

A RESEARCH LABORATORY FOR THE BETHLEHEM
STEEL COMPANY AT BETHLEHEM PENNSYLVANIA

by Richard Wellington Homer

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF ARCHITECTURE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Signature of Author

August 20, 1956.

Certified by _____

Head, Department of Architecture



A RESEARCH LABORATORY FOR THE BETHLEHEM
STEEL COMPANY AT BETHLEHEM PENNSYLVANIA

I

A RESEARCH LABORATORY FOR THE BETHLEHEM
STEEL COMPANY AT BETHLEHEM PENNSYLVANIA

by Richard Wellington Homer

Submitted for the degree of Master of
Architecture in the Department of Archi-
tecture on August 20, 1956.

As the rapid advancement of technology
changes the pattern of life, industrial
research becomes a requisit for industrial
survival. Aware of this, the Bethlehem
Steel Company is studying proposals for a
new research facility to be associated
with the main office and plant at Bethle-
hem, Pennsylvania.

This thesis presents: a possible direction
and form that this research laboratory
might take, both in its initial and future
expanded form; a plan organized for flex-
ibility and universality of space and use;
an attempt at retaining the quality of
scale within a large complex; and a char-
acter of design based on more than utili-
tarian requirements.

Arch. Jour. 30. 1957

August 20, 1956

Pietro Belluschi, Dean
School of Architecture and Planning
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dear Dean Belluschi:

In partial fulfillment of the requirements
for the degree of Master of Architecture
I herewith respectfully submit this thesis
entitled:

A RESEARCH LABORATORY FOR THE BETHLEHEM
STEEL COMPANY AT BETHLEHEM PENNSYLVANIA

Sincerely yours,

Richard Wellington Homer

84 Duff Street

Watertown, Massachusetts.

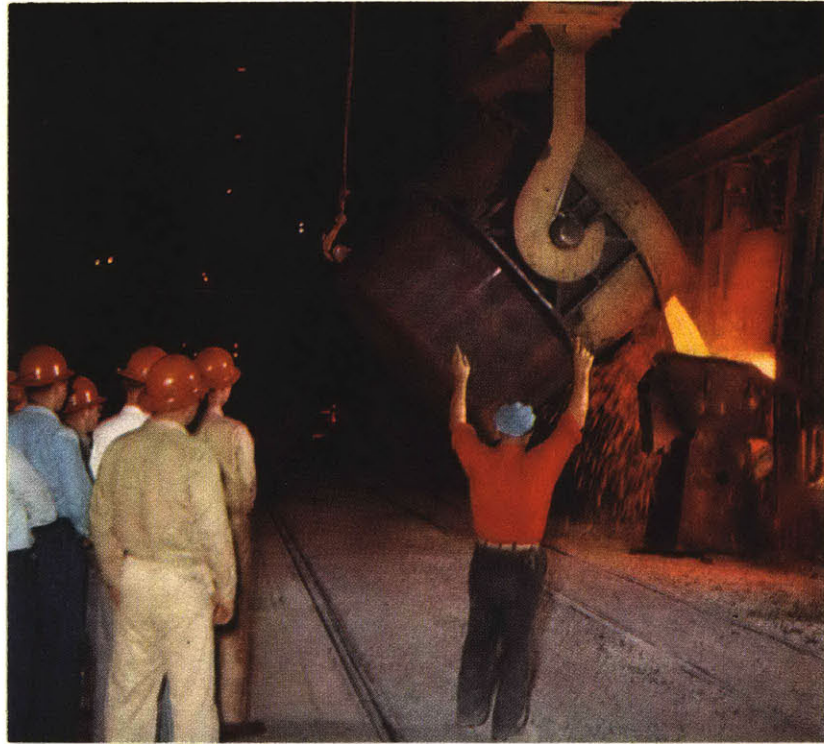
TABLE OF CONTENTS

Title Page.....	i
Abstract.....	ii
Letter of Transmittal.....	iii
Table of Contents.....	iv
Preface.....	v
The Role of Research.....	1
The Problem.....	5
Map.....	9
Site Photography.....	10
The Program.....	11
The Solution.....	18
Design.....	20
Bibliography.....	vi

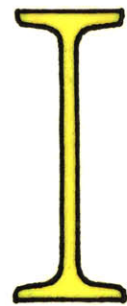
"Industrial technology provides the extra food on the table, the extra mile on the speedometer, the extra dollar in the wallet. It is the extra bushel in the barn, the extra suit in the closet, the extra diploma at commencement time. It is extra hours of leisure, the extra years of health and of life, the extra measure of security.

"Our very security as a free people is dependent upon our capacity to produce and to employ the most modern industrial techniques."

- Henry B. duPont



THE ROLE OF RESEARCH



THE ROLE OF RESEARCH

Industrial research is, today, broadly accepted as a requisite of industrial survival. Surprisingly, however, industrial research is one of the younger industrial functions and that as a fully recognized procedure for corporate progress it is hardly more than 15 years old.

Chronologically, industrial research was an infant in the boom year of 1929. The gross expenditure for research at that time was \$160 million, representing 0.15 percent of the gross national product. Included in this is medical, university, industrial, and agricultural research plus all the physical and biological sciences. Through the depression research grew slowly and it was not until 1941 and World War II that tremendous growth was realized. Then, as the impact of war hit our economy, it brought problems that had to be solved for survival. By the end of the war, research spending was up to \$1.3 billion annually, or 0.62 percent of the gross national product.

The thought that research would shrink with industrial output at war's end proved unfounded. Industry found instead that it not only had a backlog of technical developments ready for commercial exploitation, but it had discovered scientific research as a new frontier equally as important as those of land or natural resources for creating economic activity. Through research, a company could develop new products, improve old products, reduce costs, find diversification opportunities, and solve raw materials difficulties. The result was

that industry took up the slack when government research dropped in 1946 and added more to it, swelling the total research activity by \$190 million in the first peacetime year. Now, with government research added, research has passed the \$4 billion per annum mark, or 1.25 percent of the gross national product.

Obviously, the rapid growth of research cannot continue forever at such a fast pace, but knowing that certain industries can economically carry 12 - 13 percent of net sales for their research budget, there is still a tremendous area for growth. The present industry-wide average is 2 percent of net sales, so a tripling or quadrupling of industrial expenditures seem possible before reaching economic limits.

Research as we know it today is a significant new force in the industrial economy and its effect on the future can not be predicted by old standards. The use of the laboratory as a frontier of new industrial opportunity has produced the "Technological Revolution", the beginning of which was about 1940 when research took over as a primary basis for industrial expansion. Since that time, the "revolution" has produced huge new industries that have changed our lives. The plastic and detergent industries are but two of many. The chemical industry markets some 7000 products, of which 5000 are organic compounds and are adding 10,000 per year. Add to this the growing list of inorganic compounds and it is evident that uses have been found for less than 1 percent of our potential.

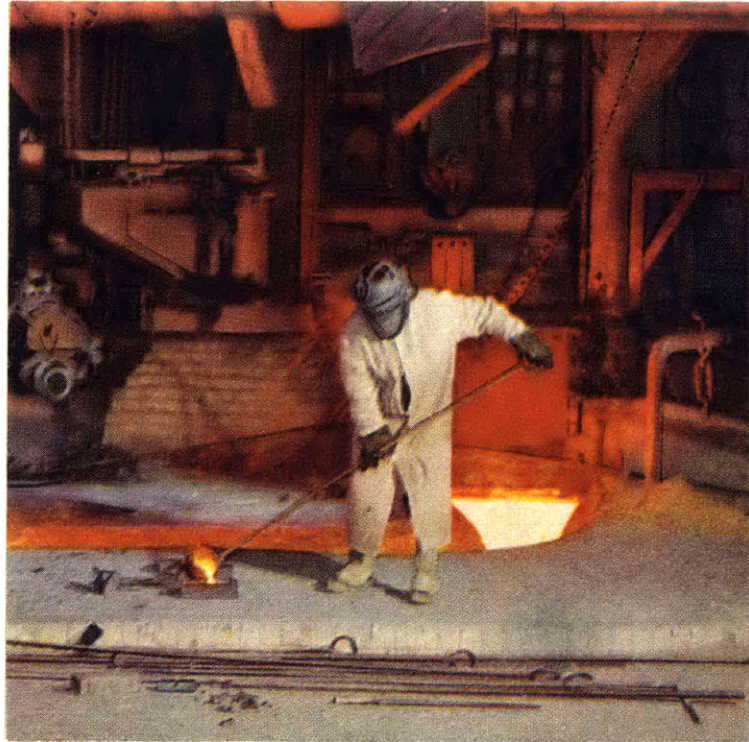
In the metals field, the story is similar, of some 80 metallic elements, less than 30 have been developed to economic significance as metals or alloying agents, and atomic research is increasing the list.

Some metallic elements have important uses as ions or chemical compounds but this does not alter the possibilities of their use in metallic form. Rarity makes it probable that some metals will never be of commercial importance, but as research goes on, discovery of very special properties could make these metals of exceptional economic significance.

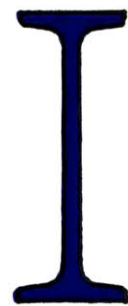
Others among the "unused" metals have properties that do not make them useful at the present stage of technology. The remainder are not used because technology has not advanced to the point where usefulness can be recognized. Current information is just sufficient to suspect that these unused metals constitute a reserve from which can be drawn new and unusual materials to supplement more familiar ones in building the industrial future. Research is the key to this reserve and coupled with research in other fields, their progeny is beyond the realm of current comprehension.

Industrial research has also produced profound changes in the approach to scientific experimentation. The time honored system of the autonomous experimenter, working on his personal project, has given way to the highly organized research team of many different talents. Industry, necessarily needing quick results, followed the reasoning of the old algebraic problem; if one man requires N hours per job, how many hours are required for N men per job. To everyone's surprise, the research team demonstrated that it was a synergetic group, for it has been proven time and again that in modern complex scientific research, the sum of the efforts of many persons working together is greater than their individual contributions working separately.

A final factor in the development of research has been public recognition of the value of science and the research function. Through the efforts of the advertising profession, scientific writers, spokesmen of industry, and others, the general public has become attuned emotionally and intellectually, and has developed increasing faith in science and research. Public demand for the newest and best is a powerful force behind industrial research. Add to this the factors of great technological advancement, and vast area of untouched materials, the synergy and quickness of collaborative research, the fact that each dollar spent for research yields approximately \$36 in return, and it is evident why industrial research is a requisit of industrial survival.



THE PROBLEM



THE PROBLEM

In steel making operations, research and production have an exceptionally close relationship. There are many reasons for this relationship, but basically, the large capital investment in equipment and scientifically trained men required for production requires both men and equipment to be utilized on a double duty basis. Carrying this procedure logically to the divisional level, Bethlehem Steel has a wide network of research facilities scattered throughout its various operating divisions.

The primary consideration regarding the proposed new research facility was a matter of direction and policy. Two choices as to type of facilities were apparent. First, the laboratory could be developed as a central research plant incorporating all phases of research under unified direction that was closely associated with the main office. Or, second, it could be developed as a research adjunct of the steel producing division in direct liason with the Bethlehem Plant. The second proposal was adopted because it closely followed the pattern of current research activities, yet would allow consolidation of steel division research. Obviously, it would be of smaller proportions than proposal number 1, hence retaining the necessary atmosphere for direct interaction and mutual stimulation by the scientific personnel. Also, by consolidating research activity to some degree, a widely trained group could be brought together and have the capacity to solve problems too large or broad to be handled effectively by any one of the Company's operating divisions.

Having established the framework for the proposed laboratory, a study was made to determine the various fields of work to be incorporated in the laboratory. The five major fields are:

1. Metal Processing
2. Metallurgy
3. Ceramics
4. Chemistry and Chemical Processes
5. Physics

plus the necessary Services and Administration.

Simultaneously, a study was made of the required types of space and facilities for each of the component categories. This of course lead to the very practical consideration of how large the laboratory plant should be, and how, when, and what type of expansion should be considered.

As is documented in this Program, the current proposal calls for approximately $\frac{1}{4}$ million square feet of laboratory complex. However, in view of the present trends in research activity it seems exceedingly doubtful that the laboratory would long remain that size and that expansion constitutes a major problem in the design of this laboratory. Keeping in mind the expected expansion of research nationally, and the fact that the steel industry carries a research budget slightly under the national average, I am making the assumption that expansion will be 2 or 3 times the size of the presently proposed laboratory complex. Hence the problem of this thesis incorporates the primary development of the laboratory and the logical extension of basic concepts to the development of a larger order in the future.

Regarding the primary laboratory complex, certain requirements became evident in the preliminary study that need special attention in the problem.

1. Flexibility - Problems and methods of experimentation are always changing so that flexibility of partition, furniture, and service arrangements should be as great as possible.

2. Universality - As investigational projects change, space requirements and experimental equipment to be housed in the space will change also. Therefore, it seems desirable to design buildings in which the space should be "universal space" where any research facility could be installed in any area desired.

3. Interrelation of Sections - Free interchange of ideas among all scientists is of primary importance. Hence, the separation into distinct self sufficient, autonomous groups should be avoided.

4. Specialization of Buildings - The chronological order followed by research projects is:

a. Small scale or "test-tube" experiments seeking new processes or trying theoretical hypotheses.

b. Large scale or "batch-size" experiments to prove or improve results obtained in small scale tests.

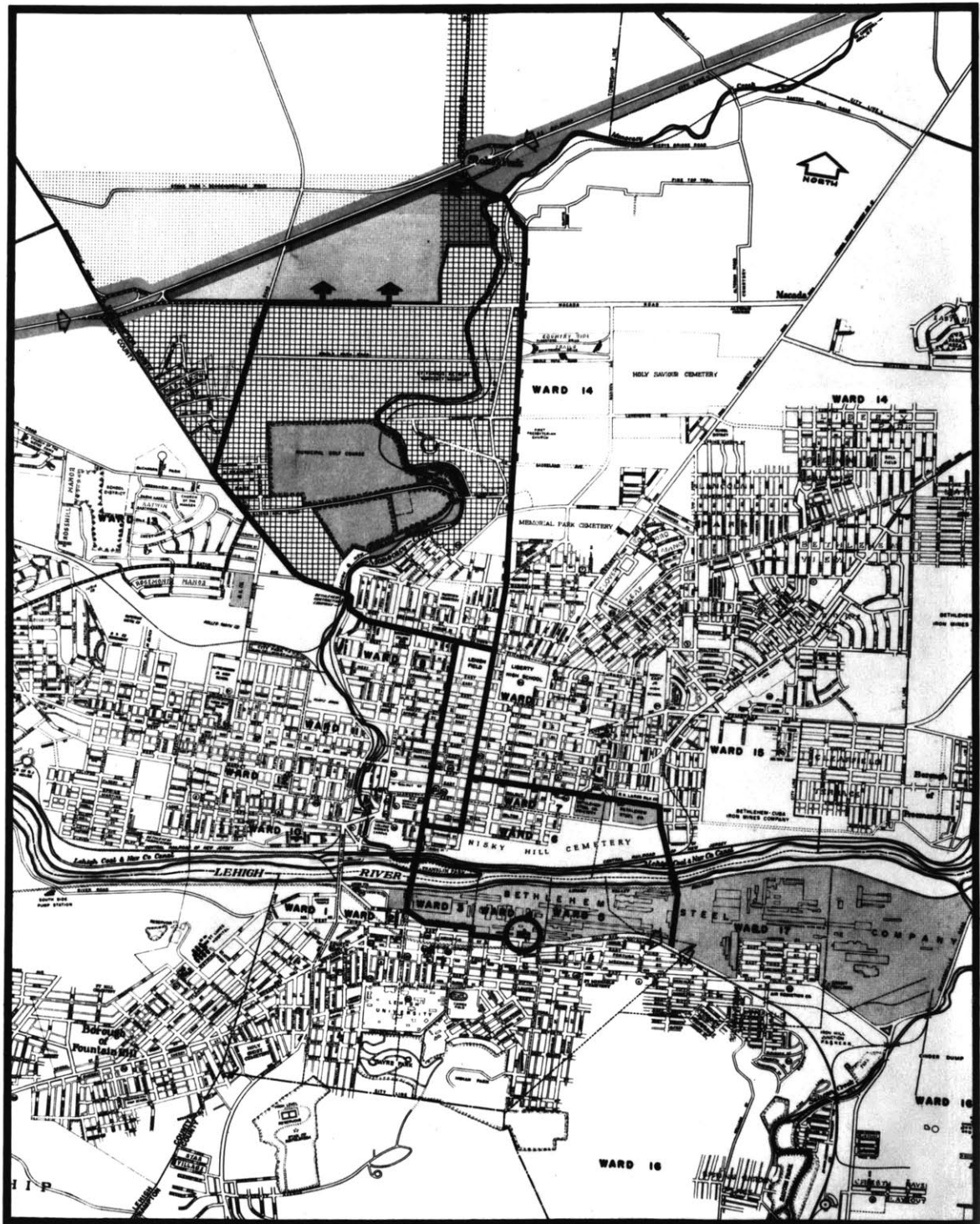
c. Semiproduction or "pilot plant" operations with products or processes which show promise for full scale production.

The building complex should recognize the relationship of these functions as much as possible in the design of the various types of space required.

5. Cleanliness - There is a wide variance in the relative cleanliness of the various functions of the laboratory and the design should reflect the necessary requirements for good housekeeping.





The site is a 242.1 acre tract of rolling farmland located 3 miles north of the main office and plant of the Bethlehem Steel Company. The site lies in Hanover Township which extends as a wedge, south, to within 3/4 of a mile of the center of the City. Some municipal facilities are located in the Township and there is an indication that it will be incorporated into the City of Bethlehem. At present, the Township has a zoning ordinance of its own and it should be noted on the following map that the major portion of the site is in the "B" residential zone. The eastern portion of the site lies in the "A" residential zone. The entire site is being rezoned to light industrial but in the site planning, cognizance of the effect the laboratory will have on the area must be carefully considered.

The northern boundary of the site is U.S. Route 22, a superhighway, and the principal link due west from New York City to the Pennsylvania Turnpike at Harrisburg. The site comprizes, in part, a hill overlooking this highway and the design of the laboratory should consider the impressions gathered by the thousands of motorists who pass by daily.

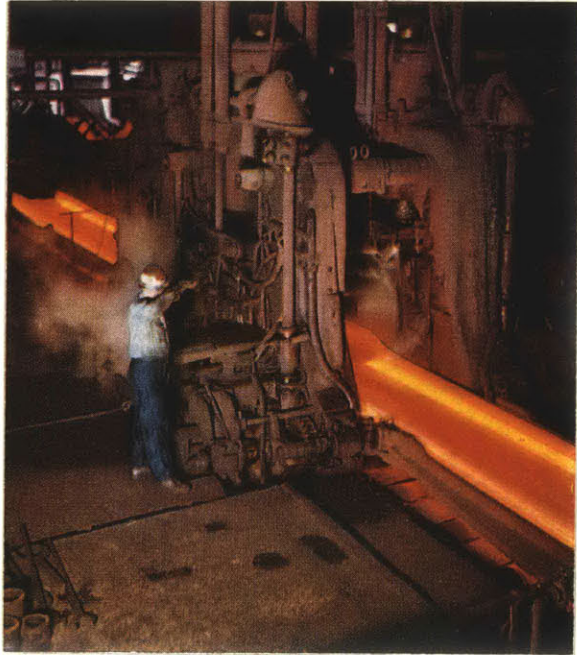


CURRENT ZONING OF SITE & ADJACENT AREAS

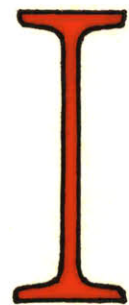
	"A" RESIDENTIAL ZONE
	"B" RESIDENTIAL ZONE
	PARKS OR PARKWAYS

	SITE & BETHLEHEM STEEL CO. PROPERTIES
	MAIN OFFICE OF BETHLEHEM STEEL COMPANY
	PRINCIPAL ROUTES FROM MAIN OFFICE & PLANT
	PRINCIPAL ROUTES FROM OTHER URBAN AREAS





THE PROGRAM



THE PROGRAM

The requirements of the Primary Group are divided into seven rough categories:

1. Metal Processing
2. Metallurgy
3. Ceramics
4. Chemistry and Chemical Processes
5. Physics
6. Services
7. Administration

From the analysis made of requirements, 4 types of space were developed:

1. Offices
2. Laboratories
3. Pilot plant or work areas
4. Storage, shop or service areas

In addition, the following factors are included:

1. Standard or high bay areas
2. Air conditioning
3. Special hooding or radiation shielding
4. Vibration
5. Temperature control
6. Cleanliness

Area Required - Sq. Ft.

<u>Function</u>	<u>Office</u>	<u>Labs.</u>	<u>Pilot Plant</u>	<u>Storage</u>
Metal Processing				
rolling mill			3500	
Al & Zn coating			7760	
wire draw., welding, etc.	1000		9960	
Metallurgy				
physical metallurgy	864	5700	6780	
steel production	580	900		
process metallurgy	720	1500	8550	
Ceramics	720	2850	5000	
Chem. & Chem. Processes				
dir. reduction pilot plant			8600	
coke & byproducts	870	1800	6000	
ore beneficiation	570	3600	9600	1125
general stock room		1750		
electroplating	1950	2850	9900	
organic coatings		1200		
surface prop. (corrosion)	144	1800		
analytical chemistry	288	1800		
Physics				
x-ray difrac. & electr. micr.	288	1200		
physical measurement		900		

<u>Function</u>	<u>Area Required - Sq. Ft.</u>			
	<u>Office</u>	<u>Labs.</u>	<u>Pilot Plant</u>	<u>Storage</u>
Physics (contd.)				
nucleonics	114	900		
electronics	114	1500		
mass spectroscopy	114	300		
spectrography	1870	5550		
Services				
photography	114	600		
duplicating		600		
drafting	114	1200		
library	216	1200+		
cafeteria		1500+		
kitchen	114	900+		
dining room		600+		
meeting room		900		
conference room		450		
first aid		450		
lobby & display		1100+		
storage and maintenance				13500
building maintenance				1500
machine shop			6000	
boiler room			2500	

<u>Function</u>	<u>Area Required - Sq. Ft.</u>			
	<u>Office</u>	<u>Labs.</u>	<u>Pilot Plant</u>	<u>Storage</u>
Administration				
offices	1730			
stenographic pool	600			
<hr/>				
Sub Totals	13274	45600	84150	16125
	Total Required Net Area			159,319 sq.ft.
	Offices at 70% eff.	=	18,950	
	Labs. at 55% eff.	=	82,900	
	P.Plant at 65% eff.	=	129,400	
	Storage at 75% eff.	=	21,500	
	Total Required Gross Area			252,750 sq.ft.

Functions grouped by physical factors

All offices, where practicable, will be air conditioned.

Bench laboratories, relatively clean and quiet in nature, are capable of being combined with offices. These will be air conditioned and the same standard height as offices. The labs included are:

physical metallurgy and metallography

steel products

physical chemistry and process metallurgy

spectrography and spectroscopy

electronics

nucleonics

physical measurements
electron microscopy and x-ray diffraction
corrosion
coke chemicals
ore beneficiation
general analytical
creep
electrochemical

Clean work areas and laboratories that do not require high bays or crane service may be grouped with other laboratories and offices. Due to the nature of the work carried on, however, the following group cannot be air conditioned.

machine shop
heat treat shop
welding lab
mechanical testing lab
machinability lab
ceramics lab
wire drawing lab

Clean work areas, not air conditioned and requiring high ceilings and crane service are:

structures testing lab
rolling mills
heat treating pilot plants (continuous annealing, etc.)

electroplating pilot lines

Al & Zn coating pilot lines

Moderately dirty works areas requiring high ceilings and crane service plus special facilities for erection of large pilot plants are:

metal processing pilot plant area

melt shop

process development area

Very dirty work areas that should be well removed from other research or residential areas are as follows:

chemical processing pilot plants

coke ovens

sintering pilot plant

ore beneficiation pilot plant

Functions listed under 'Services' should be located and handled in a manner commensurate with their use.

Laboratories requiring vibration and temperature control are:

mechanical testing

creep testing

physical measurements

spectrography

Radiation shielding is required in the tracer lab.

Supply of Services

The following services are potentially required in all laboratory

areas:

hot water	oxygen
cold water	compressed air
lab drain	rough vacuum
gas	steam
120/208 v 3 phase	60 cycle electricity
265/440 v 3 phase	60 cycle electricity
telephone	

Access to Laboratory

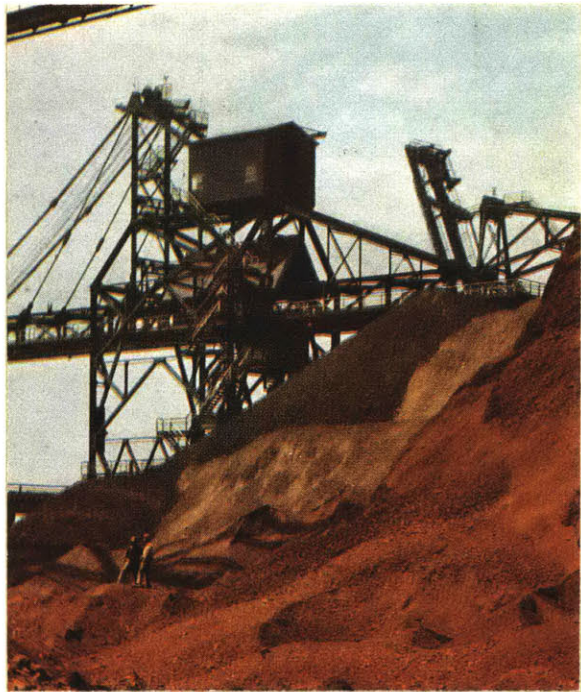
Access to the site should be provided from the two interchanges on Route 22, and from the principal north-south routes.

Parking

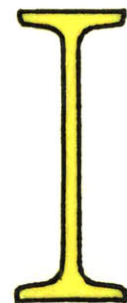
100% parking is desired. The estimate for the primary group is 500 cars.

Materials Transportation

A rail spur is required with adjacent facilities for the storage of rail transported materials. Supply to the various buildings will be by truck or pipe.



THE SOLUTION



THE SOLUTION

The preliminary studies gave evidence that the principal moving part of the laboratory is the scientist himself, moving from office, to laboratory, to project area, in pursuit of his work. The pattern of this motion is completely flexible and the space encountered or required by the scientist should reflect this ever changing motion or progress.

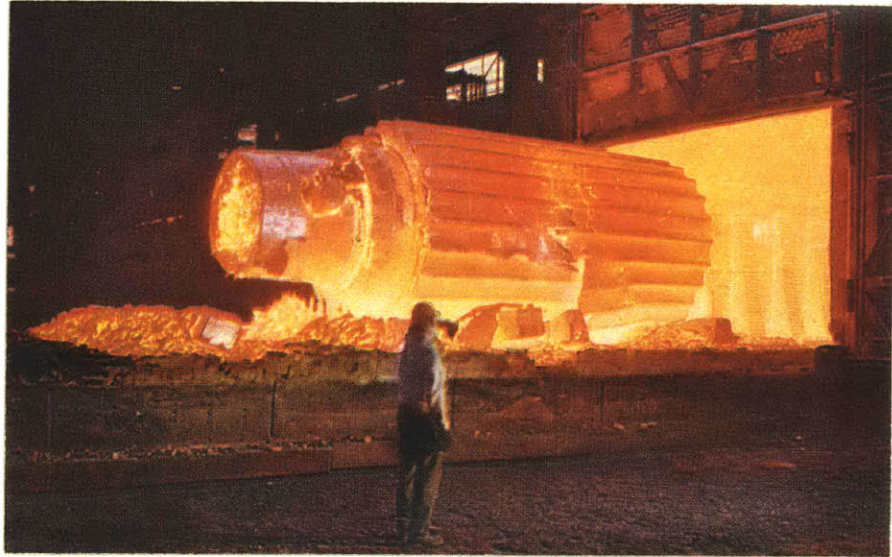
With this in mind, the design has been developed around two compatible modular systems, one for office or laboratory use, the other for large work areas, having the capability of blending into or out from each other, and allowing growth or recession as the demand changes. The core of the complex is the circulatory system which includes circulation and all services. The complex develops outward from this core in stages, through interior functions, to exterior functions, to parking and access.

Since the laboratory is ultimately a controlled environment for the most efficient functioning of men's minds, that environment must represent more than the physical implementation for the development of ideas. It is the author's belief that the psychology of space has a direct bearing on the enhancement of creativity, the stuff of which higher productivity in research is made. The attempt in the design, therefore, is to create spaces, with void and solid, of large enough scale to give freedom to the eye and hence thought, yet controlled to prevent

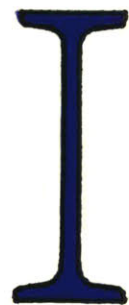
overpowering distances or size. Monumentality is inspiring, but it would defeat its purpose if sacrifice was made of human associations and scale.

In the development of the larger projected complex, expansion was found to increase in either a linear or exponential pattern. This presented no difficulty in the development since it was of finite value. However, the purpose of physical expansion, the enlargement of the research team, produces a dichotomy at some indefinite order of magnitude. At this point, the weight of numbers of personnel causes the cohesive group to splinter apart into small segments. This destroys the philosophy around which the laboratory was planned and hence makes the plan meaningless.

In searching for some maximum levels for group and intergroup participation, the author has found no conclusive statements. Therefore the assumption has been made that expansion of the laboratory should be subdivided into physical groups not larger than the primary complex, and that integration of the second order commences at this stage. As there is no validation for this assumption, the projected future plan is presented only as a possible architectural composition.



DESIGN



BIBLIOGRAPHY

Architectural Forum

General Motors Technical Center. 93 (Sept. 1950) 129;
95 (Nov. 1951) 111; 104 (June 1956) 121.

Bethlehem Steel Co.

Bethlehem Review. Sept. 1955 through June 1956.

Furst & d'Arcy

Versailles. Vienna: Waldheim-Eberle, 1950.

Gromort, G.

Grandes Compositions Executees. Paris: Auguste Vincent, 1910.

Leech, Robert C.

The Metals and Ceramics Building at the General Electric Research Laboratory. Schenectady: General Electric Co., 1955.

Maier, Otto

Neue Industriebauten. Ravensburg: 1954.

Race, H.H.

The Research Laboratory Builds a House. Schenectady: General Electric Co., 1948.

United States Steel Corporation.

Applied Research Laboratory. Monroeville: 1955.

Williams, Clyde

Trends in Industrial Research. Columbus: Battelle Memorial
Institute, 1955.