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Basic Utility Distribution Systems. Laboratory Design Notes.
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The scope of facilities required for the conduct of research in health-related sciences is governed by the type of work to be undertaken and the physical characteristics of the building, and can range from a simple office to extremely complex laboratories with numerous utility services. Every laboratory should be designed to accommodate--(1) all immediate and foreseeable functional needs, (2) changes in room arrangement, location of equipment and utility distribution, (3) extreme but isolated changes in utility demand, and (4) unanticipated major utility changes affecting the entire building. Pictorial diagrams illustrate various means of obtaining flexibility of utility layouts. Advantages and disadvantages of each method are listed. (RH)

Laboratory Design Notes

Distributed in the interest of improved research laboratory design

BASIC UTILITY DISTRIBUTION SYSTEMS

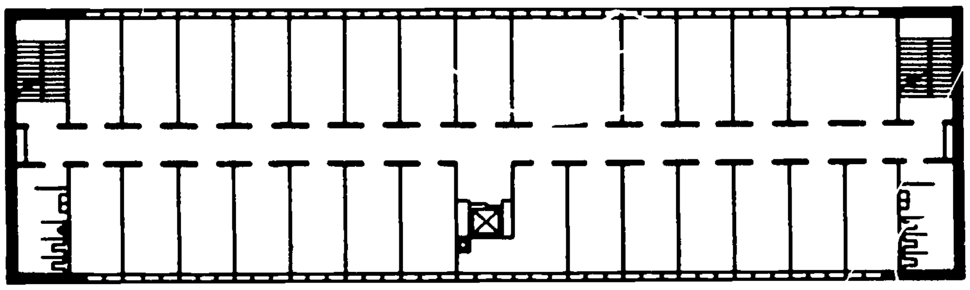
The scope of facilities required for the conduct of research in health-related sciences is governed by the work to be undertaken and ranges from a simple office to extremely complex laboratories having numerous utility services, potentially hazardous working conditions, and exacting controls.

The incorporation of facilities for which no immediate or foreseeable need exists is not economical or prudent, but every laboratory should be so designed that:

1. All immediate and foreseeable functional needs are provided for.
2. Changes in room arrangement, location of equipment, and utility distribution can be readily and inexpensively accomplished.
3. Extreme, but isolated, changes in utility demand can be easily satisfied.
4. Unanticipated and major utility changes affecting the entire building can be accomplished without major structural modifications.

The following collection of pictorial diagrams illustrates the most common means of obtaining flexibility of utility layouts in research laboratory design. Each method has its advantages and disadvantages, and each is more suitable for some applications than for others. The most suitable selection will be governed by the type of laboratory work to be performed and the necessary physical characteristics of the building. It may be that a combination of methods will prove the most satisfactory.

CEILING DISTRIBUTION with the utilities suspended from room or corridor ceilings and connected by extensions to a few vertical pipe shafts. Distribution may be downward at each floor or downward and upward at alternate floors. Designs employing exposed utilities are ideal for two-story or one-story and basement "work buildings" where economy of construction is a major consideration.



Typical Floor Plan

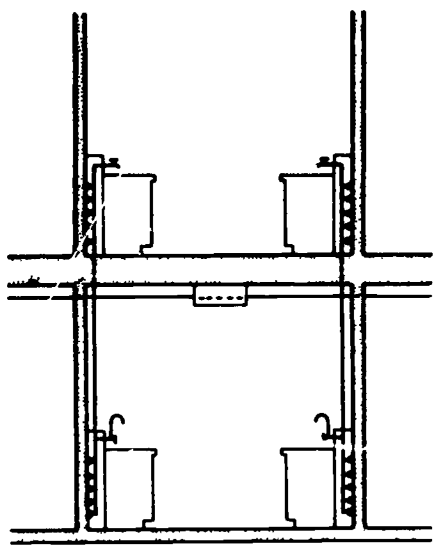
Duct work may be carried at ceiling of personnel corridor.

Utility mains may be carried at ceilings of both floors or exposed on first floor and concealed on second.

Waste stacks are usually most advantageously located in the load bearing corridor wall, or exterior wall, at the juncture of modules.

Second floor fume hood supply and exhaust systems may be easily served by equipment located in the attic. The installation of fume hoods at the lower level should be avoided but, if necessary, may be accomplished by the installation of shafts through the second floor.

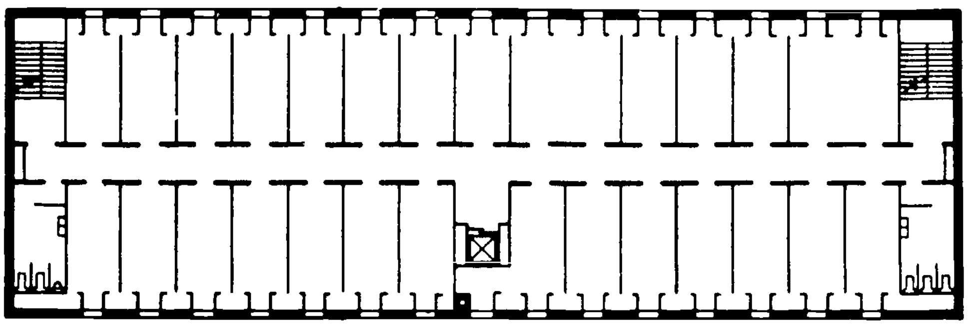
Electrical feeder conduits may be run exposed along the ceilings parallel with other utilities. Distribution boxes may be located at the ceiling in each laboratory module with exposed conduit run to surface mounted panelboards located on the reagent shelves. If conduit is concealed on the second floor, the panelboards may be surface mounted on the reagent shelves or concealed in the knee space of base cabinets. Receptacles may be mounted in the splash backs or in multi-outlet assemblies above the reagent shelves.



Transverse Section Through Laboratory Module Showing Utility Lines

Advantages	Disadvantages
Excellent flexibility.	Requires increased ceiling height for same clearance.
Low first cost.	Limits installation of wall cabinets.
Low modification cost.	Increased cleaning (maintenance) costs.
Low replacement cost.	Requires independent type of air duct installation and drainage system.
High net to gross area efficiency.	Unsightly.
Modifications do not interfere with conduct of work in adjacent modules.	

The MULTIPLE EXTERIOR UTILITY SHAFT was one of the first design approaches used to obtain the advantages of improved sanitation and appearance through the concealing of utilities, In it, all service mains and duct work are brought to the various floor levels by a series of exterior wall vertical shafts, located at each or alternate modules, from which distribution of utilities is made in the pipe space of base cabinets. The utility shaft principle is not a good selection for other than multi-story laboratories.



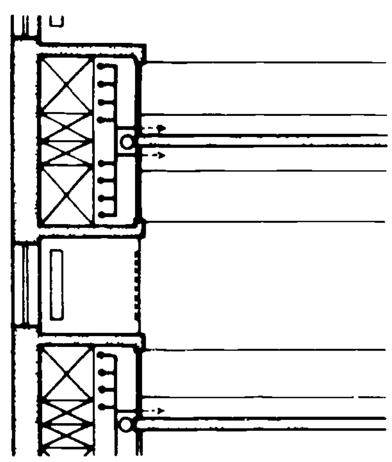
Typical Floor Pl .n

Utility mains should be carried free of duct work in a manner permitting ready servicing.

Waste stacks are usually most advantageously located in the utility shaft at the juncture of modules.

Fume hoods must normally be supplied and exhausted by common duct work.

Electrical feeder conduits may be carried through the utility shafts along with other utilities, with tap boxes located at each floor se ved by the feeder. Panelboards, if located in laboratories, may be mounted on a reagent shelf or concealed in the knee space of base cabinets. Receptacles may be mounted in the splash backs or in multi-outlet assemblies above the reagent shelves.



Typical Plan of Multiple Exterior Utility Shaft

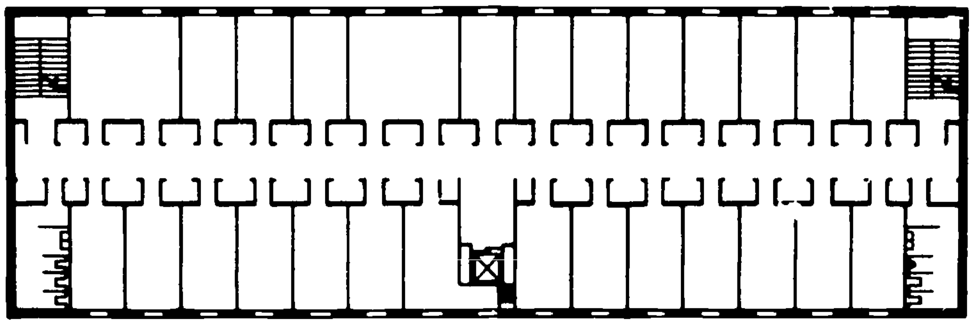
Advantages

Good flexibility.
Moderate net to gross area efficiency.
Moderate initial cost.
Moderate modification cost.
Moderate replacement cost.
Low cleaning (maintenance) cost.
Permits full usage of walls.
Utilities are common with duct work and drainage systems.
Good appearance.

Disadvantages

More difficult to service or modify than other recommended systems.
Requires removal of one section of casework.
Modifications interfere with conduct of work in adjacent modules.
More expensive and not as flexible as exposed systems.
Available space usually does not permit individual supply and exhaust of fume hoods.

The MULTIPLE INTERIOR UTILITY SHAFT provides concealed utilities with a common duct work and drainage system and does so in a manner more easily serviced than the exterior utility shaft arrangement. In it, all service mains and duct work are brought to the various floor levels by means of a series of interior corridor wall shafts located at each or alternate modules, from which distribution of utilities is made in the pipe space of base cabinets. The interior utility shaft principle is not a good selection for other than multi-story buildings.



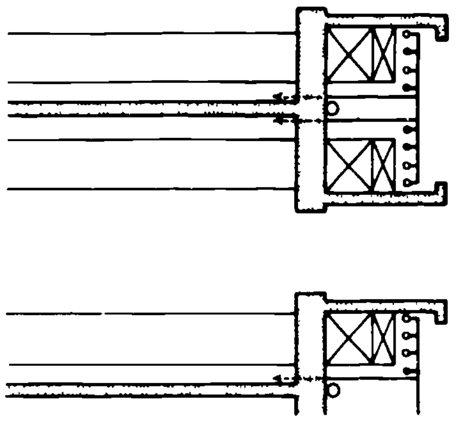
Typical Floor Plan

Utility mains should be carried free of duct work in a manner permitting ready servicing.

Waste stacks are usually most advantageously located in the utility shaft at the juncture of modules.

Fume hoods must normally be supplied and exhausted by common duct work.

Electrical feeder conduits may be carried through the utility shafts along with other utilities, with tap boxes located at each floor served by the feeder. Panelboards, if located in laboratories, may be mounted on a reagent shelf or concealed in the knee space of base cabinets. Receptacles may be mounted in the splash backs or in multi-outlet assemblies above the reagent shelves.



Typical Plan of Multiple Interior Utility Shaft

Advantages

Good flexibility.
Moderate net to gross area efficiency.
Moderate initial cost.
Moderate modification cost.
Moderate replacement cost.
Easier to service than the exterior shaft system.

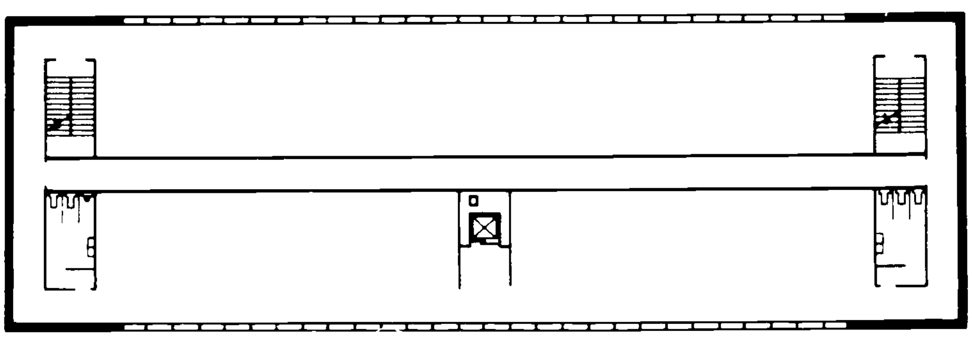
Disadvantages

More expensive and not as flexible as exposed systems.
Available space usually does not permit individual supply and exhaust of fume hoods.
Servicing interferes with traffic flow in corridors.

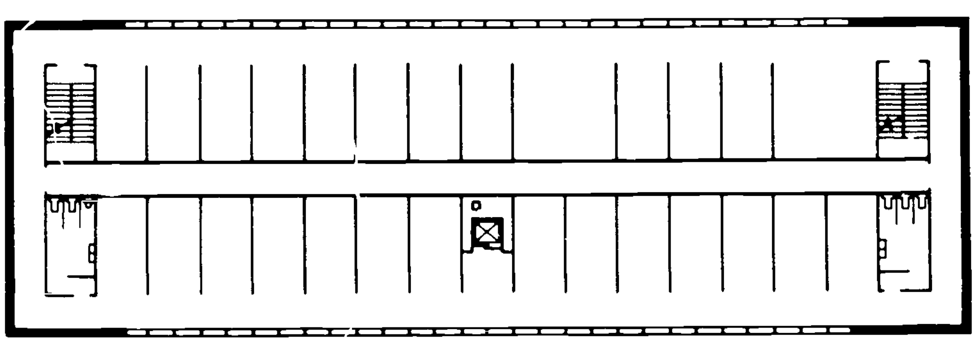
Advantages Continued

Low cleaning (maintenance) cost.
Provides shield at doorway.
Permits full usage of walls.
Modifications do not interfere with conduct of work in adjacent modules.
Utilities are common with duct work and drainage systems.
Good appearance.

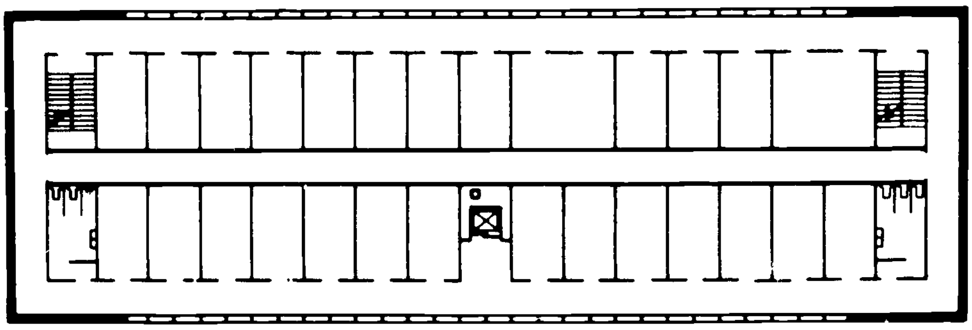
The UTILITY CORRIDOR design permits, with concealed utilities and duct work, a degree of flexibility not found in previously described systems, however, it does so at an increase in cost and a decrease in the net to gross area efficiency. In it, all service mains and duct work are brought to the various floor levels by means of a central vertical core from which distribution of utilities is made in the pipe space of base cabinets. It can be used in laboratories having only one or two floors but is more suitable for multi-story buildings. Very large and functionally efficient structures can readily be designed about a number of units in parallel.



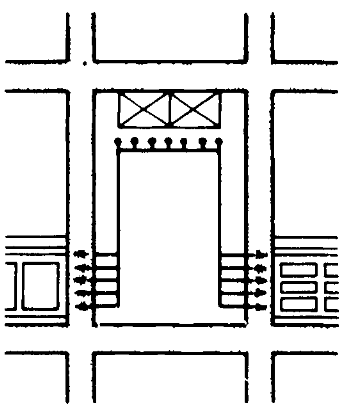
Open laboratories are economical and especially suitable for industrial or other work in which privacy is not desired. Any arrangement of casework may be utilized.



The conventional "horse stall" arrangement is a refinement of the open plan and provides a degree of privacy for laboratories in which the work is of such a nature that free movement of personnel is desired.



Typical Utility Corridor Laboratory With Perimeter Corridor



Transverse Section Through Utility Corridor Showing Horizontal Distribution

Duct work may be carried at ceiling of utility corridor, at ceiling of personnel corridor, or both.

Duct work may be carried at center or at one or both sides of corridor.

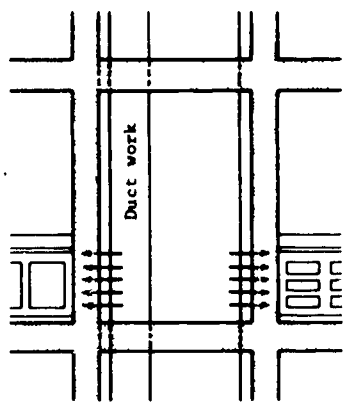
Utility mains may be carried at ceiling or on one or both walls.

Utility mains may be carried at junctures of modules at one or both sides of corridor.

Waste stacks are usually most advantageously located at junctures of modules on both sides of utility corridor.

Fume hoods may be individually supplied and exhausted by means of vertical ducts.

Electrical conduit with tap boxes may be carried at personnel corridor ceiling with flush mounted panelboards at junction of modules, or may be carried in utility corridor. Panelboards, if located in laboratories, may be at reagent shelf height, flush or surface mounted, or may be mounted in knee space of base cabinets. Receptacles may be located in splash backs or in a multi-outlet assembly above reagent shelf.



Transverse Section Through Utility Corridor Showing Vertical Distribution

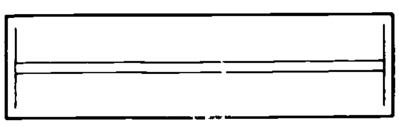
Advantages

- Excellent flexibility.
- Moderately high initial cost.
- Low modification cost.
- Low replacement cost.
- Low cleaning (maintenance) cost.
- Permits full utilization of walls.
- Modifications do not interfere with conduct of work in adjacent modules.

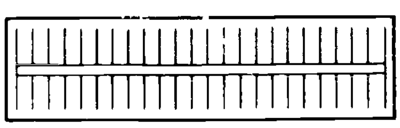
Disadvantages

- Fair net to gross area efficiency which improves when units are located in parallel, thus, saving one corridor.
- All rooms are "inside rooms."

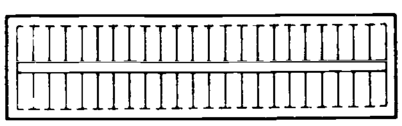
Variations in the Utility Corridor design concept



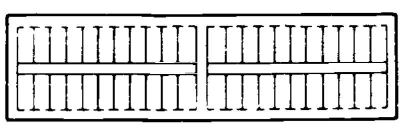
Open



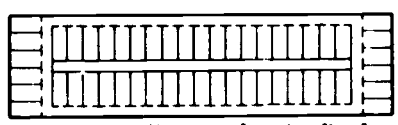
"Horse Stall"



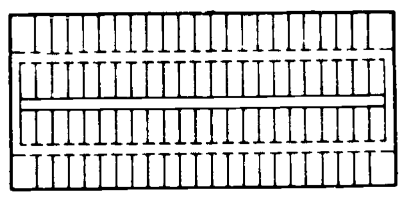
Typical



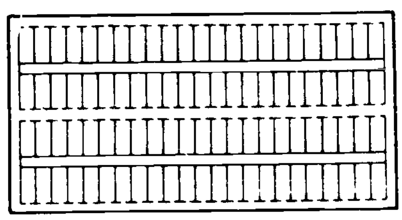
Typical with transverse corridor



Typical with offices at longitudinal ends

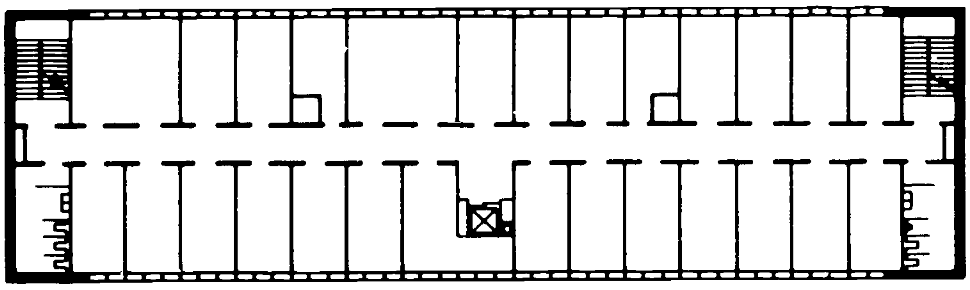


Typical with offices at transverse sides



Typical units in parallel

The UTILITY FLOOR provides concealed utilities with a common duct work and drainage system in a manner which permits almost unlimited flexibility, however, it does so at a very high cost and a low net to gross area efficiency. In it, all service mains and duct work are brought to the various utility floors, by means of centrally located shafts, from which distribution is made laterally to any point of the floor above or ceiling below. The utility floor principle is not a good selection for other than multi-story buildings.

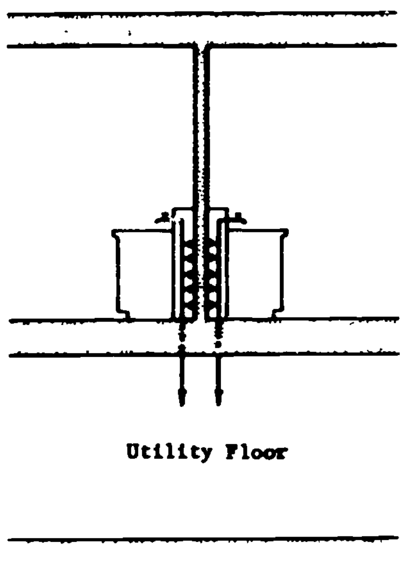


The floor plan above follows other illustrations for the purpose of area comparison, but the utility floor concept is best utilized in a near-square or series of near-square segments so oriented as to permit complete flexibility of partition and casework arrangements.

Duct work, utility mains and drainage systems, originating at shafts, may be distributed in any manner desired.

Fume hoods may be individually supplied and exhausted if near a vertical shaft or if immediately below a utility floor.

Electrical conduit with tap boxes may be carried at the utility floor ceiling with runs to panelboards in laboratories above or below. Panelboards may be surface mounted on reagent shelves or concealed in the knee space of base cabinets. Receptacles may be mounted in the splash backs or in multi-outlet assemblies above the reagent shelves. Distribution centers, motor control centers, and unit substations may be located on the utility floor.



Vertical Section Through Utility Floor and Floor Above

Advantages	Disadvantages
Excellent flexibility to any portion of room.	Very high first cost.
Low modification cost.	Low net to gross area efficiency.
Low replacement cost.	
Modifications do not interfere with conduct of work in adjacent modules.	
May be used with up-feed at every floor or may be combined with down-feed and located at every third floor.	

GENERAL DESIGN CONSIDERATIONS

1. The completion of a farsighted and well-considered master development plan is the first step in the successful planning of any component--including a research laboratory.

2. The flexibility of a laboratory will be increased and its unit area cost reduced if it is designed on a modular basis. The most common modular dimensions for room widths are four feet and five feet, and the most common room depths vary between sixteen and twenty feet.

3. Personnel corridors should not be narrower than six feet, and there is seldom justification for a width greater than eight feet.

4. Uti ity corridors should not be narrower than four feet and normally need not be wider than eight feet.

5. The installation of floor drains should be avoided if functionally practicable, however, if it is anticipated that floor drains will be required, all should be installed initially.

6. Laboratory floors should be designed for a live loading of not less than 80 pounds per sq. ft. Most building codes require 100 pounds but some permit as low as 50.

7. There is seldom need for a clear ceiling height in excess of nine feet. In rooms requiring a large number of air changes per hour and no recirculation, a high ceiling is a distinct disadvantage.

8. Rooms in which the control of vermin is of major importance should not be equipped with hung ceilings, multi-outlet assemblies, or hollow partitions which can be penetrated by insects. If such control extends to other floors, a grating type of floor construction should not be employed in utility shafts or utility corridors.

9. If a laboratory building is to be less than four stories in height, and if it is not to be located in a seismic area, wall bearing construction should be seriously considered. Such buildings have no columns or beams to interfere with casework or the passage of pipe and, in most instances, will provide greater flexibility at a lower cost than laboratories designed within a structural frame.

10. Research laboratories should never be laid out with dead-end corridors which may trap occupants in the event of a fire or other hazard.

11. The construction cost of a laboratory can be appreciably reduced if the architectural and framing plans are kept simple and if materials are stock in size, limited in type, and if the required cutting of masonry is kept to a minimum.

12. Materials of construction should be selected in light of the functions they will serve. If they will be subject to the action of acids, alkalis, or steam cleaning, they should be of a type resistant to such usage.

13. A typical level of illumination in laboratory areas is 100 foot candles.

14. The most frequently used electrical secondary distribution system is 120/208 volt, 3 phase, 4 wire, 60 cycle.

15. A typical value on which to base the capacity of the building's electrical supply (including air conditioning) approximates 15 volt-amperes per gross sq. ft.

16. The control of odors in animal rooms through increasing the number of air changes reaches the point of diminishing returns at about 15 changes per hour; after which, it is more economical to raise the standard of sanitation. Recirculation of air should not be employed in those rooms in which the control of odors is a major consideration.

17. If filtering of incoming air is not of major importance, and if the control of humidity is not critical, the use of fan-coil units may be found more satisfactory and more economical than a system employing large and elaborate duct work.

18. The unitized module concept of laboratory design in which all utilities, temperature, and air handling are subject to a wide range of control, independent of adjacent rooms, is generally to be preferred.

Additional copies of this leaflet may be obtained from: Office of Architecture and Engineering, Division of Research Facilities and Resources, National Institutes of Health, Bethesda, Maryland 20014