RESEARCH LABORATORY RECORD

THE PIONEER MAGAZINE DEVOTED TO RESEARCH AND INDUSTRIAL LABORATORIES

NATIONAL ACADEMY OF SCIENCES NATIONAL RESEARCH COUNCIL BUILDING

THE National Academy of Sciences, a body of active scientific workers, was incorporated by Act of Congress approved by President Lincoln in 1863, for the purpose of investigating and reporting upon any subject of science or art, whenever called upon by any department of the government.

The National Research Council, as an agent of the National Academy, is devoted primarily to the promotion and cooperative coordination of scientific research, rather than to actual conduct of research. Its members include professional scientific men and a representation of men of affairs interested in industry and fundamental and applied science.

NOVEMBER, 1932

NEW

All Automatic Burettes

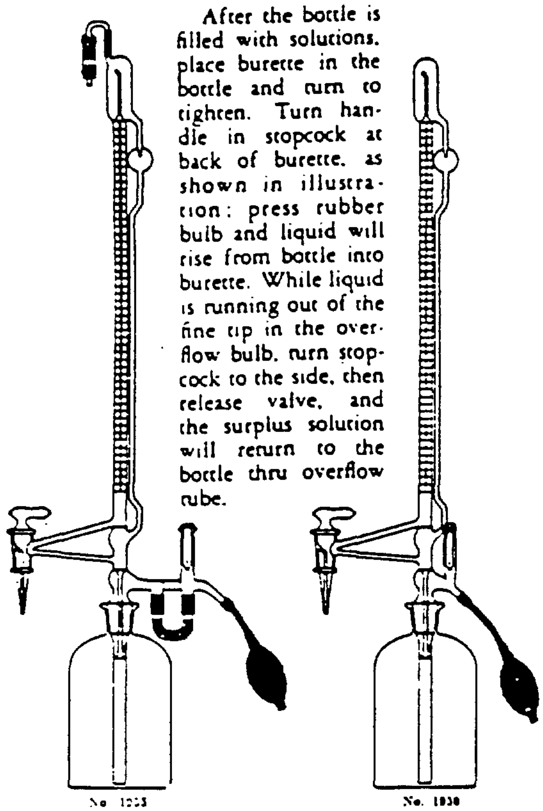
Made of Corning resistant glass with interchangeable ground glass joints and stopcocks. These are more efficient than any other style of automatic burettes on the market.

The lines on these burettes are just as fine as on regular glass, thru our new etching process, and the graduations are guaranteed to be accurate.

The zero point, or meniscus, thru the arrangement of the fine tip in the overflow bulb sets itself in automatically regardless of the kind of solution used. This is one of the outstanding features of this instrument.

METHOD OF OPERATION

After the bottle is filled with solutions, place burette in the bottle and turn to tighten. Turn handle in stopcock at back of burette, as shown in illustration; press rubber bulb and liquid will rise from bottle into burette. While liquid is running out of the fine tip in the overflow bulb, turn stopcock to the side, then release valve, and the surplus solution will return to the bottle thru overflow tube.



No 1955 No. 1950

BURETTE No 1955 is made for alkali solution, with a U shaped drying tube filled with soda lime to eliminate CO_2, connected to the burette with rubber tubing, making it easy to replace soda lime. There is also a drying tube at the top of the burette connected with rubber tubing. The prices on this type of burette are 10% above those of our No. 1950.

Nos. 1950 and 1955 can also be furnished with a blue stripe, so called, Schellbach glass. The prices are the same as on the Nos. 1950 and 1955 in resistant glass.

No 1950 capacity, ml.	10	25	50
Graduation subdivisions	1/20	1/10	1/10
Capacity bottle ml.	1000	1000	2000
Price complete	$8 50	$9 00	$10 00
Bottle only	$2.00	$2 00	$2 00

We also make a MICRO BOTTLE (No 1960) of Corning resistant glass, with interchangeable ground glass joints and stopcock.

No 1960 capacity, ml	1/10	1	2	5
Graduation subdivision	1/1000	1/100	1/100	1/50
Capacity bottle, ml	1000	1000	1000	1000
Price complete	$9 00	$9 00	$9 50	$9 00
Bottle only	$2 00	$2 00	$2 00	$2.00

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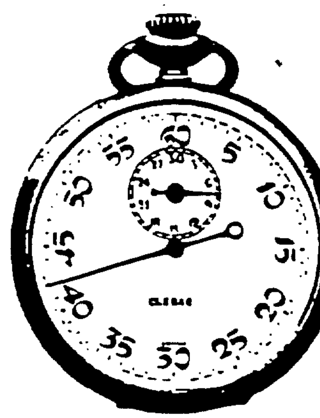

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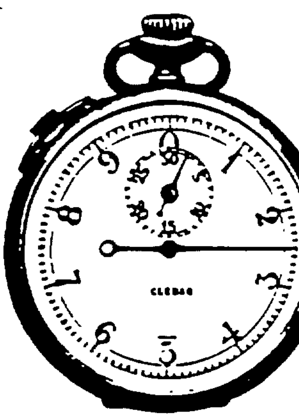

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VOL. 2. No. 2

RESEARCH LABORATORY RECORD

NOVEMBER, 1932

THE PIONEER MAGAZINE DEVOTED TO RESEARCH AND INDUSTRIAL LABORATORIES

EDITORIAL . . .

"Does Research Pay?"

DESPITE such convincing answers as cellophane, bakelite, and hundreds of other profitable products of research the question still is asked in some quarters—Does Research Pay? It has been more exactingly and severely queried during these present troublous times.

We present here some informal expressions on the subject by an outstanding research executive who asked that his identity be withheld, but who nevertheless advocates that RESEARCH LABORATORY RECORD open up the topic editorially. We are reproducing his remarks as close to verbatim as possible:

"When I started in research 25 years ago I had two ideas about it: first, that research is profitable; second, that I could select any research problem and state in advance that it would be remunerative. Now, my first idea was really conjectural—I THOUGHT research was profitable, but I was CERTAIN of my second idea, and confident of my ability to prejudge the profitability of any given problem.

"Now, 25 years later, the first idea is no longer conjectural. I am POSITIVE from years of proved experience, that research is profitable but I am equally positive that I cannot select any given research problem and prejudge it to be remunerative. I am speaking of research, not of development.

"About 10 years ago the president of my company asked me to present to him the program of projects, and he would select the ones for which appropriations could be made, on the basis of their profitability. I told him he couldn't do it, because he knew nothing about it. I also told him that I couldn't do it, because I knew nothing about it. Selecting research projects is like betting on a horse race. Only one can win.

• • •

"THE research man who has cut down on research during the depression doesn't believe in research. If research pays, and I believe it does, it won't be reduced. If a million dollars spent on research produces a million and a quarter dollars of return, anything short of a million dollars spent gives the lie to the sincerity of the man who says he believes research pays.

• • •

"If I were the autocrat of my company I would never stop appropriating money for research, because research always pays. If 99 out of 100 research problems are worked out at a loss the one that succeeds more than pays the cost of the failures."

THE EDUCATIONAL INSTITUTION AND INDUSTRIAL RESEARCH

"Without encroaching upon the field of (commercial consulting firms and laboratories) and in fact while furthering their best interests, it is entirely possible for the educational institution to be of service to industry in a vital way by reason of its unique staff or facilities, its purposes and its position in the community."

By DR. VANNEVAR BUSH

Vice President and Dean of Engineering
Massachusetts Institute of Technology

IT IS the object of this paper to analyze the proper relationship of an educational institution to industrial research. The principal problem considered here is that of the privately endowed institution, although some of the analysis applies to state-supported institutions as well. The writer, of course, will draw his conclusions largely from the experience at the Massachusetts Institute of Technology, although it is hoped that the analysis is of more general applicability.

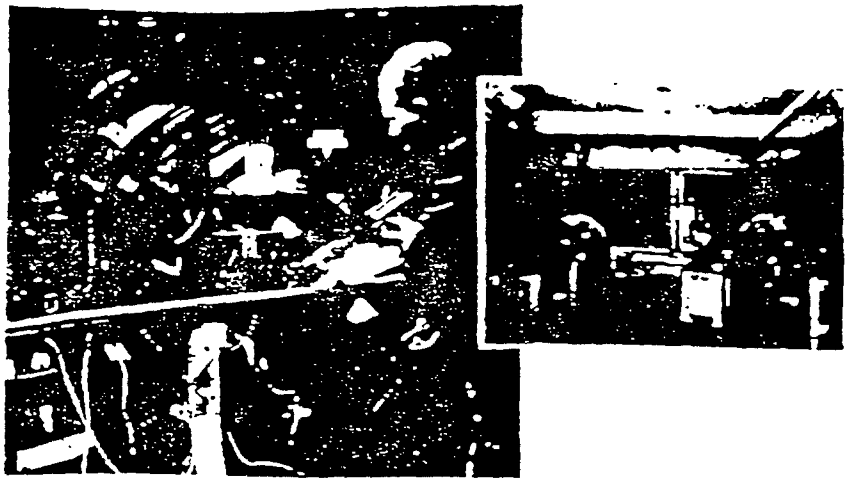
Certainly there is a part that the privately endowed institution can play with complete propriety and with some advantage not only to industry but also to its own educational processes. The problem then resolves itself into the delimitation of the field in which such activities can properly be carried out, and the means by which contacts may be furthered with these purposes in mind.

Where an institution has unique facilities, an outstanding staff of specialists, and a location in the midst of intense industrial development, it is certainly incumbent upon it to play a part in the industrial world about it, not only because its existence may thereby become a matter of greater utility to industry, but also because the resulting relationships when properly nurtured are capable of exerting a profound and beneficial influence upon its educational processes. This is especially true in a case of a school of engineering, where the relationship between the pedagogical processes and many types of industrial problems is particularly close; but it applies as well to an institution of science, where that science is applied, whatever may be the field.

Institution Should Not Compete

IT IS also evident at the outset that an educational institution should not attempt to usurp the province of the consulting engineer, nor should it attempt to compete with those independent industrial research laboratories which have been created specifically for the purpose of serving industry in its problems. It is not necessary to encroach upon these fields in order to render real service, for the educational institution is a far different affair from either of these, and as it has a unique position so it has a unique opportunity.

The main funds of a privately endowed educational institution have been supplied for educational purposes. In many instances they are also provided for research, but academic research, research in the field of pure science, and often many



Left—A new type of stroboscope, in use at Massachusetts Institute of Technology to study the behaviour of machines operating at high speed. When this photograph of a 160 h.p. motor was made, the machine was running at full speed and the letters S and N on the north and south poles of the rotor were moving past the camera lens at a rate of 95 miles per hour ground speed.

Inset—The network analyzer, used for the solution of power system problems by reproducing the network and its operation on a reduced scale.

which its presence can have upon students while it is employed on such projects, and secondly, that it should be available for problems of industrial interest which it is expected will be published and of benefit to large groups. If the time should come when it is capable of being applied to closed research problems without interfering with these primary purposes then it undoubtedly should be so applied if the need arises.

A third illustration occurs in the so-called network analyzer.* This is an electrical network, arranged with switching and metering facilities, on which can be reproduced in miniature the electrical equivalent of the important part of practically any power system of the country. When thus duplicated in miniature the system can be studied for its performance under unusual conditions, and proposed extensions with their effect on performance may be investigated. There are only two devices of this sort in the country which are thus available for the reproduction of a variety of power systems, although some companies have miniature reproductions of parts of their own systems. It was constructed by cooperation with the General Electric Company, which contributed to its cost.

There were two reasons for undertaking this development, first, it has direct utility in solving the problems of power system engineers and hence gives aid in the extension and proper utilization of such systems of great importance to the public; second, it is a research tool which in the hands of students and staff is capable of advancing knowledge in a general way so that power systems may be better understood. Both functions have been important in its use. Of course the results of research and of general studies have been published and made generally available, but many of the problems which have been carried on with its aid have been studies of specific systems of interest only to the public utility to which the systems belong.

In these cases it has been made available at a charge which would reimburse the Institute completely for its cost of operation and provide a fund for the amortization of its initial cost. The charges have been adequate to include all items of expense, such as labor of assistants, minor use of materials and the cost of space, power, light and so on, together with a percentage to cover the cost of supervision. From the fund thus built up it is expected to amortize the initial cost over a period of years, although this period remains somewhat indefinite in view of the present business situation, which has prevented power engineers from utilizing it as much as they would perhaps like to.

The other instrument of the sort was constructed by Westinghouse Electric and Manufacturing Company undoubtedly with the same general purposes in mind, and it has been similarly useful for power system studies. There was the closest of cooperation between the company and the Institute, as the two developments were carried on simultaneously, and the experience of each group was of assistance to the other.

Consulting Laboratories Use Facilities

NOW there is no doubt that with unique facilities there is an obligation to make them useful, and there can be no question in a situation of this sort of interference with independent consulting agencies. In fact consulting agencies frequently come to us to use such unique features for the benefit of their clients.

The second type of research in which the educational institution may properly engage is that involving the cooperation between individuals who are specialists in widely separated fields, seldom found together except under academic auspices.

The research problems facing the textile industry at the present time require a comprehensive study involving questions of chemistry, physical chemistry, physics, mechanical engineering, biology and so on.* In this country at the present time there is no textile research institution so situated that it can bring to bear the attention of all of these diversified groups. Yet under a single roof at M.I.T. will be found men

* "The M.I.T. Network Analyzer," M.I.T. Publication January 1930 and "The M.I.T. Network Analyzer," M.I.T. Publication April 1931.

* "Textile Research: A Survey of Progress," compiled by U. S. Institute of Textile Research, Inc., published by the Technology Press, Cambridge, Mass.

who are active not only in these various branches, but also in various special aspects of them. There is a real benefit therefore to be here derived from textile research, especially when the work is carried on in close cooperation with other textile research organizations, and the results are made immediately available by publication to the entire industry.

Certain branches of science have become so highly specialized that there are very few men who are thoroughly versed in many specific aspects. Another common situation is that in which only perhaps a single engineer has had the exact professional experience which will enable him to answer a given question immediately and authoritatively, where an equally competent engineer without the experience would have to conduct an investigation. When problems arise which require the services of such men on the staff of an educational institution it is to the best interests of all for the institution to aid in any way possible in the making of fruitful contacts. This situation is again well recognized by consulting firms, who are able to give better service to their clients by being able to cooperate with an educational institution and its staff.

Preliminary and Educative Research

FINALLY we have the type of research which is in essence preliminary and educative. It sometimes happens that an organization considering seriously embarking upon a research program can take advantage of a preliminary study made by a group who have had contacts with a variety of such endeavors. Once the project is under way it may well be carried out by the formation of a research department within the organization itself, or by the subdivision of the study and its allocation to various research agencies, and particularly to commercial laboratories. At the outset however, there is need for a preliminary survey of the field in order that a decision in regard to the soundness of the project may be intelligently arrived at, and this survey can sometimes best be conducted by an institution which is not financially interested in any way, and then its conclusions are the more readily acceptable. Where there appears to be an opportunity, therefore, to make a preliminary study which will result either in the furtherance of research where research is proper, or in the turning aside of an ill-advised project, it is sometimes incumbent upon an educational institution to lend its aid.

Research of the semi-closed or open type is more readily justifiable in an educational institution, and it is not necessary that conditions such as above outlined obtain in order to render it desirable. Here the educational institution has a stake in the research because of the beneficial influence which it may have upon staff and students. Especially when the research is completely open, so that its progress may be reported upon in staff gatherings, its problems discussed with advanced students, and its results promptly published to advance the prestige of those who make valuable contributions, there is a stimulation to staff and students which is very valuable.

The institution is often justified in carrying on scientific research, or engineering research of a fundamental nature, entirely at its own expense as a vital link in any well conceived advanced educational process with those very objects in mind. Where the objects are fully attainable in an industrial research, the institution is very well justified in contributing a part of the cost in a cooperative effort with industry. Of course in order to attain the objects, the research must not only be open, but it must also be truly scientific and of broad significance. There is no such benefit to be derived from the presence of routine testing.

Training Industrial Research Workers

THERE is another reason which often justifies the carrying on of industrial research of semi-closed or, better, of open type. This is when such work can serve for the training of industrial research workers in the atmosphere of an academic institution. When the research worker is also a graduate student and taking courses, the process is in fact part of the pedagogical scheme. He may also be an individual who is loaned by an industry which contributes all or a part of his expense during his training period. There is here a natural and effective process for cooperation in the selection and training of men and their introduction into suitable permanent positions in industry. This feature may in fact be the major interest back of the research, and the expected material results may be secondary. Forward-looking concerns with important research activities of their own are already taking advantage of the possibilities of this arrangement.

There is one further basis on which research may be justifiable within the walls of an educational institution, but this has not yet been thoroughly thrashed out and it raises an exceedingly important problem in our national economy. *Is there a duty on the part of an educational institution to furnish unprejudiced, uninfluenced information to the public in regard to the value of products which the public is constantly asked to purchase?* Certainly it would appear that such a service might well be of real public benefit, if carried out in a thorough-going scientific manner, conscientiously, and entirely free from commercial bias. It appears also that the individual purchaser is in a woefully weak situation, as compared to the purchasing agent of a large organization in regard to his meagre knowledge of the things he buys. If it could be demonstrated that there would be an actual benefit to the educational processes which would follow the undertaking of such a public service to a sufficient degree to fully compensate for the well recognized difficulty of carrying out such a program effectively, then there is a justification for the work from the standpoint of the privately endowed institution. Such a relationship does not appear to exist in any generality although it may well obtain in certain restricted fields. Unless the pedagogical benefit is large, there is certainly no justification for spending the funds of the institution in such a project unless indeed they are contributed for the specific purpose. It should then, if undertaken, be placed on such a financial basis that it is entirely self-supporting when all costs are accounted for, and this financial return should be provided for in such a way that it cannot possibly influence the detached nature of the work. Now if such a set-up can be arranged from a financial standpoint, it would appear that there are other agencies which could carry it on just as well as an educational institution provided they are equally independent. The problem therefore revolves about the intimacy that is possible between such a project and the general educational scheme. At the present time it certainly appears that this matter requires careful study and that it is yet to be resolved into a form where a solution is apparent.

Organizing Institutional Research

FOR types of research which can properly be undertaken by an institution there is necessarily some scheme of organization. This is readily provided for if there is an officer whose primary duty it is to supervise research of an industrial nature. At the M.I.T. this officer is the Director of the Division of Industrial Cooperation. Through him an outside organization may readily make contacts with the various departments and individuals of the institution. Oftentimes his function is simply to refer an inquiry to that individual, inside or outside our own walls, who can best give advice of a technical nature. Where facilities are to be used for research however, he supervises the making of a contract which provides for the proper fees and which is in accordance with the general policy of the institution. Work undertaken under such a contract may be in the hands of a single laboratory which makes its own reports and which takes the responsibility for their technical soundness. It is the policy that an individual laboratory shall in this way undertake work only for a single client, although of course work is often undertaken for a trade association which represents a large section of industry. There is no reason however, why various laboratories may not at the same time be carrying on work for different clients within a single industry. It happens sometimes that industrial organizations which are competitive are simultaneously utilizing Institute facilities, one for a problem in chemistry for example, and another for a problem in mechanics. In every contract the emphasis is placed on the desirability of open research and a very large fraction of the work carried on within the walls of M.I.T. is promptly published and made a matter of general knowledge.

There are three parties in this consideration of the industrial research situation; first the industrial organization, with or without its own laboratories; second, the commercial consulting firms and laboratories; and third, the educational institutions. *Without encroaching upon the field of the second and in fact while furthering their best interests, it is entirely possible for the educational institution to be of service to industry in a vital way by reason of its unique staff or facilities, its purposes and its position in the community.* It can do this without interfering with its own educational processes, and can in fact improve them by the contacts produced. This service it stands ready to perform.

TECHNICAL EDITOR APPOINTED

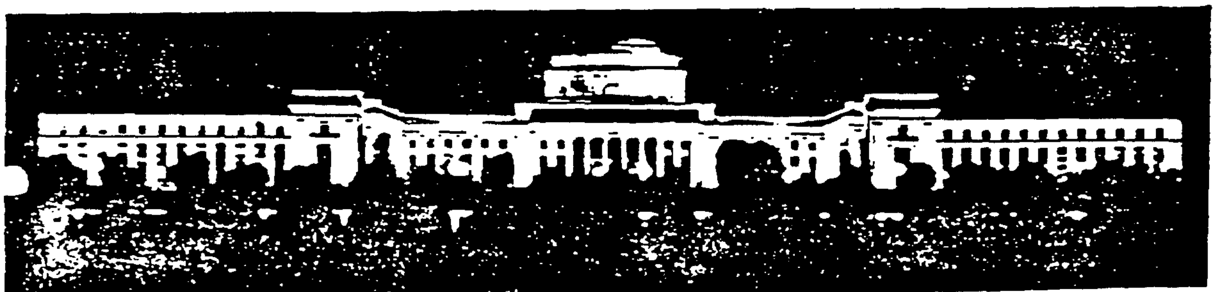
RESEARCH LABORATORY RECORD announces with this issue the addition to its staff of Emery L. Lasier as Technical Editor.

Mr. Lasier's scholastic preparation for his work as a consultant in engineering research, production and distribution, was made at George Washington University, Massachusetts Institute of Technology, Naval Fuel Oil School, and Alexander Hamilton Institute.

He was a member of the staff of the Materials and Engineering Laboratories of the U. S. Bureau of Standards, engineer of tests on construction work for the American Waterworks and Guarantee Company, Materials Engineer of the U. S. Navy, Chief Chemist and Materials Engineer of The Merchant Fleet Corporation, Pacific Coast Manager, John Lucas & Co., Inc., General Business and Laboratory Manager of U. S. Testing Company, Inc., and on the faculty of the Engineering Experiment Station, College of Engineering, Rutgers University.

Between 1916 and 1924 Mr. Lasier was a member of approximately 20 technical committees of the Federal Specifications Board, and is now a member of about 12 technical committees of the A.S.T.M. of which he is secretary of the New York District Committee.

He is known also for his contributions of technical papers to meetings and publications. His general experience embraces materials laboratory work, testing, inspection, specification writing, technical supervision, teaching, writing, selling, cost accounting, budgetary control and management, credits, purchases, sales, service, advertising, publicity, sales promotion, technical operation, technical research and manufacture.



INDUSTRIAL RESEARCH PLAYS IN LIFE INSURANCE

The Industrial Hygiene Laboratory of the Metropolitan Life Insurance Company

By W. J. McCONNELL, B.S., M.D.
Assistant Medical Director, in Charge of Industrial Health Service

THE Metropolitan Life Insurance Company for many years has maintained in connection with the Industrial Health Service of the Policyholder's Service Bureau an industrial research laboratory whose technical staff are engaged in the promotion of industrial hygiene, including studies in factories, shops and offices of environmental conditions affecting health, such as:

- Atmospheric pollution by injurious dusts and fumes.
- Ventilation.
- Illumination.
- Special occupational hazards.

The work carried on in the Laboratory of Industrial Hygiene has so expanded in recent years that the company is opening this November, in its new building, model physical and chemical laboratories fully equipped for the study of industrial health problems. Chemists and technicians make the required observations in factories, mills or other industrial establishments, collect necessary air samples by means of the most modern devices, and subsequently complete their studies in the Laboratory at the Home Office. In connection with field studies, air samples are taken under actual industrial conditions and analyzed for the dust content or for poisonous substances in this Laboratory. There is thus acquired definite information which furnishes a sound basis of knowledge which can serve in the full recognition of unfavorable working conditions and in the development of measures for their abatement.

The Industrial Health Service fully recognizes the confidential relationship which should exist between the Company and those whom it serves. It undertakes no field investigation except on the invitation of the insured and with his unqualified cooperation.

Specially-Designed Instruments

MANY of the scientific instruments used in these studies are designed especially for application to field studies. All instruments are calibrated in the physical laboratory before use in the field work.

Wherever the physical air factors are studied in working places, a record of outdoor conditions is made by means of the Tycos recording wet and dry bulb thermometer, with a seven-day chart, having a small electrically-driven fan for drawing the air over the thermometer bulb for determining the outside temperature and humidity conditions. For inside work, in addition to the sling psychrometer, specially constructed psychrometers are used. These consist of small electrically-driven fans for drawing the air at a velocity of 600 linear feet per minute, first over a dry bulb thermometer and then over a wet bulb thermometer, both mounted in a trumpet-shaped intake tube, painted dull black so as to avoid heat losses by radiation. The wick of the wet bulb thermometer is supplied with water in a small reservoir on the under side of the trumpet directly below the wet bulb thermometer. The whole apparatus is mounted on an adjustable stand. These instruments are set up in different sections of the plant and readings are taken at regular intervals, the number taken being determined by the rapidity of temperature and humidity changes. This type of instrument was adopted because it was found that the recording type of psychrometer was not sensitive enough to record small and rapid changes, due to the slow heat transfer, the quantity of metal, and the actuating liquid in the recording type.

The anemometer is used for measuring high air velocities and the kata-thermometer is used to determine air motion of low velocities. The kata-thermometer is an instrument designed to record temperatures in degrees proportionate to body temperatures. By measuring the rate of cooling of the kata-thermometer, it is possible to calculate the air motion.

Measuring Skin Temperatures

TO CORRELATE the significance of skin temperatures of workers exposed to high temperatures and humidities, these are measured by means of an instrument built according to specifications developed by the United States Public Health Service and the United States Bureau of Mines, cooperating with the American Society of Heating and Ventilattypes of research in applied science of general applicability, properly form a part of any comprehensive educational project. It is not possible to thoroughly train a professional engineer, whose activities in life should be the utilization of the principles of science in an economic manner for the benefit of mankind, except when such training is carried on in a scientific atmosphere, and no atmosphere can be thoroughly scientific today unless associated with vigorous and coordinated research. So the educational institution can properly devote part of its funds to research, not only when those funds have been specifically donated for the purpose of extending the range of human knowledge, but also when the research forms an integral part of the pedagogical scheme.

On the other hand, there is certainly no warrant for using the funds of a privately endowed institution for the pecuniary benefit of an individual corporation. From this it follows that where research for such a corporation is carried on, and where the expected results are of value to that corporation alone, the institution is justified in proceeding only when it receives in fees an amount completely adequate to reimburse itself for all costs.

It is convenient to distinguish between several forms of research.* First, we have what may be called closed research, conducted confidentially for an individual or corporation, with no provision for the publication of results; second, semi-closed research, which is similar, except that provision is made for publication upon release by the client; third, open research, involving no secrecy, and contemplating immediate publication of all important results; fourth, minor research, not ordinarily of sufficient importance to warrant publication, and involving short tests, library searches, or the like.

Justification of Closed Research

IN ORDER to justify the carrying on of research of the first type, not only should the fees be such that all costs are properly paid, but also it should be shown that there is a reason why the same piece of work cannot be as well carried out by a commercial agency, such as a consulting firm. This reason may appear in one of several forms. First, there is the matter of unique facilities. Second, the project may be of such nature that the cooperation of men of different specialties may be dictated where no commercial firm includes a staff of the necessarily diversified type, or it may even be of such nature that there are only one or two men in the country thoroughly qualified to advise upon it, and these men located in academic posts. Third, it may sometimes be shown that there is a basis for an initial piece of work of this sort as an introduction to a more complete program the allocation of which can then be undertaken on its own merits.

The most usual justification is that of the existence of unique facilities. Of course, just because the facilities are unique does not mean that the resulting research is necessarily of the closed type. In fact, whatever the reason for undertaking the work, there is always a powerful incentive toward making the research semi-closed or open, for to keep it closed means to forego some of the important benefits of the open type. Hence, the possession of unique facilities, while often justifying the undertaking of closed research, still more often justifies carrying on work which will result in publication, wide contact of the staff with the work, and a larger benefit than to the individual or corporation.

The nature of the unique facilities depends of course upon the field in which the institution is acting. For example, here at M.I.T. there has been constructed recently a spectroscopic laboratory which is as thoroughly adapted for its work as careful recent study could make it, and in which every attempt has been made to provide apparatus and surroundings capable of enlarging our knowledge in that fascinating field of physics to which it appertains. It is not likely that equipment of this sort would be found unique and necessary for a problem of interest only to a single corporation. Yet if that should occur, and if such a problem could be undertaken without interfering with the primary purpose of the laboratory, there is certainly an obligation to carry it on, and to render as completely useful as possible the existence of a laboratory of a sort which is rare. More probable is the opportunity to utilize such equipment for research which, while having a scientific aspect warranting publication of the results for the attention of other scientific workers, still has an industrial utility to an organization.*

Justified By Unique Facilities

ANOTHER illustration of the existence of unique facilities is the differential analyzer of this institution.** Here is an instrument which is capable of solving certain types of differential equations and which is the only apparatus in existence by which this can be done as readily. It has already been utilized on a large number of problems, and since it is primarily a research tool these problems have been quite largely of a basic scientific nature. It has been made fully available in fact to any research worker having a problem of general scientific interest, and since there are more of these than can possibly be handled, they have been given precedence on the machine in the order in which it has appeared most likely that results of scientific interest would be produced. Nevertheless, and while the machine was still in its early stages, a commercial problem arose to which the machine was immediately applicable, and which apparently could not be solved in any other way except by prohibitive labor. The problem was solved and the results were made freely available to anyone having similar problems. The attitude of the institution is quite properly that the primary use of the machine should be for the advancement of the underlying science, and for the stimulating effect

*Report of the Visiting Committee of the Division of Industrial Cooperation, M.I.T., published in The Technology Review, October, 1932.

* "New Spectroscopic Laboratory of the M.I.T.," Karl T. Compton, Physics, Vol. 2, No. 4, April 1932.

** "The Differential Analyzer," V. Bush, Franklin Institute Journal, November 1931.

ITS PART

ing Engineers. The thermo-electric method used depends on the fact that whenever two dissimilar metals are in contact an electro-motive force is set up, the magnitude of which depends upon the temperature of the point of contact. A measure of this electro-motive force is, therefore, a measure of the temperature of the function of the two metals. The thermocouple is made by welding one end of each of two wires of different metals or alloys, as copper and constantan, the junction of these wires is placed at the point the surface of which is to be measured. The copper wire goes directly to a potentiometer, an instrument for measuring electro-motive force. The other end of the constantan wire is joined in a constant temperature bath, to a second copper wire, which also goes to the indicating instrument. The thermocouple is standardized by immersion in constant temperature baths in thermos bottles, so that electro-motive force readings on the potentiometer indicate temperature directly.

The method usually employed for collecting air samples for dust determinations is known as the Greenburg-Smith impinger method. This apparatus is very efficient and readily transportable and also easily adaptable for taking half hour air samples at the breathing level and in close proximity to the worker. By means of the impinger a column of air is drawn through a glass tube, through a constricted orifice and then impinged at right angles upon a horizontal surface immersed under a liquid (either distilled water or distilled water and alcohol) in a wide mouthed Pyrex flask. Thus the surface tension of the liquid is broken down and the dust particles are entrapped in the solution. The impinger is actuated by suction supplied by steam ejectors operated by compressed air. The rate of air flow, during sampling, is measured by means of a small vacuum gauge inserted into the suction line. The flasks are then corked with rubber stoppers and transported to the Laboratory for analysis and count.

Size Measurements of Dust Particles

THE electric precipitator, an instrument designed upon the principle of a Cottrell precipitator, is used for collecting air samples for the purpose of determining particle size measurements of dust. The electric precipitator is placed in a position similar to that of the impinger. The air is drawn through this instrument by means of a small rotary fan, run by a motor, the quantity being measured by a flow meter.

Wherever grab samples of air are desired either the konimeter, an instrument much used for dust determinations in South Africa, or the Owens jet dust counter and settling chamber, a method popular in Great Britain, is used.

Equipment of the Industrial Hygiene Laboratory ready for shipment to take field studies

The samples collected in the field are subjected in the Laboratory to either a chemical analysis whenever poisonous substances, such as lead, mercury, manganese, etc., are inspected, or dust counts and particle size measurements are made of such substances as silica, asbestos, and dust known to cause changes in the lungs when inhaled.

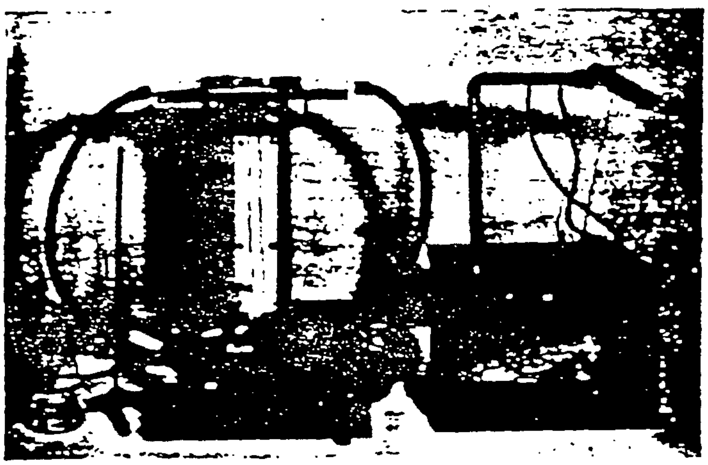
It is obvious that only particles in a state of very fine subdivision can possibly penetrate to the lung tissue. It has been commonly accepted that only particles of less than 10 microns can reach the lung tissue. A micron is one-twenty-five thousandth of an inch.

It is necessary, therefore, to count these minute particles with the aid of the microscope, using a standard procedure, in order to estimate the dosage of harmful dusts to which workers are exposed.

Microphotographs to Stereopticons

PARTICLE size measurements are made by taking microphotographs at a known magnification of the dust and then enlarging the negative further by projecting the images upon a screen by means of a stereopticon. The longest diameters of the images of the dust particles are then measured upon the screen. From the results of a sufficient number of these measurements a curve is plotted of the size frequency relations on Hazens' logarithmic [illegible] paper, the logarithms of the function measured [illegible] plotted as ordinates and the probability [illegible] as abscissæ. It is a simple procedure [illegible] [illegible]late

Air sampling apparatus in operation



Dust sampling apparatus for determination of the quantity and quality of injurious dust in dusty industrial processes. Left: Smith-Greenburg impinger. Right: Electric precipitator

from these plots, which develop into straight lines, the frequency of occurrence of dust particles of any size less than ten microns present in the particular dust under investigation.

In addition to dust analyses, other analyses, which the Laboratory is called upon to make are the determination of carbon monoxide gas escaping into rooms occupied by workers; analyses of water used for drinking purposes; and the collection and detection of poisonous vapors of all varieties escaping into workrooms, etc.

Illumination studies are conducted in factories where adequate and proper lighting is an essential factor in production and in the protection of workers. Standard methods used for measuring levels of illumination are employed. Photographs are made of hazardous processes and of the locations where samples are taken for the purposes of identification.

Recent studies of the Laboratory of Industrial Hygiene have concerned such matters as the effects upon the lungs of various inorganic dusts such as rock dust produced in hard rock drilling, the atmospheric pollution by specified poisonous substances, temperature, humidity and air movement in various industries. For example, dust studies were made in foundries and in asbestos mills and reports were prepared concerning the extent of the dust hazard and embodying recommendations for its control.

The Library Facilities

THE Laboratory has at its command exceptional library facilities to supplement the many sources of information made available through its wide and numerous contacts with health work in various industrial and mercantile organizations. The service endeavors in every instance to be of the utmost practical assistance to those who submit problems for its consideration. When indicated, visits are made to the plant to assure a comprehensive first hand understanding of the circumstances which are involved.

The study of those insured Groups showing an unfavorable and excessive sickness or death rate, make it possible to localize, by cause or sex or age group, the particular health problem most urgently calling for attack. The individual policyholder thus receives direct information of the objectives against which corrective measures should be directed.

Metropolitan's Laboratory Equipment

LABORATORY equipment in the Chemical Laboratory Room, Noxious Fume Room, Physical Laboratory Room, Storage Room, and Dark Room of the new Industrial Hygiene Laboratory of the Metropolitan Life Insurance Company, includes tables, sinks, benches, glassware cabinets, and hoods. The working surfaces, sinks, etc., are constructed of light blue-gray Alberene stone. Supports are constructed of Enameled Steel Cabinets or Enameled Steel Pipe Frames.

Table Tops These are of Alberene stone, 1¼ inches thick, supported by cabinet work or pipe frames. All tops are provided with a drip groove at the front, under the edge. Tops or working counters for fume hoods, as well as table tops on which heat work is carried on, are of 2-inch stone. A 2-inch thick hood base is provided also on fume hoods which are equipped with sliding sash.

Joints in the table tops are made flush and tight by means of the slip tongue construction in acid proof cement. The stone shelving for reagents is 1¼ inches thick and is supported by 1½-inch stone shelf supports. All exposed faces and edges of tops, high backs, and curbs, etc., are hone-finished.

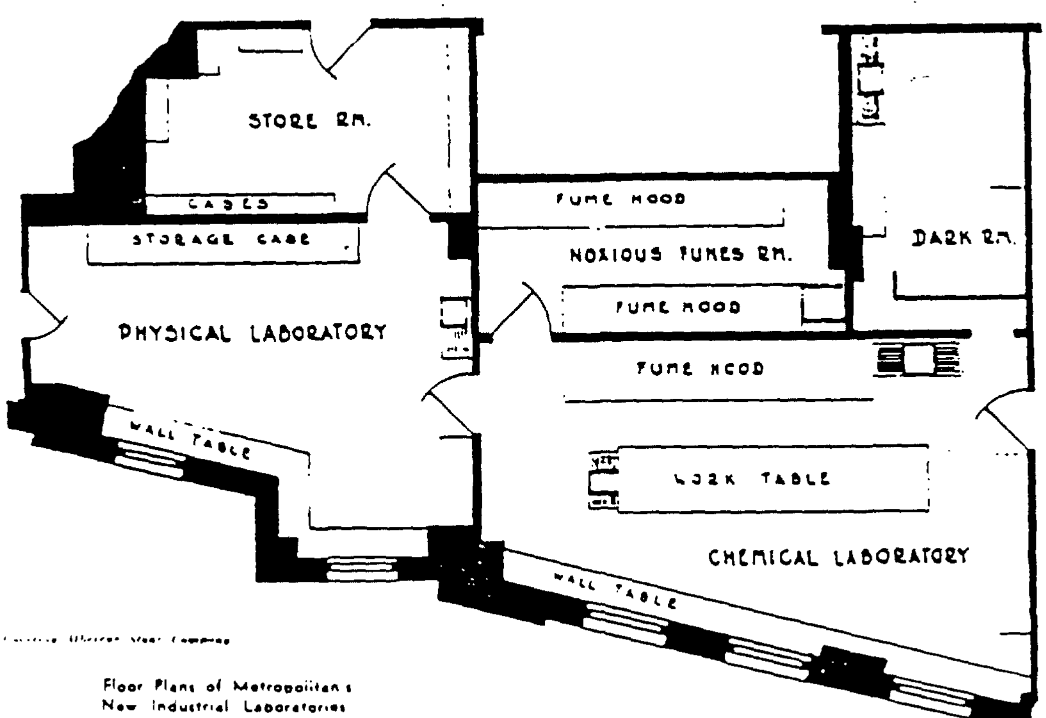
Sinks, Drainboards Laboratory sinks and tanks also constructed of Alberene stone suitable for acid work. Sides of the sinks are 1¼ inches thick with a flush bottom of 1¼- or 1½-inch thickness, grooved to receive the sides. Sinks or tanks over four feet six inches long or 12 inches deep have 1½-inch sides and 2-inch bottoms. All these sink bottoms pitch slightly to a center drain.

The drainboards or cover slabs for the sinks also are of selected stone suitable for acid work and free from veins. Slabs are grooved with parallel grooves pitching within the thickness of the stone top. Splash backs are provided for the sinks.

Fume Hoods The counter or hood base, of 2-inch thick selected stone, is supported on H frames made of 1¼-inch or 1½-inch diameter enameled steel pipe with floor plates at the bottoms of vertical standards and angle framing around the top. The counter or hood base is made of 2-inch thick specially selected stone. In all but specified cases the standard thickness, 1¼ inches was maintained. Stone backs, baffles, partitions and stone sloping roof are provided. Where light is desired at the top of sides of the hood, clear wireplate glass has been provided.

No metal surfaces are exposed inside the hood. A stone drip groove is provided in the rear of the top front lintel and delivers drip in the rear of the post supports.

An apron is provided below the counter and in the front for the reception of the hand wheels that control the varied service piping that extends inside the hoods. Clear wire glass is used for the Allegheny Metal Sliding Sash, which is balanced by lead



Floor Plans of Metropolitan's New Industrial Laboratories weights hung by a bronze chain over bronze face pulleys located in the weight boxes. All exposed faces of stone work are hone finished.

All the former stone used in the old Industrial Hygiene Laboratory was dismantled and carried to the new laboratory for reinstallation, after cleaning down, sanding, and placing it in first-class condition. Broken wire glass in the fume hoods was replaced with new clear wire glass, and the wooden sashes in the existing hoods were replaced with Alleghany Metal sashes.

Metal Cabinet Work and Enameled Steel Supports Considerable was done in the furnishing and installing of new metal cabinet work and leg supports. Former equipment of this nature was retouched and the hardware refinished for installation in the new laboratory. Specifications demanded that all sheet steel used be the best grade of mild cold rolled pickelled double annealed and patent leveled, as well as free from scale and buckle. Plates used are of the particular special grade known as metallic furniture stock.

Cupboards—Hinged Doors Uprights are made of 13-gauge steel reinforced by ¼-inch by 1-inch strike bars, electro welded thereto. The uprights are perforated with holes for fastening shelves, with five holes for each shelf, spaced 1-inch on centers.

The backs are removable, of 22-gauge steel flanged at the top and sides and bolted to uprights. The lower edge is formed up to receive rear flanges on the bottom shelf.

All plate doors are made with not less than 8-gauge steel, square, and carefully fitted to case work openings, and hung on heavy bronze hinges.

The door knobs are made of solid bronze and arranged to operate a steel latch.

The doors equipped with glass are formed of 18-gauge steel reinforced for rigidity and strength. Door stiles have a maximum ¾-inch thickness and are two inches wide. Double doors are equipped with up and down bolts concealed in the stile of the door, securing it at top, bottom, and center. Up and down members are of ½-inch round bars.

Steel Shelves in Cabinets All steel shelves are of No. 18 gauge and have a one-inch flanged face all around with flat, folded edges and an underneath return of ½-inch or more for reinforcement. All sharp edges have been eliminated and when the size of the shelf required additional reinforcement, box stiffeners were provided. These are of No. 16 gauge, three inches wide and ¾ inches return securely spotwelded to the shelf.

Drawer Construction The outside head is flat and of No. 18 gauge steel. Edges are formed into a 5/16-inch box channel section. All corners are oxyacetylene welded to prevent opening of joints and ground to a slight radius to eliminate sharp corners.

The intermediate heads are made of No. 20 gauge steel, flanged backs at sides and bottom, placed tightly against the outside head and electro-plated through the flanges to the body.

The inside heads are made of No. 18 gauge steel formed on all edges so that it could be slipped into place after the hardware was applied.

The bodies of the drawers were made of No. 18 gauge steel with sides bent up at right angles to the bottom and with top edges formed into a 5/16-inch square box stiffener. The backs are made of No. 16 gauge steel, and drawer pulls have 1.4-inch threaded shanks attached to the drawer front and held in place with nuts and lock washers.

Progressive Roller Suspensions These suspensions are formed of traveling and stationary slides the parts of which are so arranged that pressure of one member against another either upward or downward is transmitted through a hardened steel ball bearing roller, thus causing the suspension to operate freely and without friction. All parts coming in contact with the rollers are smooth and stops or bumpers are of leather or felt making operation practically noiseless. The traveling members are cross-braced at front and rear for additional rigidity. There are at least six ball bearing rollers and two floating rollers to permit drawers being easily removed from or inserted into the case. A loaded drawer may be suspended in a horizontal position when fully extended.

Hanging Wall Cases All wall cases are supported by brackets at each end of every cupboard. These run the full depth of the cabinet and have a bearing surface of at least 18 inches on the wall and are made of band iron ½-inch thick by one inch wide. From each bracket two toggle bolts penetrate the wall.

Sanitary Bases The legs are made of 18 gauge steel formed into a square tapering tube two inches at the bottom, with joints oxyacetylene welded. The bottoms of the legs are fitted with a cast bronze footing, flush with the leg and secured to same by a ¼-inch concealed bolt. To prevent marring the floors the bottom of the footings have been ovaled, the legs interlocking with a 3-inch channel base frame and securely fastened to frame and top by concealed fastenings.

Iron Pipe Support These are made of 1¼-inch wrought-iron pipe (about 1⅝-inch outside diameter). All connections are of the ball type made of malleable iron foot plates, about six inches in diameter. All pipe is threaded into the fittings.

Finish All steel parts were thoroughly cleaned before finishing. Framing parts were made smooth, plate surfaces sand-papered and the entire product was treated to a benzine bath to remove oil and dirt, followed by a heavy coat of well baked mineral filler applied by dipping to insure covering all surfaces.

SOME SIGNS OF THE TIMES

Evidence of 24 Research Directors Shows Research Man As Executive Head

IS INDUSTRY properly recognizing the growing importance of the research man? What are the signs of the times that indicate this to be the case

RESEARCH LABORATORY RECORD has assembled some facts that reveal how, with growing celerity, the research executive in recent years and continuously in the present times, meets with the recognition that is his due, not only through reorganization within his company in deference to the value of his services, but by public recognition and acclaim.

Sixty-three outstanding research men were queried in an effort to assemble evidence of this trend. They were asked:

(1) To give specific instances where a research director has been advanced to an officership or directorship in his company.

(2) To cite other executives of their companies who got their start in the laboratory.

(3) To state (as an indication of his growing importance), whether the laboratory director authorizes purchases of equipment and materials for (a) his laboratory (b) the plant.

(4) To offer his reasons if he believes that the research director should occupy a position of higher executive authority than is demanded by the laboratory work alone.

Twenty-four of these men graciously found time to reply to the questionnaire. Their evidence, is reproduced in this article. It is presented here as a cold and unaltered report of the belief of these authorities, uneditorialized, unshaded, and unemphasized. Their direct statements speak with more eloquence than any adornment of editorial rhetoric could evoke. THE RECORD naturally believes this recognition of the research man's all-importance is and should be forthcoming. It will always champion the cause of the research man and is proud to offer this authoritative evidence that industry is finding a place for him among the directing heads of the business.

Specific Instances of Recognition

ELSEWHERE on the pages of this article are listed the known instances where research or laboratory directors have been advanced to officerships or directorships in their companies. Seven of the 24 men who participated in this consensus interview took the trouble to set down known cases. Read them over. The list is merely a beginning. It will suggest dozens of omissions to you. If you think of them, send them in to THE RECORD.

Dr. L. H. Baekeland points out that "there are numerous instances of prominent researchers who occupied foremost positions in the enterprises with which they were connected. In quite a number of cases they were presidents of their corporations. I have only to point to such men as Acheson, Sperry, Dow, Northrup, Charles F. Burgess, Edward Weston, Elihu Thomson, and many others.

"In other enterprises they were taken from the laboratory to become directors or vice presidents, for instance, Whitney of G. E., Redman of Bakelite Corporation, Kettering of General Motors, Reese of du Pont, Mees of Eastman Kodak." Dr. Baekeland goes on to make this wry reservation: "Of course, all this depends on the qualifications of the research worker. Some of them are good enough on laboratory problems, but worse than useless, even dangerous, in practical matters or as executives."

Offering Further Proof

A FEW other general expressions were elicited by the questionnaire which deserve quotation:

F. R. MCMILLAN, Director of Research, Portland Cement Association—"The Industry has continued to support our research work in a most gratifying manner considering the extremely unsatisfactory conditions that have prevailed."

J. C. HOSTETTER, Director, Development and Research, Corning Glass Works—"Our company is very thoroughly sold on the value of research and we have technically trained men throughout our entire organization."

C. E. K. MEES, Research Director, Eastman Kodak Company—"The relation of the research department to the executive authority in any business must depend very much upon the nature of the business, and each business will undoubtedly find its own solution. In the case of the Eastman Kodak Company, my functions are definitely related to research and development, and I have no other responsibilities except those arising from my position on the board."

W. D. BIGELOW, Director, National Canners' Association Research Laboratories—"In manufacturing corporations men are going out from the laboratory to the sales department and other departments all the time and some of these men reach executive positions. I know, too, that some of the research directors have been made members of the Board of Directors of their respective companies."

HARDEN F. TAYLOR, President The Atlantic Coast Fisheries Company—"The Research Department is represented on the official staff of the Company. It has always been and is now a policy of this company to employ the service, knowledge, and skill of its director of research in the general management of its affairs."

Laboratory's Part in Purchases

THE reports on the procedure and the part played by the laboratory director in authorizing or influencing purchases of materials and equipment for the laboratory and the plant present an interesting and varied set of circumstances.

Of 18 replies to this question three showed that the director *advises or recommends* purchases for the laboratory only; five *actually authorize* purchases for the laboratory only; two *authorize* both laboratory and plant purchases; six *authorize* laboratory purchases and *influence* plant purchases through consultation, advice and testing operations, and two definitely *have nothing to do* with laboratory or plant purchases.

Detailed explanations of the methods pursued are quoted below:

FREDERICK A. MELMOTH, Research Director, The Detroit Steel Casting Company—"While in my experience the laboratory has not had direct control of such purchases, yet their opinion and advice is almost invariably sought in these days. Manufacturing control really demands that this be the case, and I would look rather for an extension of the practice. We feel, of course, that it is just as essential to exert intelligent control over raw materials as it is over the resultant product, and only by bringing the laboratory into close cooperation with the purchasing department can this be accomplished."

HAROLD R. MURDOCK, Director of Research Department, The Champion Fibre Company—"In regard to authority of purchases, the writer takes the responsibility for laboratory equipment, but equipment for plant operation is divided in its purchase."

DR. L. W. BLAU, In Charge of Geophysics Research, Humble Oil & Refining Company—"I believe it to be general practice that the director of the laboratory authorizes all purchases of materials for the laboratory. This is the practice in the Geophysics Research Department of the Humble Oil & Refining Company."

DR. FOSTER D. SNELL, Foster D. Snell, Inc.—"It is our practice that the laboratory director authorizes all purchases of materials and equipment for his laboratory. Our account executives specify to clients the sources from which they are to buy materials and equipment. We therefore recommend materials and equipment to probably a greater extent than the average laboratory."

CHARLES A. LUNN, Chief Chemist, Consolidated Gas Company of New York—"Our laboratory does not attempt to specify the source of purchase if the item is of standard quality or covered by specification. We do indicate the source of purchase of special items not falling within the above classification and I personally feel this to be a wise and justified practice. From a company standpoint I feel that it is desirable to encourage competition in purchases to whatever extent is warranted, but this should involve considerations of reliability and service as demonstrated by prior dealings."

G. J. FINK, Director of Research, National Aluminate Corporation—"I am glad to say that our company places upon the laboratory the responsibility for purchases of material and equipment for all of our processes, which have not been thoroughly standardized in respect to these items, and this responsibility is continued until the process can be turned over completely to the operating department, and even after that period, all raw materials are analyzed and all batches produced in the plant are analyzed before being used, in the first case, or before shipped out, in the second case. This system has resulted in a very marked improvement in quality of products and has helped us in the standardization of our treatments."

DR. NORMAN A. SHEPARD, Director of Chemical Research, The Firestone Tire and Rubber Company—"We authorize purchases of our own equipment and materials for the laboratory. As far as the plant goes, the approval of all materials is handled by the control laboratory, which tests all these materials to specification and approves the sources of supply. The research department enters into this phase of purchasing only on new and unusual materials which have not been previously purchased, or when there is some controversy regarding the quality of a regularly used material. The research laboratory and research director act largely in an advisory capacity at Firestone."

G. E. JOHNSON, Manufacturing Division, Fairbanks, Morse & Company—"Our Laboratory Director approves, but does not authorize the purchased material used in our equipment. In other words, our laboratory operates as a part of our Engineering Department and is under the supervision of that department, which department likewise works very closely with our Purchasing Department in the specifications of any materials or equipment to be used in our product or our plant."

JAMES C. MCFARLAND, Technical Superintendent, The Wadsworth Watch Case Company—"In our plant the Laboratory Director authorizes purchases of material and equipment for the laboratory and sets and enforces specifications for materials purchased for the plant. I believe that this practice is somewhat general in this territory." (Dayton, Kentucky.)

DR. W. H. BASSETT, Metallurgical Manager, The American Brass Company—"The director of research proposes the material which is to be purchased for his laboratory and advises in regard to purchases for the plant but gives no authorization."

DR. MEES, Research Director, Eastman Kodak Company—"The final authorization of purchases for the laboratory and the plant lies with the general manager rather than with the director of the laboratory."

DR. ARTHUR D. LITTLE, Arthur D. Little, Inc.—"The research director does ordinarily pass on purchases of equipment and materials for his laboratory. To what extent he may do so for the plant I [illegible] know, but I would expect that ordinarily it would [illegible] in other hands except in those special cases which relate to equipment for new processes."

HARDEN F. TAYLOR, President, The Atlantic Coast Fisheries Company—"The research department does not perform routine analytical functions for checking the purchase of supplies. We find it cheaper to have this analytical work done outside for such products as coal, paper, and the like, and employ our Research Department as a Research Department only for any of the new processes, which usually specifies the kind and quality of materials to be used."

C. E. SKINNER, Assistant Director of Engineering, Westinghouse Electric & Manufacturing Company—"The executive in charge of our Research Laboratories has always been responsible for the purchase of equipment and material for the laboratories under the budget provision, but the budget is, of course, always subject to the approval of the executive officers of the Company."

DR. CHARLES L. REESE, Vice President and Director, E. I. du Pont de Nemours & Company—"Director of Research is usually authorized to purchase equipment and materials for his laboratory up to certain limits, and his authorization is often required for purchase of equipment in plants."

DR. H. E. BARNARD, Director, Corn Industries Research Foundation—"I assume that every director who is directing anything has pretty complete authority in the matter of purchasing equipment and materials for his laboratory. When it comes to purchases for the plant the situation is changed somewhat, but an intelligent management will naturally consult the research director."

D. E. REPLOGLE, Chief Engineer, De Forest Radio Company—"All new materials used in our plant are designed and ordered by the research engineers. Routine re-orders of materials are taken care of by the Purchasing Department. In our own plant and in other plants we contact we find there is an increasing tendency for the research man or engineer to specify the materials he intends to use—often specifying the particular company in which he has the greatest confidence. It is only in this way we are able to foresee difficulties that may be encountered by the introduction of new material or changes in materials in the plant."

A. L. BROWN, Director, Inspection Department, Associated Factory Mutual Fire Insurance Companies—"In our own laboratories the director must authorize the purchases of all materials and equipment. In our case we do not have occasion to purchase materials, for manufacturing or plant purposes."

Other Proofs of Research Man's Importance

IN ADDITION to the elevation of the research man to positions of executive importance in industry some of the replies to the questionnaire produced other interesting indications of this trend towards recognition of his growing importance. Dr. Little offers as a strong bit of evidence "the exceeding frequency with which research directors are invited to speak before organizations and gatherings of business men, clubs, etc.; the appearance of such books as 'Industrial Explorers,' by Holland; 'Science

SOME RESEARCH DIRECTORS ELEVATED TO COMPANY OFFICERSHIPS

Frank B. Jewett, Vice President in Charge of Development and Research, American Telephone and Telegraph Company.

Walter S. Landis, Vice President and Chief Technologist, American Cyanamid Company.

M. C. Whitaker, Vice President, American Cyanamid Company.

L. H. Baekeland, President, Bakelite Corporation.

Willis R. Whitney, Vice President in Charge of Research, General Electric Company.

Lawrence V. Redman, Vice President and Director of Research, Bakelite Corporation.

Charles L. Reese, Director, E. I. Du Pont de Nemours & Company.

Charles M. A. Stine, Director and Vice President, E. I. Du Pont de Nemours & Company.

George O. Curme, Jr., Vice President, Carbide and Carbon Chemicals Corporation.

Charles F. Kettering, Vice President, General Motors Corporation.

Earl P. Stevenson, Vice President and Director, Arthur D. Little, Inc.

Irenee du Pont, Vice Chairman of Board, E. I. Du Pont de Nemours & Company.

—Cited by Dr. Arthur D. Little.

A. H. Cooke, Vice President for Engineering and Research, The Atlantic Coast Fisheries Company.

—Cited by Harden F. Taylor.

S. M. Kintner, Vice President in Charge of Engineering, Westinghouse Electric and Manufacturing Company.

—Cited by Dr. C. E. Skinner.

IN THE DU PONT ORGANIZATION ALONE:

William P. Allen, Vice President and Director.
H. Fletcher Brown, Vice President and Director.

Jasper E. Crane, Vice President, Director and Member of the Executive Committee.

W. F. Harrington, Vice President, Director and Member of the Executive Committee.

Fin Sparre, Director.

E. G. Robinson, General Manager of Organic Chemicals.

J. W. McCoy, General Manager of Explosives Department.

—Cited by Dr. Charles L. Reese.

C. J. Patterson, Officer, Campbell, Taggart Baking Industry.

G. Cullen Thomas, Vice President, General Mills, Inc.

—Cited by Dr. H. E. Barnard.

in Action," by Weidlein and Hamor; "Chemistry in Industry," by Howe." He refers also to the 1930 and 1931 tours organized by the National Research Council for the purpose of taking bankers and executives to industrial research laboratories. "There are many reasons why it is advantageous to a corporation to advance its research director to an executive position or to a directorship," states Dr. Little. "Perhaps the fundamental one is that he brings to either office the scientific point of view and a specialized knowledge of the technical aspects of the company's affairs, processes and products."

Taking the opposite view Dr. Bassett states that, "A research director may be promoted to a position of higher executive authority, but if this is done he would be unable to conduct his regular line of duty."

In the opinion of Dr. Reese, "every large company with a number of directors should have at least one chemist on its board of directors, and also on its executive committee, since many questions naturally come up which require the knowledge and experience of a chemist. Of course these can be discussed with the chemical directors by a non-technical board, but it is much better to have men on the board with experience to enable them to discuss these questions, not as an advisor, but as an actual member."

Dr. Barnard believes that, "A research director whose field of work is limited to the laboratory operations would not be a successful director very long. His value may be in part due to his scientific ability but even more important is the successful application of what he knows and what he discovers to factory production."

Recognition of "Industrial Explorers"

THIS entire subject of indications of the growing importance of the research man grew from a conversation in which conjecture was made as to the surprising advances made since 1928 by the subjects of Maurice Holland's and Henry F. Pringle's "Industrial Explorers." When this volume appeared in the Fall of 1928 it was extensively reviewed throughout the technical trade and lay press. Some 300 clippings are on file in Mr. Holland's office at Division of Engineering and Industrial Research of the National Research Council,—an unusual publicity volume for a class reader book. It is interesting to follow the history of the men whose place in their respective niches in the Hall of Fame was noted in the chapters of this remarkable book. The discovery of the advances made by the subjects since its issuance four years ago is the best possible proof of the growing recognition of the research man, both through public honor and acclaim as well as through promotion within their own companies. Here are a few indications:

In the year following the appearance of "Industrial Explorers," Dr. Jewett was awarded the Edison Medal of the American Institute of Electrical Engineers for distinguished achievement in the field of communications. He has also been awarded the Honorary Degree of Doctor of Science, University of Chicago; Honorary Degree of Doctor of Laws, Miami University, and the Third Order of the Sacred Treasure, Empire of Japan.

Elmer A. Sperry was made president of the American Society of Mechanical Engineers and chairman of the American Committee of the World Engineering Congress, held in Tokyo, leader of the most distinguished delegation of professional engineers ever to leave this country in a body.

Dr. Little was elected president of the Society of Chemical Industry (London), one of few Americans to be so honored. He has received the Perkin medal and the degree of Doctor of Science from Tufts College and Columbia University. While in England in 1929 he received the same degree from Manchester University and was made Honorary Associate of the Manchester College of Technology.

Harden F. Taylor, who was vice president of Atlantic Coast Fisheries at the time the book was written, has been advanced to president.

Dr. Bassett, a year or two after the book was written, was made president of the American Institute of Mining & Metallurgical Engineers and is vice president of the American Society for Testing Materials.

E. C. Sullivan, vice president of Corning Glass in charge of research at the time the book was written, has since been made president of that company.

Dr. Barnard, president of American Institute of Baking at the time was later appointed to the distinguished post of director of The White House Conference on Child Welfare.

Since the date referred to Dr. Reese has been elected vice president of the International Union of Chemistry; vice president of the Print Club of Philadelphia; member of the Raven Society of University of Virginia; honorary member of the British Institution of Chemical Engineers; fellow of the Royal Society of Arts; member of the Visiting Committee of the Bureau of Standards; and chairman of the Board of Directors of the American Chemical Society.

George D. McLaughlin, Director of Research of the Tanner's Council of America, was called to an important post as an executive in the Tanning Industry.

C. E. Skinner has received other recognition since 1928. He was sent as a delegate to the World Engineering Congress. On June 1931 he was awarded the Lamme Medal, given by Ohio State University to an alumnus of Ohio State College of Engineering for meritorious achievement in engineering. It was the first presentation of the Medal after its establishment by the will of the late Benjamin G. Lamme, Class of 1888, Ohio State, and for many years chief engineer of the Westinghouse company. Mr. Skinner also was elected president of the American Institute of Electrical Engineers for the 1931-32 term.

This possibly does not report every honor and advancement that came to each of the subjects of Mr. Holland's book, but it serves to strongly indicate the trend toward recognition of the leadership of research men.

For elaboration of this topic see:
"Dreams and Realities," L. H. Baekeland, Journal of Chemical Education, Vol. 9, No. 8
Pages 142-149 "The Chemist," Harden F. Taylor
"Industrial Explorers," Maurice Holland and Henry F. Pringle
"Science in Action," Weidlein and Hamor
"Chemistry in Industry," Howe

Julius Stieglitz

STIEGLITZ THE INVESTIGATOR

By Prof. RALPH H. McKEE
Department of Chemical Engineering,
Columbia University.

Ralph H. McKee

THE preparation of Stieglitz for a life of research was the best the world afforded at the time, in the eighties—the public schools of New York City, the gymnasium of Karlsruhe, Germany, and the University of Berlin.

The New York City training in his formative years gave him the American viewpoint that made him the natural choice of the American Chemical Society for its President in the year of America's entrance into the Great War. The years in the Karlsruhe gymnasium gave him disciplinary training in the fundamentals of clear and intelligent thinking—a practice he has continued to this day.

In the University of Berlin, then the world center of chemistry, he attended the lectures of eminent chemists but his real interest was in his research work under Professor Thiemann. Dr. Stieglitz has ascribed much of his success in solving chemical problems in the complex field of organic chemistry not only to the thorough training of the German gymnasium but to initiative and the feeling of responsibility for his own advancement and success that were developed by freedom from direction while carrying on his thesis work.

On his return to America he worked for Parke, Davis & Company but industrial work proved uncongenial and he soon resigned and took a minor position in the Department of Chemistry of Clark University.

When The University of Chicago was founded and in 1892 took the leaders of the Department of Chemistry from Clark University to temporary laboratories at Chicago, the young Stieglitz sensed the important role that the new university would play in the chemical world and went along though he was not offered a regular position. He was given the opportunity to work and teach, but without salary as a Docent. How many young men who have had three years of chemical experience beyond the doctor's degree today *seek* teaching positions without salary?

Dr. Stieglitz's early teaching at Chicago was in analytical chemistry but his researches were primarily and preferably in the field of organic chemistry where the new and forward-looking ideas of physical chemistry could be applied. Equilibrium reactions, rates of reactions, pH relations, rather than preparative methods were important in these researches of Stieglitz and his students.

Honored, but overworked, by the many students who wish him to direct their researches leading to the degree of Doctor of Philosophy, he has for more than thirty years continued with their help and that of a few specially trained assistants the study of the general mechanism of organic reactions, the theory of indicator color changes, and the study of new organic medicinals.

How He Challenges Work

ALWAYS low voiced and never in a hurry, often encouraging but rarely critical, he can get a remarkable amount of work from the student. The writer recalls a conference 33 years ago when certain work was planned and as he left, Professor Stieglitz quietly said, "You can finish this by the last of next week." It was not an order. It was a challenge as well as a statement of what was expected. To fail would imply that the student had insufficient ability and the failure would be a disappointment to the professor. With such inspiration every effort was put forth to complete the work by the date suggested.

His broad knowledge of chemistry and its various phases has brought him to believe it the most important of the sciences. This view is well expressed in his statement that "chemistry as the fundamental science of the transformation of matter must be used more and more to insure progress."

His view of one of the supreme problems before the chemists of today may best be given in his own words. "Its goal is to discover or prepare pure specifics to destroy invading germs and thus cure disease . . . Any advance made is made for all time, for the benefit of all . . . Is not the whole history of civilization . . . evidence that the mind of man, directed on ideals, is more powerful in alleviating ill than Nature ever was or is, in the blindness of her work?"

Editor's Note—The December installment of [illegible] series will find Dr. Karl T. Compton, president of Massachusetts Institute of Technology, writing [illegible] Dr. Hugh Taylor.

THIS LABORATORY LITERATURE

By A. W. ANDERSON

Supervisor, the Literature
Bausch & Lomb Optical Company.

WRITING sales literature may seem a little far-removed from the usual activity of the Research and Engineering Staff of a manufacturing concern, and often the members of this division wish it could be farther removed. There are included in the various types of literature published by manufacturers, two broad mediums through which a member of the Research Department may express his ideas to distinct advantage: namely catalogs and directions. The descriptive leaflet or catalog describes in detail the product available for the prospective purchaser. Directions for use go to the customer with the item and tell him how to use it.

Sales volume is affected to a marked degree by the type of printed material that precedes as well as accompanies the delivery of the product. The magnitude of the sales volume may be used as a convenient type of yardstick enabling the research director to measure in a way the productivity of his division. From this it is apparent that the Research Department should be willing to accept its share in the responsibility of writing sales literature.

The task of producing literature is by no means a simple one. Writing the manuscript is one phase of the project, but maximum value of printed matter is observed when it is distributed at the proper time. It is advisable, therefore, to utilize some sort of follow-up in order to prevent any possibility of the product remaining inactive on the shelves due to lack of distribution of printed matter.

System of Preparing Literature

THE Bausch & Lomb Optical Company conducts a wide program in the development of scientific instruments. In addition to the spectacle lens and frame sales, it enjoys the sale of a large variety of highly technical instruments, serving practically all professional, educational and industrial needs. The company has in operation an effective system of preparing and routing manuscripts necessary for introducing and accompanying new products. This system, requiring but little effort, succeeds in producing literature with a considerable degree of satisfaction and promptness.

In general, the advertising staff of a manufacturing firm is not always in touch with the factory production schedules. It remains the duty of some one division with access to the necessary information to coordinate the Development, Production, Sales, Advertising and Printing Departments, so that literature will be on schedule.

With our company the Research Division takes the initiative in the establishment of new products and also originates the move for new printed matter. When the last step is taken in the official authorization for manufacture of a new product, there is issued from the office of the Research Manager, and directed to the designer, a form (Fig. 1) giving some history relating to the progress of the project, with a request for certain literature. When the Production Department has received a promise date from the factory, the information is relayed to the Research Manager's office. If literature has not been submitted by the time the promise date is received, the same form is again sent out, with the added information regarding the factory promise date. This serves as a gentle reminder that time is getting short and the manuscript must soon be submitted.

Advertising material is not entirely technical in its nature and therefore the write-up as supplied by the Research Department is not taken as a finished product and so put in print. The Sales and Advertising Departments contribute their share in the number of points that have been set up as a guide to the editing of the company's sales manual. Fourteen points have been listed under two headings, namely Technical Data and Sales Data. The first request is for the Technical Data, which is to be written by the Research Department, and is expected to embrace the following points:

1. Definition and General Description
2. Purpose and General Functioning
3. Distinctive Features
4. Equipment Application
5. References and Bibliography

The manuscript covering the foregoing points is then submitted to the Research Director's office. It is next forwarded to the Sales Department with a request that steps be taken to add to this Technical Data material of such a nature that it will complete

WRITES THE SALES

the story. The points that should receive consideration are listed as follows:

6. Market. Prospective Users. Buyers
7. Equipment Photos with Legend
8. Accessory Photos with Legend
9. Sales Points with Advantages
10. Comparison with Competitors Products
11. Meeting of Objections
12. Demonstration Method
13. Specifications, Terms, Price and Delivery
14. Placing of Order

The request is made by using the same form as shown in Figure 1, and gives the Sales Department further dates so that they know when the literature must be ready. Using the Technical Data as a basis and supplementing it with the Sales Data supplied by the Sales Department, it is now sent to the Advertising Department, who whip it into final shape. This step crystallizes the write-ups and results in the attractive leaflet, booklet, folder or the sort of thing the firm needs to advertise its new product.

The Advertising Department is advised by the Sales Department as to the date desired for the production of printed matter. This is derived from information received by the Sales Department from the Research Manager's office.

To (*The Designer*)
Subject (*The project in case*)

New Unit Progress	Remarks
Sample Approved	....
Estimate Approved	....
Authorization Approved ..	....
Production Promised	....
Directions for Use	
Required	(Packing, Unpacking and Setting-up
Not Required	(Technique and Manipulation (Adjusting
Submitted	(Trouble Shooting
Technical Data	
Required	(Definitions and General Description (Purpose and General Functioning
Not Required	(Distinctive Features (Equipment Applications
Submitted	(Reference and Bibliography
Sales Data	(Market, Prospective Users, Buyers (Equipment Photos with Legend (Accessory Photos with Legend (Sales Points and Advantages (Comparison with Competitors Product (Meeting of Objections (Demonstration Method (Specifications, Terms, Price & Delivery (Placing of the Order

Figure 1

Description of Laboratory

Bausch & Lomb Optical Company (Lenses and Optical Instruments)

Scientific Bureau

Research Staff: W. B. Rayton, eleven optical engineers and seven assistants.

Research Work: Development and use of optical apparatus, ophthalmic optics, photographic and projection apparatus, range finders and all types of optical measuring instruments.

Chemical Laboratory

Research Staff: F. P. Kolb, three chemists and two assistants.

Research Work: Emery and rouge washing and grading, grinding and polishing, experiments, cements, fillers, glass washing, glass silvering, metal plating and all progress control problems of chemical nature.

Ceramic Laboratory

Research Staff: M. R. Scott, one ceramic chemist and one assistant.

Research Work: Problems connected with the manufacture of optical and colored glass.

Research Department Supervises Literature

THE question might be raised as to where the Advertising Department comes in. Advertising specialists produce excellent literature in numerous and attractive forms. But the advertising staff is not always in a position to be fully conversant with the more technical side of a particular new product or the technical tie-in with other products of the firm. The man who writes copy cannot be expected to be a research associate and know the new product as familiarly as does the scientist who has worked, played and dreamed his problem for a considerable period of time.

It is a reasonable request to make when asking the scientist to develop or improve an item in the sales listing, that he also consider writing the descriptive matter for that development. Obviously, this man knows the item better than anyone else, and should, therefore, be drafted to write the manuscript.

The scientist must exercise judgment when writing for his familiarity with the product may allow him to leave out many pertinent thoughts that appear unnecessary to mention. These thoughts may appear obvious to the technical man, but are just the items necessary for the purchaser to help him make up his mind. It is sometimes possible that the designer is prejudiced to the extent that he may under-rate or over-rate his own work. The thought that the research worker must hold uppermost in his mind while writing is the degree of technical development of the person who is expected to use the product.

Literature should not be printed so far ahead of the production of the product that advertising [illegible] inventory is needlessly increased before there is use for the material, or so that prospective purchasers must be advised after receiving literature that the product will not be available until some later date. In like manner, literature should not be delayed so that stock lies idly on the warehouse shelves until the silent salesmen create the demand necessary for moving the product. Production promise dates, as supplied by the Research Manager's office, in an attempt to coordinate Sales, Advertising and Printing Departments is one way of assuring the prompt supply of literature.

It is up to the Sales Department to determine the quantity of printed matter to be made up. This is obtained from a complete mailing list that is kept active by the Sales Department. This list is divided by the type of purchaser so that one group gets one type of literature, a second group gets a second type and a third group may get both types, etc.

Writing Directions for Use

PRODUCTS should be accompanied by appropriate "Directions for Use" whenever the product is of such a nature that directions are required. These directions must be ready to go out with the instrument when the product is shipped. Nothing is more disconcerting to a purchaser than to receive the product and not know how to properly set it up or how to operate it correctly, or put it into adjustment. These four points are covered by the directions:

1. The packing, unpacking and setting up.
2. Technique and Manipulation.
3. Adjusting.
4. Trouble Shooting.

It is obvious that if these points are to be adequately and correctly covered, the member or members of the Research Department responsible for the development of the new product must write them.

Requesting manuscript for the Directions and the subsequent writing of the manuscript is done in the same way as for the sales literature. Sometimes the Directions are utilized as sales literature and in that case the manuscript is turned over to the Sales Department, so that they can make distribution of this combination piece of literature. However, in most cases the directions are considered as part of the specifications of the instrument itself. They should be attractive, but not necessarily showy so that they are in competition with the descriptive literature. They should be made up as a serviceable card, booklet, or whatever the need indicates. Directions must be accurate. Care should be taken not to have the directions written in such a manner as to be over the head of the operators. On the other hand, it must not be made too elementary, thereby insulting the intelligence of the purchaser. The use of photographs always enhances the value of directions for use. The photographs are of a different type from those used with the sales literature, in that they should be action pictures. For instance, in photographing instruments, it is well to show the hands inserting a part or making some adjustment. Line drawings and schematics are also valuable to the directions for use. In the same way that judgment should be used in the writing of technical data for the sales literature, the prejudices of the designer must be overlooked, so that certain features of the instrument, as far as operation is concerned, are not favored.

Submitting to Other Departments

AFTER the directions for use have been completed by the designer, they should be submitted to other people in the organization: for instance, the Sales Department and the Inspection Department, for their impartial and valuable criticism. Having others look over the directions will help insure against the fault of having the directions apply only to the research type of individual, as was the writer. The Sales Department can watch for possible additions of notes and use of auxiliary items, and in the same way the Sales and Sales Service Departments can caution and correct the use of language which may arouse unwarranted sales resistance.

The same follow-up system is used to insure getting the directions for use out with the instrument at the proper time. One feature in the printing order for directions differs from that of the sales literature, in that the ordering is done by the Production Department from specifications, as is the ordering of the instrument, instead of the Sales Department originating the order. This is done to prevent a large stock of obsolete directions from accumulating, because it is sometimes considered just as cheap to print 20,000 as 500. Quantity printing is economy if no changes will be evident on ordering the second lot of the instrument in the factory, but often directions must be altered, as well as the instrument, after the first lot has been out and suggestions have come from the field. This leaves the corrections of instruments and directions up to the Specifications Department.

There are other types of literature in which the Research Division is also interested, such as the periodic publications of scientific abstracts. A good many times the research man or the designer writes technical articles for technical papers and presents them before various technical organizations. Also, magazines, or the house organ, require articles written in the language of the interested layman. These items, being of a special nature, do not require any type of systematic follow up service, as do the items discussed in the foregoing paragraphs.

Following the rather simple procedure outlined in the foregoing paragraphs, the Bausch & Lomb Optical Company produces well-prepared literature written in the language of the consumer, and available on time. It has come to be considered not only a responsibility, but an added privilege of the Research Department. Ambiguity and misunderstanding dealing with technical subjects is prevented from finding its way into our literature and in their stead we have accurate and frank discussion of scientific achievement. The set-up as briefly described here may not be applicable to all firms, but we find that our results have justified our continuing the system, and we hope others may find some suggestions of merit in the foregoing.

STANDARDS :

Special Editor, Charles A. Marlies,
School of Technology, College of the City of New York

STANDARDS OF TEMPERATURE

AS IS well known, temperature expresses the degree of warmth or coldness of a body. Two bodies are said to be at different temperatures if one becomes hotter and the other cooler when brought in contact. The last statement is a simple definition of temperature. That is, temperature controls the flow of heat, and it is sometimes defined as the intensity factor of heat energy, just as voltage, controlling the flow of electric charge, is called the intensity factor of electrical energy.

Change of temperature produces a great variety of changes in a body. The color, size, pressure if the body is confined, electrical resistance, magnetic properties, contact electromotive force—all undergo changes with the change of temperature and have all been used to measure temperature change. Indeed, to date, the only property of a body which has not been found to change on heating or cooling is its mass; and from Einstein's mass-energy equation, theoretically, even the mass should increase on rise of temperature, but the increment is far too small to be detected by our present methods of measuring mass, delicate though they may be. This universal influence of temperature on physical properties emphasizes the necessity for temperature measurement and control in all scientific measurements and industrial processes.

Establishment of a Temperature Scale

TWO conditions are essential to the establishment of a temperature scale:

(1) Two bodies at different temperatures must be available and it must be possible for any competent and properly-equipped observer to reproduce these two temperatures at any time and place.

(2) The temperature interval between these two fixed temperatures must be divided into a convenient number of steps, or degrees.

An instrument used for interpolation between the fixed points is termed a thermometer if used at ordinary temperatures and a pyrometer if used at elevated temperatures, although these terms are by no means universal. Thus thermoelectric pyrometers are commonly called thermocouples.

The temperature measuring instruments in ordinary use depend for their action upon the change of some physical property with temperature. It might be pointed out that another system of thermometry is possible, one founded upon the measurement of quantities of heat rather than upon the change in some physical property of a substance. Such a method is too inconvenient for ordinary use, although it should be noted that the thermodynamic scale of temperature (see below) is based on such a method and this scale has the very desirable property of being independent of the particular physical properties and the characteristics of the substance.

The two fixed temperatures used in the establishment of all temperature scales are the freezing and boiling points of water under standardized conditions. These were fixed early in the development of thermometer scales, the others, such as the temperatures of summer and winter, the temperature of melting butter, etc., having been tried and discarded for one reason or another. Fahrenheit, the German maker of meteorological instruments, was the first to use the fixed points of freezing and boiling water. The inconvenient numerical values of his scale are a survival from one he used in some earlier work in which a mixture of ice, water and sea salt (0°F) and the body temperature (appr. 100°F) were used as the fixed points. The Centigrade scale was introduced about 100 years later, in the middle of the eighteenth century by an astronomer, Celsius, and has supplanted all other types in scientific work and is in common use everywhere except in the English speaking countries, where the Fahrenheit scale still prevails, and in Germany, where a scale due to Reaumier which divides the range between the freezing and boiling points of water into 80 parts is extensively used. A certain temperature may be expressed on the three scales as follows:

$$t_c = 5/9\,(t_f - 32) = 5/4\,t_r$$

The universal use of the Centigrade scale in the laboratory along with the common use of the Farenheit scale in the plant has made the quick conversion from one scale to the other a decided convenience. Therefore charts and tables for such conversion are in common use. One of the best methods is that used in the Sauveur tables, which uses three columns of figures, the middle set being the temperature to be converted and the left and right the corresponding °C and °F respectively.

Liquid in Glass Thermometers

THE temperature measuring devices in commonest use are liquid in glass thermometers. Their wide use is due to their compactness and low cost of manufacture. Furthermore, since liquids in general have much greater coefficients of expansion than solids, such thermometers can be made of almost any desired sensitivity merely by proper choice of size of bulb and capillary stem by which the expansion is made apparent.

For such thermometers mercury is used in practically all cases for ordinary temperatures because of its large and fairly uniform volume coefficient of expansion, its low freezing point (−40°C) and high boiling point (356°C) making a wide working range, its high surface tension so that it does not cling to the glass, its opacity and high reflecting power so that it is readily visible.

For low temperatures toluene, alcohol or pentane may be used instead of mercury, the freezing points of which are -97°C, -113°C and -200°C respectively. A small amount of dye is frequently added to render the liquid visible.

Since increase of pressure raises the boiling point of a liquid, the upper range of the mercury thermometer may be extended beyond 356°C by filling the upper part of the thermometer with an inert gas. This is usually done by filling with nitrogen and sealing at a low temperature. As the mercury expands on heating the nitrogen is compressed, the pressure increased and consequently the boiling point of the mercury raised. For very high temperatures special borosilicate glass or even fused quartz must be used as the container, because ordinary glasses will soften and become stretched under the high pressure. By this means the upper temperature limit of mercury thermometers may be extended to 650°C which is a cherry red heat. Recently a gallium in quartz thermometer has been made which can be used from 30°C, the freezing point of gallium, to 1000°C, the softening point of quartz (gallium boils over 1600°C).

Liquid in glass thermometers is subject to many errors. Thus the capillary bore is never uniform so that calibration at several points must be resorted to: the glass of the bulb is very thin so that its volume is affected by the external pressure, although in most cases this error is appreciable only when the difference in pressure from normal is half an atmosphere or more. Furthermore, due to hysteresis and/or secular changes of the bulb and capillary the volume of the bulb, the length of the stem and the diameter of the capillary may change slowly, necessitating frequent calibration. Finally, under the usual conditions of graduation whereby the distance between the initial calibration points, e.g. 0° and 100°, is divided into equal parts, the thermometer must be used with all the mercury at the same temperature. If not, a correction must be applied for the temperature of the emergent stem.

As a consequence of these corrections and sources of error the liquid-in-glass thermometer has been abandoned as an instrument of high precision. This has resulted in the use of partial immersion thermometers, graduated and standardized for a particular depth of immersion, thus avoiding the necessity of determining and applying the correction for the emergent stem. These thermometers are standardized for stem temperatures corresponding to the average likely to occur in the use of the thermometer.

Standards for Thermometers

TO DATE the only industrial standards for thermometers which have been set up in the United States are concerned with liquid-in-glass instruments, although the American Society of Mechanical Engineers gives in its Power Test Codes a description and classification of other types of temperature measuring devices, their accuracy, corrections and installation rules.

The first of these standards was promulgated by the Bureau of Standards shortly after its organization. In response to numerous inquiries, the Bureau made an exhaustive study of clinical thermometers, the magnitude of their errors and the most common defects. Specifications were set up and thermometers passing the test were given a certificate. This work distinctly improved the quality of the clinical thermometers made in this country as was shown by the fact that the corrections found after the standard had been in operation a few years were very much smaller than the corrections of those submitted at the beginning. This standard with slight modifications has been adopted as mandatory by several states and by the Federal Specifications Board. A Commercial Standard for Clinical Thermometers was set up in 1928 and revised in 1932 (the effective date for new production was June 1, 1932.) Thermometers passing this standard are accompanied by a certificate of the manufacturer to that effect.

The American Society for Testing Materials has set up specifications for the various thermometers used in its standards. Some of these are total immersion, others partial, depending upon the use to which it is put. In setting up a new standard in which a thermometer is required, one already in use is designated wherever possible. Thus Standard Methods of Test:

D 20—30 Distillation of Bituminous Materials
D 86—30 Distillation of Gasoline, etc.
D 246—30 Distillation of Creosote Oil

all use the same thermometer—A.S.T.M. High Distillation Thermometer. All A.S.T.M. thermometers, with but one exception, are mercury-in-glass: the exception being the Low Cloud and Pour Thermometer, a toluene-in-glass instrument.

The Federal Specifications Board has set up a standard for Industrial Thermometers, which is mandatory for all Government Departments. Essentially the same standard has been adopted by the Scientific Apparatus Makers' Association. The thermometers described are the familiar mercury-in-glass type, and in addition various holders and sockets are specified, adapting the instrument for industrial use.

For many years the Bureau of Standards has accepted thermometers for test. Thermometers which are free from defects of design, material or construction, and are correct within reasonable tolerances are given certificates. If a thermometer is not eligible for certification, a report giving the result of the test is issued. Thermometers which receive certificates from the Bureau of Standards are probably as precise as such instruments can be made. If such a thermometer is properly used, provided the calibration is recent and all corrections are properly applied, a temperature measurement may be made with a limit of accuracy of 0.1 the graduation interval, i.e. to 0.01°C if the thermometer is graduated to 0.1°C. Such accuracy is possible only with total immersion thermometers. Differential thermometers, e.g. Beckmann type, which are graduated to 0.01°C can under proper conditions give a temperature difference accurate to 0.001°C.

This article will be concluded in the next issue with a discussion of the other instruments used for temperature measurement, and the establishment of the Thermodynamic Temperature Scale and the International Temperature Scale, and list of standards

: OUR NOVEMBER AUTHORS :

Dr. Vannevar Bush—Vice-President and Dean of the School of Engineering of the Massachusetts Institute of Technology. Noted for achievements in research and contributions to technical education. A native of Everett, Mass., the son of the late Rev. R. Perry Bush, for 50 years a clergyman in the vicinity of Boston. Graduated from Tufts College in 1913, and in 1916 awarded the degree of doctor of engineering from Harvard University and Technology. In 1932 received honorary degree of doctor of science from Tufts. Has taken particular interest in the design of scientific calculating instruments. For development of product integraph was awarded the Levy Medal of the Franklin Institute in 1928. Recently won wide recognition for design of an intricate calculating machine called the differential analyzer, which greatly increases the accuracy and speed of engineering calculations. Also known for contributions to the development of vacuum tubes and for investigations in electric power transmission. Under his direction there has been built at Technology an instrument known as the network analyzer. On this device a great power network covering several states may be accurately reproduced and its operating characteristics studied under the most satisfactory conditions. Has also carried on important studies of transients in machines and dielectric phenomena. Was invited to join faculty of Institute in 1923 to undertake comprehensive study of undergraduate curriculum in electrical engineering and to develop most efficient methods of teaching in this field, working closely with Professor Dugald C. Jackson, head of the department. Has also been professor of electric power transmission. Career as a teacher has been no less notable than work in research, and has been for some time in charge of graduate study and research in the department. His appointment as Vice-President and Dean of the School of Engineering of the Institute was announced March 10, 1932. At the same time was elected member of the Corporation of Technology. Early in his career Dr Bush held a position in the test department of General Electric Company, and then returned to Tufts as instructor in mathematics. Subsequently was promoted to assistant professor of electrical engineering. In 1917-18 carried on important research in submarine detection for the special board on submarine devices of U. S. Navy. Now holds commission of lieutenant commander in U. S. Naval Reserve Forces. Is an enthusiastic yachtsman and during the summer makes along-shore cruises on his yacht, the Caribou. Following the World War, was consulting engineer for American Radio and Research Corporation. Is a director of Spencer Thermostat Company and of Raytheon, Inc. Dr. Bush is a Fellow of the American Institute of Electrical Engineers, the American Academy of Arts and Sciences, and the American Physical Society. Is a member of the Society for the Promotion of Engineering Education, and of Alpha Tau Omega, Tau Beta Pi, Kappa Eta Kappa, and Phi Beta Kappa fraternities. Author of "Operational Circuit Analysis", and joint author with Professor W. H. Timbie of "Principles of Electrical Engineering", one of the most widely used books in its field. Has also contributed numerous articles to scientific and engineering publications. In 1916 Dr. Bush married Miss Phoebe Davis of Chelsea. They have two sons, Richard D., who is 14, and John H., 10. Dr. Bush makes his home in Belmont, Mass.

Dr. W. J. McConnell—Graduated from St. Louis University, School of Arts and Sciences and School of Medicine. With outbreak of war, was commissioned First Lieutenant in the U. S. Medical Corps, serving with Field Signal Corps in France 18 months. Promoted to Captain and then Major. Is still Major in Army Reserve Corps. At the close of the war, entered the U. S. Public Health Service, Office of Industrial Hygiene. In 1921 appointed Surgeon of U. S. Bureau of Mines engaged in research on physiological effects of heat. As Medical Director of Philadelphia Health Council and Tuberculosis Committee, promoted health service in groups of small industrial plants. Was also medical director of several large industrial concerns. In addition to his present work as Director in Charge of Industrial Health Service of Policyholders' Service Bureau, Dr. McConnell is Consulting Physiologist to the U. S. Bureau of Mines and Industrial Consultant to Philadelphia Health Council. Has published several articles on different research phases of ventilation and industrial health service.

A. W. Anderson—Member of American Society of Mechanical Engineers. Member of Rochester Section, Optical Society of America. Graduate of Worcester Polytechnic Institute, B.S. in Mechanical Engineering, 1922. Equipment Engineer, Western Electric Co., Hawthorne Plant, 1922-1923. Instructor, Machine Drawing and Descriptive Geometry, Armour Institute of Technology, Chicago, 1923-1924. Instructor Applied Mechanics and Strength of Materials, Mechanics Institute, Rochester, 1924-1929. Engineering and Research Department, Bausch & Lomb Optical Company, 1929.

Alfred V. de Forest—Consulting Engineer, American Chain Company, Bridgeport, John Chatillon & Sons, New York, Spang Chalfant and Company, Pittsburgh. Research Engineer, American Chain, 1919-28. Previous to that time, Associate Research Engineer, ~~Union Metallic Cartridge Company;~~ instructor, Princeton University and draughtsman, New London Ship & Engine Company. Class of 1911 at Massachusetts Institute of Technology. Inventor of several methods of magnetic testing used in industry one of which received the Dudley medal in 1928. Invented fatigue testing methods for springs and wire; a magnetic method of measuring stress; a magnetic strain gauge; the Isothermal electro-magnetic method of measuring wall thickness. Formed the A. V. de Forest Associates to apply the Magnaflux test for surface defects. Contributor to A.S.T.M.; International A.S.T.M., A.S.S.T., A.I.M.M.E., and many trade papers. Secretary, committee on Magnetic Analysis and chairman committee on Non-Destructive Testing, A.I.M.M.E.

Charles A. Marlies—Born in New York State. Studied at the College of the City of New York and Columbia University. Degrees: B.S., Ch.E., C. C. N. Y.; A.M. Columbia. Carried on industrial research and consulting work in several fields among which are: Corrosion proof electrodeposits and lubricating oils and greases. Present position: Department of Chemistry, School of Technology, College of the City of New York, giving courses in Physical Chemistry, Electrochemistry and Technical Analysis. Member: American Chemical Society, American Society for Testing Materials, American Standards Association, The Electrochemical Society, New International Association for Testing Materials. Fellow of the American Institute of Chemists

NOTES ON LABORATORY EQUIPMENT

A Novel Recording Strain Gauge

By
A. V. deFOREST

Leeuwenhoeck, the first man to discover the world of living micro-organisms, on June 1, 1674, wrote to the Royal Society reporting the discovery of corpuscles in blood. "Blood corpuscles are 25,000 times smaller than a grain of sand."

In laboratory work, perhaps more than in any other sphere of activity, measurements are the basis of knowledge. Nearly all laboratory activity centers about the making of measurements, and the development of special methods and instruments for new and better measurements are very generally the most time consuming and expensive part of a research development.

Logical design of any mechanical structure requires a knowledge of the loads to be imposed, and the ability to calculate the stresses which will be set up by such loads. In many cases of static loading this process is simple. In many other cases, especially with dynamic loading, it is difficult on account of the uncertainty of load distribution. The familiar examples are the indeterminate and redundant structures used (or avoided) in bridge design. If sufficiently cheap and simple recording strain gauges were available, the degree of uncertainty could be greatly reduced.

A more difficult problem lies hidden in every structure or machine. What are the accidental load factors in addition to the regular assumed normal conditions?

The accidental factor usually occurs so infrequently that measurement is difficult unless recording instruments can be used over considerable periods of time. With the novel method here described, however, records can be made extending over a sufficient time to include the accidents. In other cases tests can be set up and synthetic "accidents" produced. Measurements of stresses in airplanes during drop tests and in rough landings are of this type. Usually some standard of "accident" must be set up, but usually the loading is dynamic and the resulting stresses difficult or impossible to calculate. A record of strains in all important members during the test, will usually allow simplified calculations for the next design, which in turn may be refined by further tests.

Another important function of such testing is the reduction in weight of low stressed parts. In the development of any structure, for instance an automobile, the parts which are too weak are readily found by experience; but those too heavy and too strong are very generally ignored. Well considered stress measurements at peak overloads would allow weight reduction without the expense of cutting below, and then strengthening above, the danger point.

We may smile at Leeuwenhoeck's grain of sand as a basis for measurement, but in very many cases we find that design is based on estimates of load quite as loosely conceived as the dimensions of a casual sand grain. As in the 17th century, a great sense of virtue is obtained by measuring with a good degree of accuracy the figures which correspond to the factor "25,000". Careful and accurate figures are used for stress calculations based on loose assumptions of load and its distribution.

A concrete problem. The Autogiro Company of America wished to know the bending and direct stresses in the rotating wing spars of their "flying windmill."

The instrument must here operate at accelerations up to 80 g., withstand impacts, be self contained, weigh almost nothing, and cost very little.

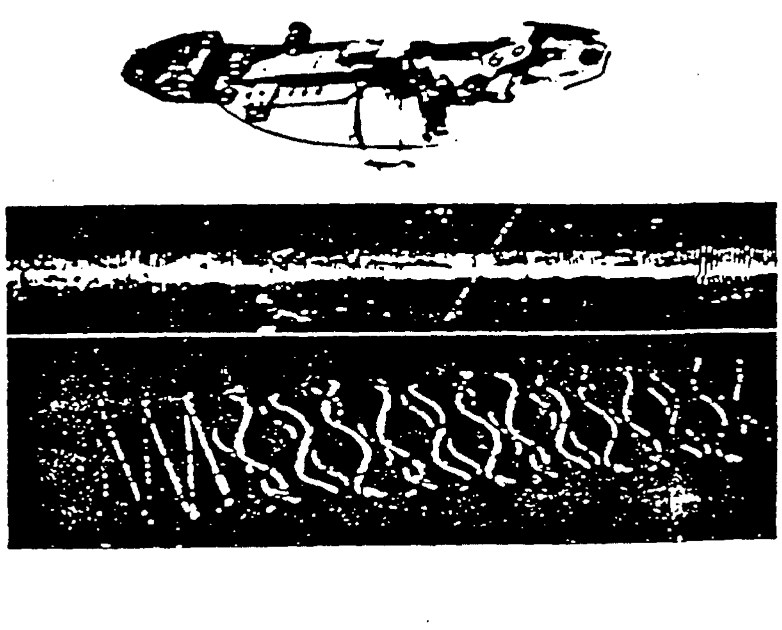
As an answer to the problem, the deForest scratch extensometer was invented. This device produces a full size record of the strain in the member to which it is attached, thereby eliminating optical, mechanical or electrical systems of multiplication of motion. The resulting record is magnified and measured, or photographed with any metallographic microscope. In this way a single multiplying system is used in conjunction with a number of simple individual recorders. Instead of using time as a coordinate of the record, a component of the change of motion to be measured is utilized. This is done by providing a light adjustable friction which restrains a spring from moving the target crosswise under the recording diamond. As a relative motion between gauge points scratches the record of deformation, the difference between static and moving friction allows the spring to traverse the target under the diamond, so that a second deformation leaves its record alongside instead of on top of the first.

For occasional or intermittent phenomena, this is an ideal arrangement; no record is made except where the transient appears. For stresses repeated at known intervals the arrangement is almost equivalent to a time basis, except that the scale is proportional to the stress changes. There is only one moving part, and this may be made exceedingly light, so that high accelerations do not cause difficulty.

Extensometers or strain gauges, hitherto in use, measure only distance between two points. The present instrument will record motion of one pair of gauge points relative to the other pair in whatever direction it takes place. For cases of combined

Additional Information about these Items Furnished on Request

Top—Scratch Extensometer, commercial type. Built by Baldwin-Southwark Company. Weight 0.8 oz.
Center—Record of bending stresses in Autogiro Rotor. Rough air condition and variable loads.
Bottom—Bending stresses and combined bending and torsional variations in shift.



longitudinal and torsion stress, the frequency relation, and extent of both components can be measured. In plates, pressure vessels, stressed skin structures, etc., where the direction of principal stress is unknown, a single record will cover both shear and direct stress in any two dimensions. This feature is a great saving in time and expense over laborious and frequently misleading calculations of secondary stresses.

In the case of the Autogiro spars, no significant torsion was present. The record gave complete readings under various wind loads and maneuvers of all kinds. The commercial instrument shown in the illustration is the latest development of this recording device. The record shown is taken from the Autogiro tests.

New Terminal Type Thermo Regulator

The Red Top Terminal Type Thermo-Regulator, announced by Hiergesell Brothers, is a development resulting from demand in the field of accurate temperature control, for a device that will control any desired temperature to a variation of 1/10th of one degree, within a range of from 0° to 200° F.

The following features of the instrument are pointed out in descriptive announcements:

The mercury is purified through a special process.

The capillary and reservoir is filled with dry hydrogen to dampen spark at contact point.

The electrodes, or contacts, are of a special alloy metal, expressly designed to contact on top of mercury.

Terminals for connecting control circuit, eliminate danger of breaking of old style, delicate "pig tail" leads to electrodes.

Outer glass shell, completely enclosing delicate parts, adds rigidity to the completed instrument.

Relays are so designed as to operate within 12 milliamperes at 110 volts, 60 cycles, through protecting condenser and resistors, which are mounted on one base.

Relays can be furnished in three types of enclosing cases.

Relay contacts will carry loads up to 30 amperes (3,000 watts) at 110 volts, A. C.

For Testing Tensile-Breaking Strength

For laboratory testing a new tensile breaking strength tester for a variety of materials is announced by the Amthor Testing Instrument Company, Inc. The manufacturers claim the virtues of accuracy, simplicity of operation, and rapidity of test.

The dial is 8½ inches diameter, is graduated directly in fractions of either pounds or kilograms, and is hand calibrated for accuracy. The dynamometer spring movement is specially designed for tensile testing and is so constructed that proper test sensitivity and elimination of friction are assured by free-floating movement throughout. When the specimen breaks, the pointer remains at the tensile strength reading. Jaws and jaw travel can be had in conformity with standard test methods for any material such as paper, cordage, wire, etc., it is stated.

New Instrument Concern Formed

The Parr Instrument Company has recently been organized by H. L. Parr and other associates of the late Professor S. W. Parr and has acquired the scientific instrument business of the Burgess-Parr Company. The new organization is fully equipped to manufacture and provide the laboratory market with the entire line of Burgess-Parr laboratory apparatus including coal calorimeters, sulfur bombs, turbidimeters, apparatus for catalytic hydrogenation, equipment for melting point determinations, goggles for glass blowers and special chemicals for sulfur, carbon and calorimetric determinations. In addition, new developments will be introduced at a later date.

Burgess-Parr Company will continue the manufacture of Illium castings for the chemical process industries.

RESEARCH IN REVIEW

Coolidge New Head of G. E. Laboratory

THE reward of valued services came to Dr. William David Coolidge, who upon the retirement November 1, of Dr. Willis R. Whitney, became director of the research laboratory of General Electric Company. Dr. Coolidge was elevated from his post as senior associate director by appointment of President Gerard Swope.

Brought to the laboratory by Dr. Whitney in 1905 from Massachusetts Institute of Technology, Dr. Coolidge was made assistant director in 1908 and associate director in 1928.

His important contributions to industry are well known to the research workers of the world. Some of them, in review, are:

Ductile tungsten as a filament material for the incandescent lamp; the wrought tungsten target in the X-ray tube; wrought tungsten electrical contact-points for make and break devices, e.g., automobile ignition systems; the hot-cathode type of X-ray tube, which bears his name; various types of X-ray generating equipment; the so-called "C-Tube"; listening device for submarine detection and under-water signalling; modifications which have greatly increased the power of the original Lenard cathode-ray tube.

Dr. Coolidge is a member of most of the important scientific societies and an honorary member of many of the foreign societies. He holds honorary degrees from Union College and Lehigh University and has been awarded the Rumford Medal, the Howard N. Potts medal, the Lewis Edward Levy medal, the Gold Medal of the American College of Radiology, the Hughes medal from the London Royal Society and the Edison medal.

Dr. Whitney Retires? Pooh!

From The Sun

"The General Electric Company announces that Dr. Willis R. Whitney has 'retired.' It means that he has been relieved of the obligations that devolve on the head of its research laboratory. In one of his numerous enlightening asides Dr. Whitney, speaking for humanity at large, has said that "we are lamentably bound by words." The corporation bulletin illustrates the truth of his incidental declaration.

"Dr. Whitney in seclusion, Dr. Whitney in retreat, Dr. Whitney withdrawn from circulation—these are unthinkable. The Whitney intellect has served knowledge too long to be suspended in its operations by a mere rearrangement of opportunities. The Whitney curiosity has so persistently projected into the abyss of man's ignorance that no shifting of titles can restrain it from future excursions into that fascinating, unplumbed gulf. The Whitney utilitarianism is too robust to be manacled by assignment to nonroutine duties. The Whitney spirituality is too pervading to be definitely engrossed on a scroll and filed away in a cabinet, no matter how artistically the engrossing be done or how elegantly the cabinet be fashioned.

"And, ultimately, Dr. Whitney possesses a sense of humor and a quality of wit which veto the notion that a useful man should or can retire."

Research Produces New Heating Substance

Research has placed at the service of industry a new heating substance whose cheapness and ease of control may benefit methods of melting and heating substances which must be handled in a range between 250 and

(Continued on page 59)

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Research in Review

(Continued from page 57)

700 degrees, according to announcement by the University of Michigan Department of Engineering Research, where experiments developing its usefulness were carried out.

This chemical is diphenyl, wax-like, geranium odored, non-poisonous and inexpensive, which may be used over and over without deterioration or injury to heating equipment, according to a recent bulletin. Diphenyl has already been shown by test to be suitable for heating asphalt. Similar commercial applications are said to be open in many related industrial fields.

The development of a new and saving heating method in asphalt working alone is of considerable economic importance, since $55,000,000 worth of native and petroleum asphalts are produced annually and used in such varied ways as road surfaces, roofing, dips, acid resisting coatings, putty and varnish.

Several advantages of diphenyl are pointed out—in the report of the experiments. It was found to be so stable chemically that it could be used under commercial conditions at 750 degrees without substantial deterioration, its boiling point being 756 degrees at 150 pounds pressure, while under normal pressure its boiling point is 492 degrees. In addition, very accurate heat control was found possible, avoiding uneven heating and coking, and the rate of heat transfer from the diphenyl filled coils to the substance being treated was found to be unusually high.

Urges Larger Research Appropriations

Much larger appropriations towards the support of research by the whole textile industry was urged on attendants at the third annual meeting of the United States Institute for Textile Research, held in New York this month, by Professor H. B. Millard of Massachusetts Institute of Technology. "A very small contribution on a percentage basis by all of the textile manufacturers would provide a huge sum for scientific research," he argued. Other speakers pointed out the growing appreciation in all branches of the textile industry of the close relationship between research and the ever-changing problems of production.

Oenslager to Receive Perkin Medal in January

George Oenslager of the B. F. Goodrich Company Laboratories, distinguished chemist of the rubber industry, will be presented with the Perkin Medal for 1933, for valuable work in applied chemistry, at a joint meeting of the American Chemical Society, the American Electro-Chemical Society, the American Institute of Chemical Engineers, and the Societie de Chimie Industrielle of France, in New York, January 6.

His selection was based on his pioneering work for the rubber industry on organic accelerators and other chemical research contributions. Chemical research on organic accelerators alone has achieved a saving of at least $50,000,000 a year to motorists, it has been estimated.

Dr. Langmuir Awarded Nobel Chemistry Prize

The greatest recognition any scientist can receive came to Dr. Irving Langmuir, associate director of the General Electric Research Laboratory, with the award to him this month of the Nobel Award in Chemistry.

Research Leads Patterson Into Heating Field

As a result of intensive research and experimental work The Patterson Foundry & Machine Company is prepared to enter the heating field about January 1, according to their November announcement. Studies were made in preparation for the manufacture of a complete line of conditioned air-heating systems, air conditioners, oil burners, domestic stokers and gas fired equipment for all types and sizes of heating loads.

Railway Association To Expand Its Research

On recommendation of the Board of Directors, The American Railway Association, at its annual meeting November 11 in New York, directed the various divisions of the Association to make a survey of their various research activities and possibilities of new fields of endeavor, with a view of recommending what further work can be undertaken in the interest of obtaining still greater safety, economy and efficiency in railroad operation.

TO HELP YOU IN YOUR WORK, INFORMATION REGARDING THE FOLLOWING LABORATORY ITEMS WILL BE SENT FREE UPON REQUEST

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Ballistic Instruments
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Barometers
Barrels, Tumbling
Baskets, Laboratory Waste
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