has become possible to complete the whole building before the supplier of the laboratory furniture is finishing the rooms. This brings a lot of advantages to the client, not least in regard to the time-table.

6. FINAL COMMENT ON DESIGN

The concept of the whole furniture is being developed from the architects' drawings, layout and functional constellations. The first project shows the internal connections and the utilization of the separate rooms. Proximities and connections in working process are made visible in detail.
After the first project is worked up and gets the approval of the client to the concept of furniture, the main project drawings, mostly scale 1 : 20, are produced. Now a standardization of all structures, cabinets and cupboards proves the effective exchangeability of a useful element system.
In the detailed project now for every installed laboratory special drawings of typical structures and connections are produced for all services.
Planning is now continued to the final description as basis of the tenders, which enable the client to compare prices as well as check the degree of standardisation and flexibility and the quality.
The following final breakdown puts the client into the picture about the overall costs to be expected.

Fig. 1

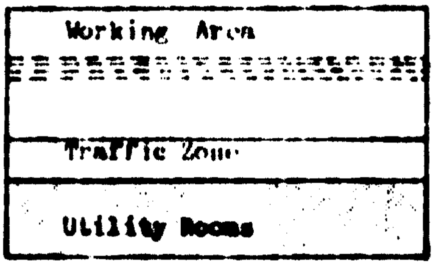


Fig. 2

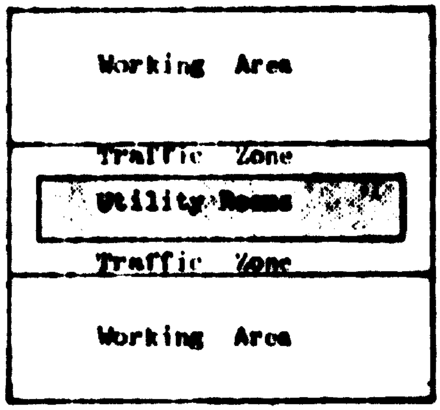


Fig. 3

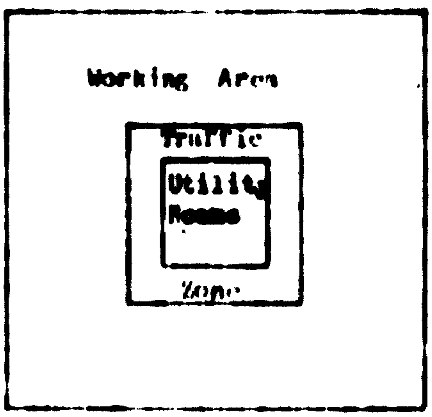


Fig. 4

Fig. 5

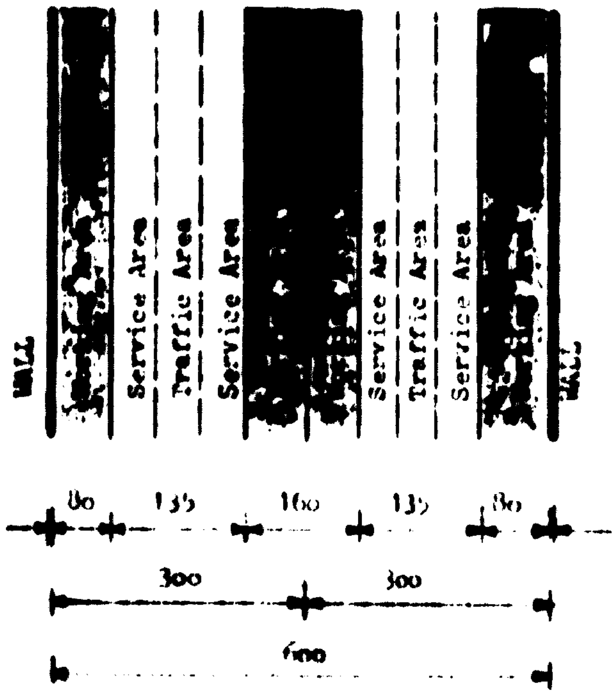


Fig. 6

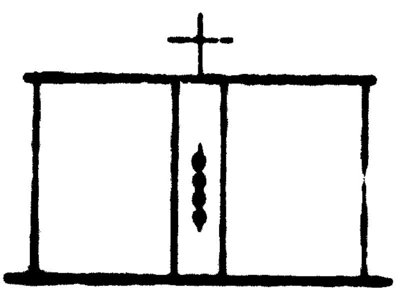
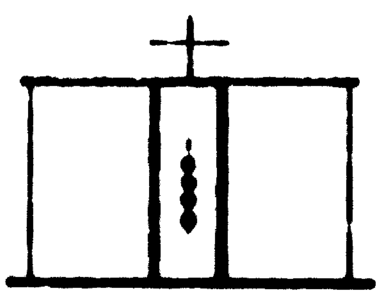


Fig. 7



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