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OF

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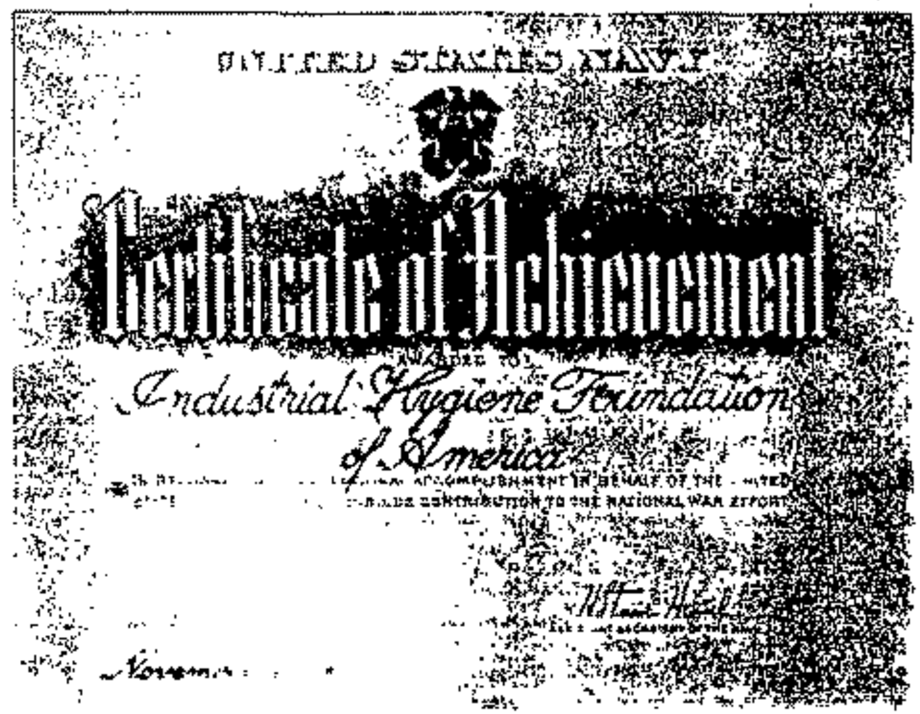

PRESENTATION OF CERTIFICATE OF ACHIEVEMENT FROM THE NAVY TO THE INDUSTRIAL HYGIENE FOUNDATION OF AMERICA

BY CAPTAIN E. W. BROWN (MC) USN

AT OPENING OF

TENTH ANNUAL MEETING AT MELLON INSTITUTE

PITTSBURGH, PENNSYLVANIA

NOVEMBER 14, 1945

It is with distinct pleasure that I come here this morning on behalf of the Navy to present the award of the Certificate of Achievement for war services to the Industrial Hygiene Foundation of America.

I will refer briefly at this point to the significance of this award in relation to the Army and Navy "E." The latter was granted to certain

TRANSACTIONS

MEDICAL AND ENGINEERING SECTION

TENTH ANNUAL MEETING

A. J. LANZA, M. D.* and PHILIP DRINKER, Sc. D.,† Presiding.

DR. LANZA: The first item on the afternoon program is the presentation of a preliminary report on one of the projects that the Foundation is conducting, namely, an evaluation of Industrial Health Department Functions and Relationships. It gives me great pleasure to introduce to you Dr. Sappington.

INDUSTRIAL HEALTH DEPARTMENT FUNCTIONS AND RELATIONSHIPS

Preliminary Report on a Foundation Field Study Now in Progress

C. O. SAPPINGTON, M. D., Dr. P. H.‡

Most surveys of this type are predominantly quantitative—this study is qualitative for the most part, although some quantitative data will be secured. We are interested particularly in finding out what the policies and procedures of industrial health departments are, how they are administered, and what the results are as to the efficiency of their application.

The great majority of the contacts were made in person and will continue to be so (since the survey is now only about 65% completed), although in some instances, on account of restrictions of travel and other difficulties, the minority has been reached by correspondence. Contacts, which have been made in person for the past several years, have been used and new ones have been made. The active work began on this study during April, 1945 and will be continued into 1946.

It is expected that several hundred different plants will be included, involving an industrial population of over one million persons, including large, medium and small plants in thirty different states, with many diversified types of manufacturing—which will constitute a fair statistical sample of what is going on in industrial health departments over the nation.

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OUTLINE OF SURVEY MATERIAL

A rather comprehensive outline has been used as a guide in securing information. This outline can be summarized as follows:

A. General Information

Name; location; date; products; average employment; person in charge; community population; date of establishment.

B. Personnel

Total—physicians, nurses, dentists, consultants, supervisors, specialists, technicians—full and part time. Selection methods.

C. Physical Setup of Department

1. Location, accessibility, distance to hospital.
2. Size and number of rooms.
3. Arrangement—separation (W & C—M & F).
4. Rest rooms and beds.
5. Equipment (surgery, illness, laboratory, special).
6. Cost (investment, maintenance, salaries, other).

D. Department Functions

1. Dispensary service (experience).
2. Examinations (kind and number, where made).
3. Dental service (inside or outside—amount).
4. Industrial Hygiene service (in—out—kind—amount).
5. Correction of physical defects (nature and scope).
6. First aid and safety (responsibility and nature).
7. Instruction (Sanitation—Health and Safety).
8. Casefinding activities.
9. Medicolegal problems.
10. Mental hygiene.
11. Records, Reports, Statistics (methods, uses).

E. Relationships (Intramural—Extramural)

1. Department responsible to whom?
2. Relation to other departments or divisions.
3. Full or partial authority.
4. Relation to private practitioners, governmental agencies.
5. Rehabilitation, labor and public relations.
6. Insurance provisions (group, hospital, etc.), family care.

F. Justification for Department

Reasons—professional, economic, social, other, supported by data, experience and opinion.

G. Miscellany

1. Departmental record forms.
2. Photographs (setup, processes, protection).
3. Departmental floor plans.

It seems advisable at this time to select three phases of this investigation for brief discussion, stressing the fact that these subjects are discussed only from the viewpoint of incomplete data, but realizing that there are certain definite trends shown by the present results. These subjects are: the

effects of reconversion and civilian adjustment activities on industrial health department services; some of the intramural relationships of industrial health departments; and the costs of industrial health services.

Effects on Reconversion

As this study has been conducted during the war emergency and also will be continued during part of the reconversion and adjustment period, there is opportunity for obtaining ideas regarding the effects of reconversion and civilian adjustment upon industrial health services. Expressions of opinion were obtained from medical directors, personnel managers, safety supervisors, and others, from widely scattered large, medium and small sized plants of diversified manufacturing, and may be briefed as follows:

1. Temporary reduction of working forces will necessarily be reflected in temporary reduction of professional personnel, with the result that health services for the time being will be reduced in quantity but not in quality. During this period of adjustment, a considerable number of industrial plants will take advantage of this situation to enlarge and rebuild their departments, installing additional equipment and services, as materials and personnel become more readily available.

2. The effects of reconversion will naturally vary with the type of products manufactured and the number of plants which were doing 100% war production. Reliable business figures indicate that *only 25% of plants need entire reconversion.*

3. A number of skilled observers have noted a decided improvement in the reduced number of health complaints, apparently because of the readjustment to shorter hours, relief from the pressure of production and the general anxiety generated because of the possibility of being called into the armed forces. The results show a reduced incidence of nervous indigestion, insomnia, cumulative fatigue, and nervous exhaustion, as well as the finding of progressive lowering of blood pressure readings in employees of 45 years of age and over.

4. On the other hand, in some quarters there has been an increase in the incidence of occupational disease in plants which have had no such experience during the years of the war emergency. This may be due to the laying off of professional personnel and termination of employment of others. It probably will have a relationship to the general increase in the number of compensation claims, especially following a period when the selection and placement of workers was difficult because of the war emergency and the shortage of professional personnel.

5. When, however, production assumes its normal levels, or increased production levels due to peacetime demands, there will tend to be an abnormally large load placed upon industrial health departments because of rapid and increased employment.

6. Thus far the experience with replacement of returning veterans has been favorable, for the most part. Indications, however, tend to show that greater difficulties may be generally experienced because of the "super-seniority" of veterans and the health problems of the older employees hired during the war period. In fact,

in some plants, it is conceivable that all male employees may eventually be veterans, in instances where the sexes were fairly equally divided during the war.

7. Although there may be some exceptions, such as instances where executives seem to feel that industrial health was solely a wartime measure, in companies where a good health program has been in effect for years, maintenance of this program will continue.

8. The differences between peak employment during the war emergency and low employment during the present reconversion period probably do not give a true expression of the number of persons employed because of housewives who have returned to their homes, farmers who have returned to their former occupation, and other individuals who had either entered war work to evade military service or have migrated back to work where production is limited to civilian products.

9. The increased interest in industrial health services shown by organized labor groups will oblige management to give increasing attention to healthful working environment, as well as good medical services, regardless of the constant broadening of the state compensation acts. Therefore, any retrogression which may occur temporarily will be followed soon by further progression. There is no question that medical services in industry will play a greater part in industrial management concepts than ever before.

10. One element in sustaining and maintaining an adequate industrial health service is the opportunity to maintain production at a high level—this interdependence is apparently overlooked in the battle for shorter working hours and more pay.

11. Professional personnel in industry has never had a greater opportunity to demonstrate the economic and industrial relations values of a well organized health maintenance program. Returning veterans and aging employees will require frequent physical checkups needing competent assistants and adequate equipment. This is no time to retrench in the activities of industrial health departments. If this should be done, mounting compensation and health insurance costs will more than offset the cost of adequate health programs.

Intramural Relationships

The discussion of this subject will be limited to a brief consideration of the relationship of the industrial health department to other departments within the same organization or plant.

For quite some time there have been varying differences of opinion as to the results occurring when the chief physician or medical director reports to the industrial relations division or officer, as compared with the effects which result when the same medical officers report to top management. There are those who believe that top management should be primarily interested in good health for employees and take an active interest in the health program, while others believe that good results may be secured by going through other divisions rather than to top management. Perhaps much depends upon the type of men to whom the reporting is done and their active interest and cooperation; perhaps also a great deal of the

success attained depends upon reliance and confidence being placed in medical leadership, with as little management interference as possible. Apparently good results have been obtained from both methods, although there are those who feel that from a strong organization point of view, reporting to top management is to be preferred.

Incomplete data available up to the present time show the percentage of these relationships in the following table:

INTRAMURAL RELATIONSHIPS

Reporting to top management	61%
Health Department has final word	77%
Industrial Relations, Health, Safety on a par	66%

It can thus be seen that more than one-half of the establishments contacted up to the present time show medical and health departments reporting to top management; the majority of instances show that the health department has the final word on health problems, and relatively the same percentage of relationship is true for industrial relations, health and safety divisions being on a par administratively.

Experience has also indicated that because of the limited number of physicians available to industry during the war emergency, there was considerable need for depending on lay technical assistants and upon nurses to the extent that industrial physicians learned much about administration. This has proved to be advantageous, because it made industrial health administration more similar to other industrial practices or procedures. However, it may not prove to be so beneficial, because too much relegation of medical functions to others than physicians may be carried over into peacetime practice and result in a deterioration in the quality of the service. This may be the reason why even among the "higher-ups" there is a feeling that the less interference with the technical functions of the health department, the better it can be administered.

All manner of variations in medical department administration have been encountered in this survey thus far. There have been instances where the department reports to a personnel committee instead of to one person; to a service officer, a layman; and other instances of reporting to a general manager by way of the medical director who is the chief of the service.

In one establishment, of long standing, it was found that the medical director's name has appeared, for the first time in the history of the organization, with the other officers of the company. It is too early to say that this may or may not be a trend, but the occurrence may be interpreted in various ways; it certainly seems wise that top management should know at first hand the problems of medical and health services, and that these be discussed directly with top management; it seems wise also that the medical director should have administrative touch with top management and appreciate more intelligently the problems of management. To this end, such an association seems advisable and advantageous. There are, however, a great many who believe that the medical officer should neither be management nor labor, but should represent an intelligent liaison between them, which by the very nature of the functions of the medical officer in his department seems an intelligent classification.

This subject will meet with further discussion and consideration during the continuation and completion of this survey.

Cost of Health Services

The cost of industrial health services has long been a favorite pastime of industrial physicians, statisticians and industrial executives, some feeling that there should be economic justification entirely on a monetary basis, while others believe that the industrial relations factors are sufficient for justification of the investment; still others use both appraisals in their evaluations.

It is not within the purview of this discussion to decide which is the most rational, but rather to discuss some of the fundamentals and give experiences from incomplete data.

Factors influencing cost may be cited as follows:

1. Type of service (kind and scope).
   a. Basic needs—type of industry.
   b. Conceptions of personnel.
2. Prevailing market (salaries—equipment—supplies).
3. Administrative methods.
4. Number of employees.

It may seem obvious that the kind of service rendered (namely, its extent and nature) should certainly be a factor in the cost of the service, but this needs further discussion; for example, there are certain types of industry, especially those manufacturing precision instruments, which need, because of economic necessity, a very extensive industrial vision service; there are others in which the nature of the industry demands an extensive toxicological program; both of these will naturally increase the cost of the service. The conceptions of the personnel of the organization may differ—the executive may think that a certain type of service is warranted only because it may cost less than another type. Also, the professional personnel have their opinions, the physician and the nurse, and in many instances the personnel directors and safety supervisors feel that they have some important ideas as to the kind and extent of the services which should be rendered.

The prevailing market as to salaries of professional personnel, and as to the prices of equipment and supplies, has a definite effect upon cost.

Administrative methods will affect the cost of industrial health services. Where there is a centralized system and supplies are bought on a wholesale basis and distributed from a central point, as occurs in some industrial medical sections of the armed services and also in some private industries, it is obvious that the unit cost may be reduced with respect to equipment and supplies, over that which obtains in decentralized groups, where the local medical officer can order what he chooses, even within reason.

Last in the importance of the factors which influence cost, is the number of employees—we have found, however, that the number of employees is not always indirectly proportional to the cost of the service, some small industries with a few hundred employees having a unit cost per person per year considerably below the cost in larger industries with well- administered services.

There are various methods of cost rating which need brief consideration. These are as follows:

UNIT RATING OF COSTS

1. Per capita per year.
2. Per capita per 1,000 man hours.
3. Per $100 payroll.
4. *Percentage of payroll.*

Probably the most common method of cost rating is the first one named, namely, per capita cost per year. Perhaps one which may be most easily *applied, and which may become general in later years,* is the cost in terms of percentage of payroll, which may be more understandable and comparable for the use of statisticians or executives.

It has been possible to assemble some material on costs with reference to a number of different types of plants. *The following table shows these* relationships:

No. Plants	Range Per Capita Cost Per Year	Av. Cost P. C. P. Y.	Number Employees
106	6.02 - 31.68	16.39	438,834
27	2.31 - 74.76	17.03	139,245
21	3.10 - 10.03	6.35	115,344
14	5.63 - 5.80	5.74	245,242

The first group of plants in this tabulation were all in the same type of industry and under the same general administration, as were also the third group. The fourth notation is an example from the industrial medical section of one branch of the armed forces and shows a low variation in range of cost per capita per year and a low average cost per capita per year, because of the possibility of standardizing on costs for equipment, supplies, and salaries. The second notation refers to a heterogeneous group of plants of all types of manufacturing in which, as one can see, there was a greater range of per capita cost per year and a higher average per capita cost per year. These figures are merely attempts to convey a rough idea as to the *range of per capita cost and the average per capita cost,* and do not represent comparable values.

It will be possible to work out certain comparison factors both with respect to cost and savings on a percentage payroll basis, according to the following outline:

COMPARISON FACTORS — COST AND SAVINGS

(Percentage Payroll)

COST

1. Personnel.
2. Investment.
3. Supplies.

SAVINGS

1. Compensation Premiums.
2. Turnover.
3. Absenteeism.
4. Placement.
5. *Better Lighting.*
6. Less Fatigue.

In the final report we will be able to show that a substantial saving can be made on a percentage payroll basis, over the cost according to the items given, which are susceptible to translation into monetary values.

There has been a great deal of difficulty in securing true cost values from industrial establishments, and an example will now be given of the kind of difficulty that has been encountered. The following table shows the difference in safety and medical costs in a very well organized and maintained division of a large national corporation:

	Safety	Medical
1944	$5.60	$9.60
1943	.30	2.40
	$5.90	$12.00
Average	$2.95	$6.00
	18	4

The fallacy of using average per capita costs per year is well demonstrated here. One can easily see that this average is not a true measure of the cost fluctuations in two consecutive years. The same kind and quantity of service was rendered during each of these years. Officials attribute these differences in cost solely to a change in concept by the accounting department as to what the same report form requested.

If this can occur in a well-managed corporation, what can be said of others? We are beginning, therefore, to doubt the validity of figures previously quoted by many of us in various reports. This, however, is no reason why we should discontinue collecting cost figures and studying them carefully as to source, treatment and soundness.

What can be done to make cost figures comparable? We believe that a "foolproof" record form can be devised for cost accounting departments, accompanied by simple, brief instructions. The form would contain expense items, common to all plant health procedures in one industry. Later, this might be adapted to industries of varying kinds of manufacture and services.

One of the first tasks to be attacked will be to make a standard, carefully thought out definition of what plant medical expense is and what it is not, so that the expense items may be mutually exclusive. If this can be done, it may represent, as one of our statistician friends has said, a real contribution to industry.

DR. LANZA: This paper will now be discussed by Dr. T. Lyle Hazlett of the Westinghouse Electric Corporation.

DR. HAZLETT: Now that you have heard Dr. Sappington's report, you can readily see the tremendous value that such reports will be to us in the maintenance of our Health Department functions in industry.

I think that we have not in the past presented our side of the picture as it should have been presented to management. Perhaps we have been too busy and perhaps we have considered our services too much as routine work. Management should receive a complete summary of our activities and accomplishments each year, just as it does from other departments. The preparation and submission of such reports will inevitably lead to a

greater amount of preventive work in industry. We know what has been accomplished in the safety field. A great deal of the energy and effort that was put into that program resulted in an actual cost saving through reduced compensation and medical expenses.

I think that the accomplishments of our medical prevention program can be presented in the same way. We are all faced with problems in our management relations, at times a little more serious than at others. In this period of reconversion I think we do have that in view, not as much perhaps as in the 20's or the early 30's, but nevertheless it is something that we must think about and must discuss with management. Adequate measures of the accomplishments of medical service are lacking. We do not know, for example, how much has been saved by the tuberculosis prevention program—the tremendous number of years otherwise lost in middle life from this disease, which is a loss to industry and to the community.

I think that Dr. Sappington's continued study will be most helpful. Because of the lack of uniform cost accounting system, comparative costs of Medical Department services have had little meaning. Due to different accounting procedures various other items only indirectly related have been charged to medical service.

There is no question in my mind that we are in the beginning of a new cycle in industrial medical service. During the war you know how much attention was paid to absenteeism. It is the continuing duty of management to understand what can be done to keep our workers on the job. I think that a study like this will be of tremendous value, and that from it will come a method of making meaningful comparisons of accomplishments and costs of medical services and also of providing management with factual information. I am sure that management desires such information, which has not been presented to them as a rule. When they see just what medical service can do in the prevention of disease through control of environment and in the reduction of absenteeism, and when we do what we can to reduce to the very minimum this waste in industry from sickness, I am sure that medical service will show a definite profit in dollars and cents.

DR. LANZA: I think you will agree with me that the task that Dr. Sappington has undertaken on behalf of the Foundation is not a simple one, but on the other hand those of us who know Dr. Sappington know that he will come up with the right answer.

The next item is "Accurate Diagnosis of Silicosis." There is always something new, and it gives me great pleasure at this time to introduce to you the gentleman who needs no introduction to this audience, Dr. Gardner.

1946

ACCURATE DIAGNOSIS OF SILICOSIS— POSSIBLE SOURCES OF ERROR

Too good
Fair
[illegible]

LEROY U. GARDNER, M. D.*

Probably most of you are wondering why an hour of this program should be devoted to such a trite and hackneyed subject as the diagnosis of silicosis. Everyone present probably knows that the diagnosis of silicosis rests on three bases: a history of adequate exposure to free silica dust, the demonstration of a characteristic nodular pattern in an x-ray film of the chest, and a physical examination which reveals very few abnormal signs in most uncomplicated cases. All of us accept these fundamentals in theory but in practice they are too often neglected. One's objective may make him forget that not one, but all three of these factors are essential to the diagnosis. From the lawyer or the physician representing a claimant for compensation we hear that the plaintiff must have silicosis because all of *his industrial life has been spent in an industry* whose atmosphere contains so many million particles of free silica dust. Yet a glance at the claimant's x-ray films may show nothing to support the contention. From the roentgenologist or the internist of an urban medical center comes the diagnosis of silicosis because the film reveals a generalized nodular pattern and the subject reports that he has worked at a dusty job. Neither roentgenologist nor internist is in a position to obtain the details of the occupational history that will indicate whether the dust contained significant quantities of free silica.

Proof of Exposure

I am here to lead a discussion emphasizing the necessity for establishing all three criteria in every case diagnosed as silicosis. Unless there is proof that the subject has been exposed to free silica dust for periods measured in years we have no right to assume that a nodular x-ray pattern is indicative of silicosis. Such patterns may be produced by other causes; some of them the result of inhaled materials other than free silica and some due to infections or systemic diseases which should be disclosed by a thorough physical examination.

I shall call attention to several conditions that are being confused with silicosis today and the three speakers who follow me will elaborate upon their apparent causes. Some of them are at least associated with disability and some are apparently benign; some seem to be due in whole or in part to the environment of industry; some are wholly unrelated. The causes of many are still unknown but assertions of industrial origin are frequent.

Among these conditions is the so-called arc welders' siderosis which was discussed by Dr. Sander at our 1943 annual meeting. In theory the nodular shadows on the x-ray film are cast by focal collections of minute iron particles within the lungs; fibrous tissue reaction and resultant symptoms are lacking. This explanation at first seems adequate, for all substances of high atomic weight are opaque to x-ray and in sufficient local concentration they cast shadows on a film. Examples of such substances are the compounds of barium and the rare earth minerals which Dr. Crouch will discuss.

* Director, Saranac Laboratory for the Study of Tuberculosis.

But mere opacity to x-rays does not explain the production of nodular shadow patterns simulating silicosis. Iron miners have siderosis whether they work in hematite or magnetite, but they develop nodulation only when they inhale enough quartz with the iron. We know this from a study of literally thousands of films correlated with detailed occupation histories and from over 50 autopsies with mineralogical analyses of the lungs. On the other hand, organic iron from the blood may at times cast nodular shadows which simulate silicosis. In the form of valvular heart disease known as mitral stenosis there is interference with the circulation in the lungs; blood cells escape into the air spaces and dust cells then concentrate their contained iron in small focal spots.

Perhaps even a more striking example of the effect of the blood is seen in the films of men who have been trapped underground in mine explosions. In them the films demonstrate the sudden appearance of fine nodulation, but this disappears again after a month or so. The effect has not been checked by autopsy but it is assumed that small hemorrhages in the lungs are responsible for the nodular shadows. Whether iron or merely the collection of blood itself casts the shadows remains to be established.

Research is in progress at the Saranac Laboratory to define the conditions under which iron, the rare earths and other radio-opaque substances may produce changes simulating silicosis.

Superficial Resemblance

Another disease is now being recognized which superficially resembles nodulation of silicosis. This is pulmonary sarcoidosis, apparently a tubercle-like infection of unknown cause. The nodular shadows are uniformly distributed throughout both lungs but they are exceedingly small. They may become confluent but they never enlarge to the size of silicotic nodules. This disease occurs here and there throughout the population at large but has frequently been attributed to pulmonary irritants of industrial environments. I recall one case from a rayon mill, one from an asbestos plant and another in a graphite miner. Recently a considerable number has been found in industries using beryllium and its compounds. It has not occurred in every plant using these materials. None of its victims has had more than slight or casual exposure to dust of these minerals. It has not been possible to reproduce sarcoidosis with beryllium compounds in animals. As a working hypothesis we are assuming that while the infection may develop in the absence of beryllium, the causative organism grows more readily in the presence of this substance. A similar combination exists in the case of the tubercle bacillus and free silica. Certain experimental observations make it necessary to consider radiation as well as infection among the hypothetical inciting causes of this condition. Much must be done before it can be concluded that sarcoidosis is an industrial disease. The Saranac Laboratory has an elaborate program of research upon this problem.

Miliary Calcification

Most of you have seen or heard of the condition called miliary calcification of the lungs. Here the x-ray reveals nodules, often scattered throughout both lungs, but these nodules are of unusual density and their distribution is not uniform. They were once thought to be due to infection with a mould, aspergillus, but this view has not been substantiated. It is assumed that they represent healing of some form of infection whose nature is still unknown. *It could not be tuberculosis, for these people have never been* sick. The cases are most common along the Ohio River and in Missouri and Kansas. Analysis of the nodules shows nothing but calcium and phosphorus in the proportions normal to human tissue. They cause no problem in diagnosis unless there happens to be an associated history of employment in the mines; then in compensation cases there may be difficulties.

Recently I have had occasion to study a case of nodular fibrosis which *was diagnosed as silicotic by a number of expert roentgenologists.* Before death we ourselves felt that this was the most probable cause, although the occupational history apparently did not support this view. The man's only dusty employment was 27 years in a limestone kiln, and his job was on the platform where the rock coming from the quarry was dumped into the top of the kiln. At the time we had no analysis of the rock or the dust in which he worked, but we suspected that they must have contained some quartz. Later they were made available, but significant quantities of free silica were lacking. Subsequently the man died of an apparently unrelated cause and an autopsy was obtained. His lungs showed chronic bronchitis and emphysema and many uniformly scattered nodules, but they were not of silicotic type. Analysis revealed only 0.04 percent of total silica; no free silica or any other substances known to cause fibrosis. The chief components of the ash were carbon and iron. Films of another man employed at the same job showed no suggestion of nodulation. The diagnosis of silicosis has not been substantiated and can be definitely excluded. The nature of this disease still remains an unsolved problem. Its pathology does not conform to that of any ordinary disease; it resembles most the changes sometimes seen in coal miners, but in them there is usually enough quartz to account for the nodules. Since such pictures do not occur regularly in limestone quarrymen, crushers or kiln tenders, one is forced to conclude that factors peculiar to this individual were responsible. Whether the inhalation of a dust that is innocuous for most persons played any part is a question that cannot now be answered.

Nodular X-ray Patterns

The various conditions that have been cited all manifest themselves by nodular x-ray patterns; all of them have been diagnosed as silicosis by one or more competent physicians. In most of them exposure to free silica dust could be excluded by anyone in a position to ascertain all the facts. In a few instances there may have been some such exposure but not of significant degree. The knowledge that such conditions exist should make us more cautious in diagnosing silicosis, particularly in cases from industries where environmental conditions are unfamiliar or not clearly defined. More progress would be made if roentgenologists would merely report a shadow pattern as nodulation with the qualification that this could be interpreted as silicotic in origin if supported by a history of adequate exposure to free silica.

ACCURATE DIAGNOSIS OF SILICOSIS—
SOME EXAMPLES OF ERROR

A. G. CRANCH, M. D.*

Along with the discussion by Dr. Gardner, I would like to mention four types of conditions that have come to our attention in the last few years. These presented x-ray findings in some respects simulating those of silicosis. First, is a group of cases in men exposed to dust in the milling of rare earth oxides and fluorides, used in core material for illuminating carbons. These are compounds of such materials as cerium, lanthanum, neodymium, praseodymium and some of the other "dymiums" present in the material from which the old Welsbach light mantles were made. They have high atomic weight, close to that of barium and lead, which are quite opaque to x-ray. This material is milled to very fine, almost impalpable powder. These men have had some exposure to silica, because in the course of their work they do have occasion to mix batches containing some silica. This exposure is usually only once or twice a month and relatively minor. It would be difficult to see how this exposure would produce any appreciable degree of fibrosis. One of these men about 60 years of age had influenza. He had also had chronic bronchitis and some heart trouble. While convalescing from his influenza his chest was *x-rayed and the film was startling. He* decided to put in a claim for compensation on the basis of the x-ray findings. The Compensation Commission made a total disability award on the ground that while other conditions might be present the x-ray indicated advanced silicosis, and this determined the award. The second case was a young man in the same department who later had influenza. He had a chest x-ray and on the basis of similar findings also made a claim for silicosis. Although *he had much less exposure there was remarkable similarity* in his films and in those of the first case. In his case, however, while the Commission confirmed the diagnosis of silicosis on the basis of x-ray findings, no compensation was awarded, as no disability could be demonstrated. Other men with this exposure were x-rayed, and a third case found who, after five or six years' exposure, showed about the same x-ray appearance in a rather diffuse shadow suggesting nodulation. This man never put in a claim, *saying, "I have no disability.* What could I claim?" These three cases would appear to illustrate a condition due to inhalation of an x-ray opaque dust, rather than to the presence of a fibrosis. When chief reliance is placed on x-ray findings such a condition might lead to error in diagnosis.

No Silica Exposure

Another type of case turned up as the result of draft board examination. One of these was a young man in his early twenties who had never done anything but go to school and do office work, with the exception of seven weeks' plant work, three weeks at one time and four at another. Part of his work involved emptying two or three bags of ground mica into a mixer. Some days he had to do this twice, but usually only once a day. There was no exposure to silica. After his draft board examination he was

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declared unacceptable for military duty because of "advanced silicosis." Reporting to us, he was referred to a prominent chest specialist, who diagnosed his case as silicosis because of his exposure to silica—as a silicate. On discussing this with the specialist he was at first unwilling to consider any other diagnosis, *in spite of the extremely minimal exposure, and that to* mica, not free silica. He finally admitted that the x-ray findings might be due to other causes. Here is the film on which the diagnosis of silicosis was based. Here is a film a year and eight months later, with nothing significant showing—*certainly no nodulation or even linear shadows.* Two years of constant study, during which tuberculosis was very definitely ruled out, resulted in a diagnosis of Boeck's sarcoid. Between the time of the two films shown there were probably eight or ten examinations, some showing decrease and some reappearance of the shadows. *During all this time* the boy felt well and was free from any clinical symptoms. But this case was diagnosed by draft board examiners and by a chest specialist as silicosis on x-ray evidence alone.

The second draft board case was rejected after x-ray with a diagnosis of silicosis, but I do not have his films here. This man's x-ray showed a widely diffused shadow, not particularly nodular, but diagnosed as silicosis nevertheless. The man was about 30 years old and worked in a dust-free chemical plant. At the opposite end of the building, on another floor was an enclosed filter which contained some silica—the only silica in the plant. This man was referred to one of our universities for study and the final diagnosis was mitral stenosis—a heart condition pure and simple—the x-ray shadows being due to congested pulmonary vessels. This man had been in fair general health and there was nothing in his history or developed in a careful study of the case to indicate anything like silicosis.

Another Case Described

The last case is a mystery to us. He was being examined by the draft board, and all went well until asked where he worked. It is reported that on hearing the name of the plant, examination stopped until an x-ray could be obtained, and he was then told that he was in the advanced third stage of silicosis with general tubercular complications, that he had only a short time to live, and by all means should go right to a hospital. That boy came back really looking sick! He had been working right along and had not felt ill, and now reported he had been told he had only a few months to live. He was immediately referred to a competent radiologist who, after careful examination, said he could find nothing on which to base even a suspicion of silicosis. He was then referred to the head of a tuberculosis sanitarium who, also after thorough examination, could find no basis for diagnosis of either silicosis or tuberculosis. Dr. Gardner has also seen the films and reports in this case and has concurred in the opinion of the others who examined him after his rejection by the draft board. Nevertheless claim has been made for disability due to silicosis, based apparently entirely upon the reported statement of the draft board.

These cases illustrate only four kinds of error which may occur in interpretation of x-rays. Three showed x-ray findings which might easily have been confused with silicosis, and yet thorough examination showed had no relation to it.

Confer

ACCURATE DIAGNOSIS OF SILICOSIS—ATYPICAL NODULATION IN FOUNDRY GRINDERS AND BURNERS

L. K. HAMLIN, M. D.*

For several years we have been concerned with chest x-ray findings among grinders and burners in our foundries because the pattern of nodulation observed in the roentgenogram, the clinical aspects and history of occupational exposure, are inconsistent with the present conception of silicosis.

The first indication of incompatibility occurred during a periodic x-ray survey in 1941, in which a diffuse, discrete nodulation appeared in serial films of burners following a period of exposure altogether too short to produce such changes, if due to silica. Similar patterns were observed in films of grinders. Since it is an accepted fact that a silica hazard exists in all foundries, it was assumed that the nodulations seen in the roentgenograms represented silicosis, and they were so interpreted. At that time we were not familiar with the work of Sander and Enzer (1938) although we were well aware that cases of atypical nodulation had been described in the literature. Our observations, therefore, were made independently, and the findings were sufficiently obvious to direct attention to the fact that we were probably dealing with a condition other than silicosis. Unlike the cases of siderosis described by Sander and Enzer, the men in our group were known to have some degree of exposure to free silica as well as iron oxide.

Description of the Operation

A description of the operation in the one plant where the greatest number of these cases developed will be representative of all of them. There is only a variation in the percent of the men involved in each plant, and this is directly related to the extent to which the cleaning and grinding department is walled off from other operations which might afford some dilution of the dust. In the plant where the greatest number and highest percentage of men showing these x-ray patterns were found, the cleaning room is one large building with about 35,000 square feet of floor area and a volume of approximately 1,000,000 cubic feet. For the most part, it is open to other buildings only through doorways, and three walls have no windows. Three shifts are worked with 125, 45, and 20 men on the day, evening, and night shifts respectively.

Castings ranging from a few pounds to several tons in weight are *shaken out* of the molds while still hot and, after the cores are knocked out quickly, they are annealed. The castings are then quenched in water and taken to the burning floor where gates, risers, and fins are burned off with oxy-acetylene torches. Some pits and holes are filled at this point by electric welding.

Here the castings enter the cleaning room; small pieces are tumbled and then are finished on pedestal grinders which are well exhausted. The

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larger pieces are finished with stiff shaft, swing frame and small hand grinders. These pieces usually have sand adhering to them, much of which is burned into the surface. It was the practice to go over practically the entire surface with the grinding wheels to produce a clean metal surface as well as to smooth off welds and the sections where gates, risers and fins had been burned off. These grinding operations are productive of a large amount of dust as well as the large particles seen as sparks. This dust is composed of the abrasive material, the wheel binder (plastic), sand, scale, and the metal which may or may not be completely oxidized. Local exhaust had been applied to the swing frame grinders only in a very minor degree.

Control Measures

The small local exhaust hood under a swing frame grinder had not been found very satisfactory, as it was in the way of some operations and was effective in collecting the dust in only a few cases. Grinding booths were suggested and although successful for swing frame grinders at another plant, were not used here because the building structure did not lend itself readily to their installation.

A circulating heater, using an ineffective steel wool and coke dust filter was altered to permit the continuous introduction of outside air through the heating coils. This was done in 1943 and showed a distinct drop in the average dust concentration in the end of the building where it was located. There was no significant change at the other end of the building where there is some general exhaust ventilation at the roof (30,000 cfm.).

Since the condition believed to be silicosis could only be attributed to the sand on the castings, a hydroblast was installed late in 1943 to clean the surface of the castings before they were ground. Although this did greatly reduce the amount of silica in the air-borne dust, the total number of dust particles per cubic foot of air was just about the same as it had been before the hydroblast was installed. Repeat x-rays in 1943 still showed progression of the silicosis-like pattern in some cases, although the amount of silica dust in the air is far below what is generally considered the threshold limit of five million particles per cubic foot.

Total Atmospheric Dust

One hundred and thirty-three midget impinger and electrostatic precipitator samples over a three-year period during the months from August to December were collected. These ranged from 4.0 to 67.2 million particles per cubic foot, and it is noteworthy that only six out of the one hundred and thirty-three samples showed over five million particles of silica dust per cubic foot of air, and only one reached 8.5 million.

Analysis of Air-borne Dust Samples

Samples were studied by x-ray diffraction, petrographic and chemical analyses of pooled impinger samples of air-borne dust. After removing the metallic elements by digesting the dust with hydrochloric acid, the insoluble residue consisting of quartz, corundum, rutile and iron glass or other silicates was separated into size fractions, and the composition of these determined.

It was found that nearly all the iron was present as the magnetic oxide Fe_3O_4 and existed mostly as fume or as fine particles less than one micron in diameter, but there were many clumps up to 40 microns, and spheres (probably iron glass) up to 25 microns. The quartz content of the entire sample was higher in the fraction above ten microns. There was little of the highly active forms of free silica (cristobalite not over 0.21% and tridymite 0); most of it existed as ordinary quartz, particles three microns and less in diameter constituting only about 0.6% by weight of the sample.

COMPOSITION OF DUST BEFORE FRACTIONATION

		Sample No. 1	Sample No. 2A
		%	%
Total SiO_2		6.5	8.9
Free SiO_2	Quartz	3.1	3.9
	Cristobalite	0.1	0.3
	Tridymite	0.0	0.0
Fe_3O_4		73.2	67.4
Mn		5.9	7.8
Corundum		1.5	4.1
Carbonates		trace	trace
Rutile		trace	trace
Loss on Ignition		8.2	8.2

Clinical Observations

Time Required for Development of Nodulation

Sixty-eight grinders and burners were observed over a period of 12 years. Chest roentgenograms were made in 1933, 1934, 1936, 1942, 1943, and 1944. A few of the men were x-rayed in the intervening years. The following tabulation (page 19) is an attempt to demonstrate the length of time required for development of nodulation in the x-ray.

Including those who had definite nodulation in their first x-ray and showed a progression after six years to second degree, together with those who went from normal or early indefinite changes to actual fibrosis, twenty-nine (42%) of the affected men developed nodulation within six years.

Duration of Exposure

Dust exposures in 68 grinders and burners ranged from five to 40 years. These are tabulated as follows:

DUST EXPOSURE IN 68 GRINDERS AND BURNERS WHO SHOW NODULATION

Years	No. of Men	Percent
5 to 10	5	7
10 to 20	28	41
20 to 30	20	29
30 to 40	15	22

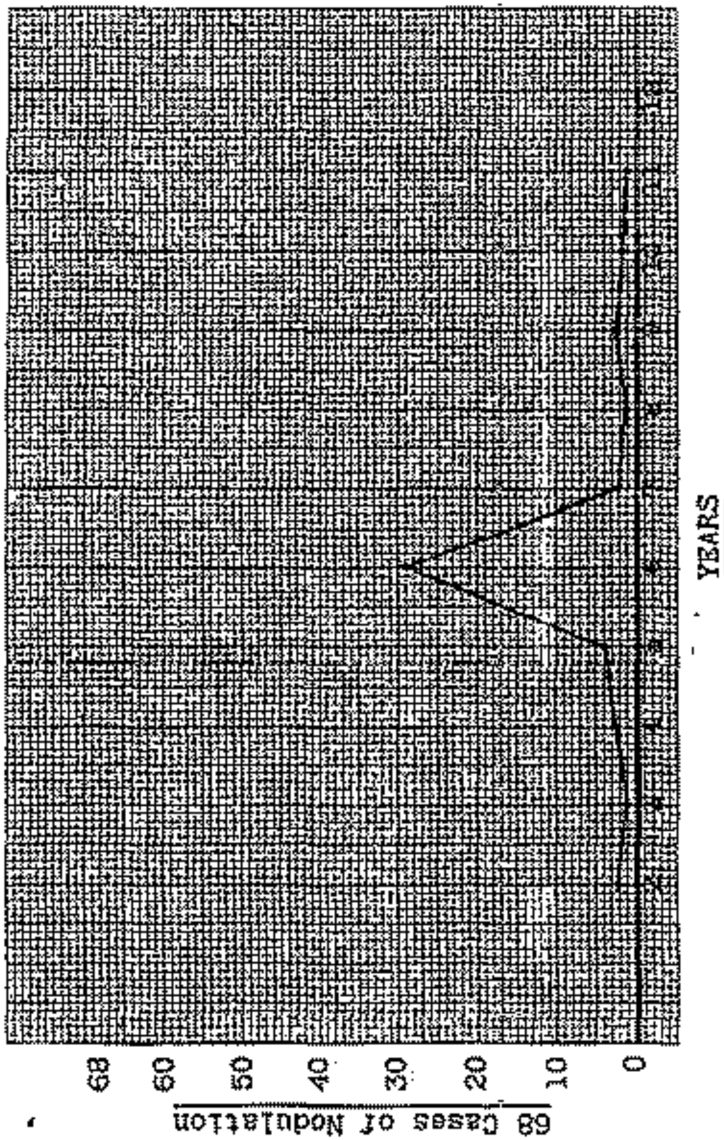
It should be pointed out that all of these workers have not been constantly employed at the same job and some have had dust exposures in other industries. A number have worked in coal mines, quarries, potteries, etc., and many have had previous foundry experience in other locations. Generally speaking, however, the majority are old employees with many years of experience in the same plant. Nor does the fact that they have been grinders for only a few years represent the entire exposure. These men have all been exposed more or less constantly to the same atmospheric conditions as shown by representative air samples throughout the cleaning rooms and machine shops.

Routine physical examinations on these individuals have not revealed significant clinical findings and, although air samples over three years indicate a definitely dusty operation, there does not appear to be enough free silica to constitute a hazard, certainly not enough to produce the rapidly developing nodulations observed in some employees' x-rays. If, on the other hand, these lung markings are due to iron oxide pigmentation, there appears to be enough iron oxide in finely divided form in the atmosphere to cause it.

APPEARANCE OF NODULATION IN X-RAYS IN 68 GRINDERS AND BURNERS

12 Year Period (1933-1944, inc.)	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	9th yr.	10th yr.	11th yr.	12th yr.	Total	Per Cent
No definite abnormal findings to Def. Nodulation		2			4	26	2	1	1		1		37	54
Increase in nodulation from S_1 to S_2			1			3			1				5	7
No change from original S_1													28	38

TIME REQUIRED FOR DEVELOPMENT OF NODULATION



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DISCUSSION

DR. O. A. SANDER (Medical Committee, Industrial Hygiene Foundation): In order to summarize this discussion, I should like to re-define the term "pneumoconiosis," which is widely misunderstood not only among laymen, but among physicians as well. It simply means "Dust added to the lungs," without any implication of fibrosis or disability. As a matter of fact, all adults, particularly those living in cities, have some degree of pneumoconiosis, in that all have some anthracotic pigmentation of their lungs due to constant inhalation of carbon particles through the years. This seldom is sufficient to be visualized by x-ray, but is clearly seen at all postmortem examinations of adults.

Most pneumoconioses which become visible on x-ray films result from industrial dust exposures. The most significant of these have been silicosis and asbestosis, in both of which the x-ray shadows are cast by fibrous tissue resulting from the toxic fibrogenic properties of *free* silica and asbestos fibers. It is because of these two fibrotic pneumoconioses that the medical mind has associated fibrosis with all the pneumoconioses.

Inert Dusts

We now know, however, that there are dusts which may become deposited in the lymphatics of the lungs which are entirely inert, in that they cause no overgrowth of connective tissue in the lungs. Among such dusts are carbon and iron, and possibly some of the heavier metals which are not as readily absorbed into the blood stream as is lead, for example. Metal dusts which become deposited in the lung lymphatics may be entirely inert, with no fibrous tissue whatever resulting from their presence. This was well shown in the case of iron in the postmortem study published by Enzer and the speaker in 1938[1, 2] and reported at your meeting two years ago, in which a tank welder who showed x-ray changes simulating silicosis had no fibrous tissue in his lungs when studied at postmortem. The shadows simulating silicosis were believed to be due entirely to radio-opaque iron particle collections in the lymphatic channels and nodes surrounding the blood vessels and bronchi.

This postmortem finding has only recently been verified by McLaughlin, Barrie, Grout and Harding,[3] a group of English investigators who have been interested in this subject for many years. A silver polisher using rouge (iron oxide, Fe_2O_3), whose x-ray film had shown stippled and reticulated shadows, was found at postmortem to have collections of iron particles in the lung lymphatics and no fibrotic changes. The published microscopic sections from these lungs were similar in every way to those published by us in the welder study.

Re-define Term

These observations require a re-defining of the term "siderosis," first introduced by Zenker in 1866. As with the general term "pneumoconiosis," so also with the specific term "siderosis," the definition is simply "Iron dust added to the lung." Zenker's definition unfortunately implied that iron deposits in the lungs resulted in fibrosis, because his cases had fibrosis due to associated tuberculosis. Later pathological reports of iron miners' lungs usually were cases of sidero-silicosis, the observers concluding that the iron was the cause of the fibrosis rather than the silica. We now know that iron oxide is entirely inert in the tissues, but that collections of large numbers of particles will cast shadows on x-ray films. The term "siderosis," therefore, is perfectly proper provided the implication of fibrosis is excluded.

The first slide is a more recent chest x-ray film of the welder foreman reported here two years ago, who has shown no changes in the discrete pseudo-nodular shadows which we still believe are due to inert collections of iron oxide around blood vessels. He no longer is exposed to welding fumes, for which reason we had expected to see evidence of some absorption of the iron, but no changes have occurred. He still works every day, still swims considerably each summer and still is entirely without symptoms on exertion. We now have been observing him periodically for over 10 years.

Difference in X-ray Appearance

While his chest film is on the screen, I should like to indicate a few points of difference in x-ray appearance between uncomplicated siderosis and silicosis, whereby we believe that we can differentiate the two. The hilum shadows at the lung roots are not enlarged with siderosis as they are with silicosis, because the iron deposits cause no fibrosis in the root glands and therefore no enlargement of these glands. Also, the iron collection shadows always are more discrete and sharply defined than are silicotic nodules as visualized on x-ray films, and there is no tendency to confluence as with silicosis. Based on these differential points, we have been able to "spot" some welders by the x-ray appearance alone before we knew the occupation.

The second slide is that of a young welder who did about 50 percent confined work inside of pontoons for landing barges, but only over a period of 33 months. His pre-employment film was entirely clear, but definite discrete stippling is noted on the film made 33 months later. This is the shortest exposure we have seen showing evidence of iron oxide deposits in the lungs. The fume concentrations inside of the pontoons were extremely dense, with no attempt at ventilation until these x-ray changes were discovered. It is interesting that in spite of these obviously intense welding fume exposures, this welder had none of the upper respiratory irritative symptoms frequently observed among shipyard welders.

Iron Oxide Fume

The third slide is that of an electric welder, age 60, who worked in a steel foundry cleaning room for 22 years until 1940. His exposure, therefore, was similar to the cases which Dr. Hamlin showed, there having been some silica exposure along with the excessive iron oxide fume exposures. Developed attack of "flu" early in 1940, which was followed by marked exertional dyspnea not present before the attack. This persisted to such a degree that he felt unable to continue his work and filed claim for compensation. His doctor's opinion was that he was totally and permanently disabled as a result of an advanced nodular silicosis, which he called advanced second stage. It was our opinion that this probably was a combined lesion, sidero-silicosis, but that we believed that the silicosis was minimal in degree because of the small hilum shadows. We pointed out that his height was 5' 2" and his regular weight had been about 140. During and after the illness, his weight increased to 180 lbs. The second film shows the marked

elevation of the diaphragm on full inspiration as a result of this increased weight, which undoubtedly was the major cause of the exertional dyspnea and easy fatigue, with hysterical manifestations which undoubtedly exaggerated the symptoms. Our Industrial Commission, however, after an independent examination at a well known midwestern clinic, concluded that the incapacity for work was due to an advanced second stage silicosis and awarded compensation for total permanent disability late in 1940.

He has not worked since then. We have observed him from time to time and have found less evidence of dyspnea as his weight decreased. The recent film, which is slide four, shows marked improvement in the diaphragmatic excursion and the dyspnea is much less than in 1940. Only a slowly increasing arthritis prevents him from doing light work now.

The medico-legal implications here are obvious in that where the chest x-ray film shows nodular shadows simulating silicosis and where there also is an admitted silica exposure, no matter how slight, the case will be regarded as primarily silicosis. Other factors which may produce nodular or stippled lung shadows will be disregarded if any degree of silica exposure can be shown. Continued education of the medical profession and our Industrial Commissions will be necessary to make them aware that all x-ray shadows having a nodular pattern are not due to silicosis.

Postmortem Studies

A plea is made to urge all who are interested in the more accurate differentiation of cases with nodular chest x-ray patterns, to make every effort to obtain detailed postmortem studies on all such lungs. Too few have been adequately analyzed and the findings correlated with the x-ray pattern. Our welder, whose films I showed last, understands our interest in his lungs and has given his consent for their study when his time arrives. Dr. Gardner will receive one of these lungs for analysis and the other will go to the doctor who testified that this man was totally and permanently disabled because of silicosis.

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3. McLaughlin, A. I. G.; Grout, J. L. A.; Barrie, H. J.; and Harding, H. E.: Iron Oxide Dust and the Lungs of Silver Finishers. Lancet XI of Vol. I, 337, (March 17, 1945).

DR. PHILIP DRINKER: The last two papers this afternoon are of special interest to the engineering profession. The first, on improvements in the accuracy of measuring the silicosis hazard, is by Dr. Holden and Messrs. Hemeon and Hyatt, members of the Foundation staff.

ACCURATE MEASUREMENT OF SILICOSIS HAZARDS—NEWER METHODS

F. R. HOLDEN, Ph. D.,* W. C. L. HEMEON, M. S.,* and E. C. HYATT*

The impossibility of diagnosing silicosis from chest roentgenograms alone stresses the need for correlation of the x-ray findings with dust exposure. It is, therefore, of primary importance that a true appraisal be made of silica dust exposures. The appraisal is dependent upon the evaluation of the following factors: How much dust is in the air? What is its particle size? What is the dust composition in the respirable sizes? For how long is the workman exposed to the dust?

The failure to accurately determine any one of these variables can result in an inaccurate conclusion. We believe that the particle size composition of dust has not received attention commensurate with its importance. In this paper we propose to show means of measuring particle size composition. Also, data obtained from several industries will be presented to substantiate the validity of the techniques.

Particle Size and Composition

During the early classic studies on silicosis[1] the composition of dust was determined by the analysis of samples of settled dust (so-called rafter samples). This practice seemed logical, as material which had settled on ledges and rafters had reached those positions after floating through the air. Later[2] it was proven that it is impossible to judge the chemical and mineralogical composition of the dust that actually gets into the lungs of exposed workers by analyzing either the parent material or rafter samples. Rafter samples, because of the higher settling rate of coarse particles, contain an exaggerated portion of them, as compared with the number in the air.

Number and Weight vs. Particle Size

For several years it has been our practice to employ the electrostatic precipitator for the collection of samples of dust for composition analysis, collecting them from the breathing zone of workmen. The analysis of these samples, however, consistently showed the presence of dust particles as large as 50 microns or even larger. Analysis for free silica is always reported on a percent by weight basis. Therefore, the presence of one 50 micron particle would have as much effect on the analysis as would 1,000 five micron particles.

It was therefore logical to modify our techniques to include separation of the air-borne dust samples into two size fractions. We chose to separate the dust into portions at the five micron level. The five micron and less dust is designated as respirable dust, in the sense that it is only this fraction that reaches the lung depths, and its analysis provides the data for appraisal of the silica dust exposure.

In earlier work Hatch and Moke[3] reported that 78 percent of the weight of dust in foundry samples was contributed by particles over 10 microns whereas these amounted to only one percent of the total number.

The I-H-F Dust Sampler

The satisfactory application of size separation required quantities of air-borne dust amounting to several hundred milligrams. In some instances it was necessary to operate the electrostatic precipitator during several work days to accomplish this result. This was impractical. Accordingly, we developed a composition dust sampler of greater air-flow capacity, which employs salicylic acid as the filtering media. This material was first suggested by British workers for obtaining dust samples from air of mines for chemical and petrographic analysis.[4] Our instrument consists of a rectangular box whose sides consist of interchangeable double screens. The box is 3 inches wide and 10 inches square. There is a one-inch opening at one end from which air can be drawn through the filter. Each side of the filter is made from two 100-mesh copper screens which serve as supports for a 1/8-inch layer of salicylic acid crystals. A number of sets of these filter screens have been provided for the instrument so that they can be filled in the laboratory, attached together, and transported for field work. It is necessary to make certain that there are no large openings in the salicylic acid filter mat. The presence of large openings will reduce the efficiency of filtration, requiring longer periods of time for the collection of the sample.

Air from the breathing zone of workmen is drawn through the filter, employing a small blower. We have modified our electrostatic precipitator so that it can be used as a source of suction, drawing approximately 20 cubic feet of air per minute. The electrostatic precipitator with the I-H-F filter will therefore collect as much dust in one hour as the precipitator alone will collect in one day. Two other blowers which we commonly use with the filter draw 50 and 65 cubic feet of air respectively.

Treatment of Samples

Salicylic acid resembles macerated blotting paper. However, it will dissolve completely in alcohol leaving the dust suspended. The dust is filtered from the alcohol on hardened filter paper (No. 50 Whatman) in a Buechner funnel employing suction. It is necessary to wash the dust until all of the salicylic acid is removed. The dust is then washed from the paper with alcohol and separated into size fractions.

The size separation is accomplished by sedimentation of the coarse dust. This is done by a repeated settling procedure with the fines being removed by suction at each time interval. We settle the coarse dust from a 3.5 centimeter layer of alcohol for 40 minutes to separate the five micron level.

A multiple unit for this purpose will size fraction four samples at one time.

* Industrial Hygiene Foundation.

Composition of Industrial Dusts

During the past 12 months we have applied these techniques for the appraisal of numerous silica dust exposures. Some of the results are presented in Table I.

It will be noted that in most of these instances there is significant difference in particle size composition. It is of particular interest that in some exposures the free silica content of the fines exceeds that of the coarse fraction of the dust. This adds even greater weight to the argument that the correct appraisal of exposures to dust containing free silica should be made on samples of dust in the respirable sizes.

How is it possible for a powdered material that contains 35 percent free silica to make a dust that contains only one-third as much; or one containing 65 percent free silica, as in a typical glass house batch, to make dust that contains only 2-3 percent free silica? Dr. W. R. Jones has offered an interesting analogy.[4]

Suppose a stone wall is composed of 900 pounds of quartz rock bound *together with a weak lime mortar weighing* 100 pounds. This wall would consist of 90 percent free silica as quartz. Suppose that a workman starts demolishing the wall with a sledge hammer. The dust he will raise will obviously be overwhelmingly mortar dust containing little free silica, a result that bears no relation to the composition of the original mixture.

In industry, mechanical mixtures of powder materials that make dust *will almost invariably show a different composition.* In *glass batch* mixtures the silica sand contains very little fine free silica, to make dust as compared with other fine ingredients.

In pottery clay bodies, the clay constituents are much finer than the powdered quartz and therefore form dust much more readily than the latter.

A similar effect is noted in foundries. In a grey iron foundry we found only eight percent free silica in the *breathable* dust *from molding* and shakeout. It is clear that many iron foundries have a much less important exposure to silica than is commonly believed.

Granite Dust Composition

At this point it is logical to inquire whether *the particle size composition* data can be correlated with the effects of dust on workmen. The limit of 5 million particles of quartz per cubic foot of air, which is accepted by many authorities, is based to a large extent upon the Barre granite study of the U. S. Public Health Service.[5] In that study the composition of the dust to which workmen were exposed was determined without reference to particle size. We must therefore conclude that *unless the results obtained* by the technique just described can be correlated with the Barre results, they would be of doubtful value. We obtained three samples of dust, one from a dust collector in the Barre field and two from Massachusetts granite sheds, and separated each into respirable and non-respirable dust sizes. The two size fractions of each dust were then analyzed by x-ray diffraction. The results appear in Table II.

These results show conclusively that the conclusions reached by the U. S. Public Health *Service* on maximum allowable dust exposure apply with equal force if the composition of the free silica in the air-borne dust is based on the five micron and less fraction of the dust. It seems probable

TABLE I.

INDUSTRIAL DUST — COMPOSITION ANALYSIS*

Industry	Operation	Wgt. Percent of Non-respirable Fraction	Wgt. Percent of Free Silica: In Total Air-borne Dust	Wgt. Percent of Free Silica: In Respirable Fraction of Air-borne Dust
Pottery	Flat Ware Brushing	96	53	12
Pottery	Jiggering	41	25	12
Glass	Batch House	76	3	7
Glass	Glass Tank	79	30	4
Foundry	Mold Operations	41	34	8
Fire Brick	Furnace Construction	63	21	27

* By x-ray diffraction analysis.

that the components of the granite are all crushed to the same extent by hammering processes. This would account for the same silica content of coarse and fine particles.

The appraisal of silica dust exposure by dust count alone or by dust count and composition on other than respirable dust sizes is outmoded. Down this road lies the explanation for many of the anomalous results which are reported from time to time wherein the effects on workmen do not correlate with the appraised exposure.

TABLE II.
GRANITE DUST — COMPOSITION ANALYSIS

SOURCE OF SAMPLE	Wgt. Percent Free Silica in Total Dust Sample	Wgt. Percent Free Silica in Respirable Fraction
Barre Granite	34	33
Massachusetts Granite	40	40
Massachusetts Granite	34	34

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2. The Mineralogical Composition of Airborne Foundry Dust: T. Hatch and C. Moke, Jour. Ind. Hyg. 18: 91 (1936).
3. Volatile Solid Filters for Dust Sampling: Matthews, J. W.; and Briscoe, H. V. A. Presented at meeting of Inst. Mining Met. (Nov. 15, 1934).
4. Silicosis in British Coal Mines: Fisher, S. W. Trans. Inst. Mining Engrs. (London) 88: (1934-1935). See discussion by W. R. Jones.

DR. DRINKER: Would anyone like to ask Dr. Holden a question on the technique which has been described?

DR. GARDNER: I would like to congratulate Dr. Holden on this development of a mechanism for collecting large air-borne samples which will enable us to secure this very necessary information. All of us working in this field feel the need for some means of securing samples of air-borne dust which could be fractionated by size so as to determine the amount of free silica in the sizes which we know are dangerous. This apparatus, I think, provides the means that we have all been looking for, and I want to congratulate him for the job that he has done.

DR. HOLDEN: I would like to say at this point that the development of this instrument is principally due to ideas that were presented by Mr. Hemeon.

DR. DRINKER: Are there any other questions?

A MEMBER: What is the influence of humidity on the technique?

DR. HOLDEN: From what work we have done so far it has no influence. We have not taken samples in atmospheres of high humidity.

DR. DRINKER: Yesterday an innovation was introduced to many engineering members of this organization. We had an engineering conference which Mr. Hemeon, the next speaker, organized. It was one of the liveliest meetings and the most informative and, technically speaking, one of the most notable ones that we have had. I welcome this chance to thank him personally for what he did for us yesterday. It is a great pleasure to introduce Mr. Hemeon.

CONTROLLING INDUSTRIAL HEALTH HAZARDS

(Foundation Plant Surveys in 1945)

W. C. L. HEMEON, M. S.*

First, I should like to report briefly on the Engineering Conference held here yesterday for plant engineers of member companies. It was attended by about 70 engineers. The plant engineer is expected to know at least a little bit about every engineering subject—or perhaps I should say is expected to know everything about everything. The purpose of the conference was to provide a medium for exchanging ideas on practical problems of executing recommendations for improving working conditions in the plant, including ventilation and dust control. Only an outline of the topics discussed will be presented here. A concentrated digest of the discussion will be prepared and made available to member companies later.

We discussed, first, various engineering details of air conditioned crane cabs, a subject that is receiving increasing attention as a means of protecting the crane operator from extremes of heat or of dust and fumes.

Following this there was an extensive and profitable discussion of the problem of maintaining ducts free of dust accumulations, in the case of dust exhaust systems. It is not always appreciated that dust exhaust systems be designed and operated to be self-cleaning.

Cold drafts in work areas during winter weather occupied our attention as well as the problem of the air sterilization for the factory. Two other topics on the agenda related to the broader problem of air volume requirements for controlling contaminants where the process itself induces a flow of air. The general subject of dust collection was covered in the final hour of the day.

The consensus of those attending the meeting was that it was well worth while and should be continued. We may, therefore, term this the "first annual" engineering conference.

* Ventilation Engineer, Industrial Hygiene Foundation.

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Silicosis

The discussion on "The Accurate Diagnosis of Silicosis" by Drs. Gardner, Hamlin, Cranch and Sander brings together recent developments of chest radiology with restatements of older principles. They illustrate clearly the interdependence of industrial medicine and industrial hygiene. As was pointed out, there must be a known history of free silica exposure to justify a diagnosis of silicosis, but this fact is sometimes overlooked; often free silica is inferred to be present, when an industrial hygiene examination of the plant will show that it is non-existent or present only in insignificant amounts.

The x-ray pictures of foundry workers showing what appears to be silicosis, but apparently is not, provoke speculation. Because free silica is present, foundry dust is often erroneously considered to be an important silicosis producer. The measurements by the industrial hygienist in this case, showing only very small amounts of free silica in the respirable dust, resulted, properly, in questioning the diagnosis. The skills and techniques of the industrial hygienist are a necessary tool in the diagnosis of silicosis.

How often does this situation occur in other industries with other dusts, where there is a silicosis reputation?

Summary of Work

Control of dust continues to be our most frequent plant problem. The extent of our activity can perhaps best be pictured in these figures. Mr. Hyatt and Dr. Holden performed more than 1,000 dust counts in the past 12 months—which means, by the way, 10,000 individual microscope field counts. In addition, they have obtained about 130 atmospheric composition dust samples and processed them for size separation in alcohol for analysis by x-ray diffraction. This work has been distributed among potteries, glass plants, foundries, refractories and several other industries.

Several hundred additional analyses were made for lead, mercury, selenium, arsenic, cadmium, antimony and miscellaneous gases and vapors in a number of different industries such as steel, rubber, chemical, butadiene, chlorine, and machinery manufacture.

Potteries

During the past year the Foundation carried out the most extensive engineering study on dust control in the pottery industry that has ever been conducted.

The improved techniques described by Dr. Holden and Mr. Hyatt have afforded an invaluable perspective in this study as well as in our other engineering work. In many instances tests have proven that some operations require no dust control equipment, where it had previously been thought otherwise. Just the reverse was true in other cases.

For instance, it has always been supposed that jiggermen, batters-out and mold runners are exposed to important silicosis hazards due to the dust conditions inherent in their occupation. But in a number of plants this was found not to be the case. The respirable fraction of dust often contained only 12-18% free silica even though the clay body being worked contained 35%. So with dust counts of only 6 or 7 million it is clear that the free silica exposure in the dust breathed is very small.

It has been held that dusty floors are a major source of atmospheric dust in potteries. We have proven that the dust kicked up into the air by plant traffic in potteries is insignificant compared with other sources. We fully agree that a clean plant with clean floors is good business and we advocate it, but it is important to understand that it does not contribute materially to silicosis hazards, at least in the pottery industry.

Moist Flint

Between 10 and 15 years ago certain potteries requested their flint suppliers to add small quantities of water to the material in order to reduce the dust from handling. The practice was inaugurated and mechanical difficulties overcome within two or three years and it is now common. The nominal moisture content is 3 percent and our studies have proven that when the flint is uniformly moist to this extent, there is practically no dust in its handling. In practice the material does not maintain uniform moisture content, due to partial drying in transit, and some dust is possible when it is handled. The effect, however, of this relatively simple measure has been a spectacular reduction in dust from flint. Simple though it be, it marks the most revolutionary improvement respecting dust control that the industry has known.

We have developed various supplementary measures to counteract the effect of drying out and to completely eliminate the hazard.

The addition of moisture to powdered materials whose dust is a hazard to health has applications to other materials and industries—notably silica cement for high silica brick masonry work and for dusty sand that is to be shoveled from the freight car in unloading.

Air Pollution

We continued work on general air pollution during the year with several hundred measurements of sulfur dioxide concentrations in the vicinity of a smelter and a power plant—(all of which were below significant concentrations from the standpoint of plant life). We conducted a preliminary investigation of odors and fumes alleged to affect a wide area in a middle western city, and have appraised dust pollution problems by measuring rates of dust escape from stacks. All straws in the wind indicate that industrial communities are becoming more insistent in reduction of general pollution. The establishment of procedures for first identifying industrial sources of contamination, and secondly weighting them as to relative importance seems inevitable in the future of community control programs.

The absence of such engineering data probably accounts for the action by one official of a certain city that has been plagued by smoke and irritating fumes. The official advises the public to "Avoid use of incinerators, if possible; do not build bonfires; do not operate an automobile which consumes an excessive amount of oil; and avoid beating rugs or otherwise releasing dust into the atmosphere"!

Gas from Trichlorethylene

It has often been stated erroneously that phosgene gas is readily formed from trichlorethylene and similar solvents when their vapors are exposed to elevated temperatures by flames or hot metal. One of our staff investigated complaints by electric welders of irritating vapors that had caused hospitalization of several with severe lung irritation. The welding was located near a degreasing tank and the presence of trichlorethylene vapors in the area suggested the formation of phosgene gas. Tests for phosgene under simulated conditions were negative even though the investigator observed a strong irritation of the upper respiratory tract. The nature of the irritant substance has not been identified although the consensus was that a severe lung irritant similar to phosgene was in fact formed by the action of the electric arcs on trichlorethylene vapor. Welding, therefore, should not be carried on near a source of trichlorethylene, such as a degreaser, and any complaints of respiratory irritation among maintenance welders should be investigated without delay.

Blasting Helmets

Occasionally we find, as in a recent case, an improperly functioning helmet in use by an abrasive blasting worker. Although the helmet was of a type approved by the Bureau of Mines, a dust concentration of 50 million was found inside. Investigation showed this was a result of insufficient air supply. Because a helmet carries Bureau of Mines approval does not mean that it will protect the man automatically. The Bureau's approval cannot extend to the installation at the plant, and it is important that the flow of air be measured for adequacy, and not merely assumed.

Glass Tanks

The dust that arises at the feed end of glass tanks, due to changing of the batch, is carried upward violently and does not constitute any hazard to health. However, the resultant accumulation of settled dust on the tank roof over a period of time requires periodic removal for technological reasons, and the removal process creates a major dust nuisance for a time. One plant has eliminated this dust at its source by feeding the material from an overhead supply bin through a vertical chute that is always full, to a short screw conveyor leading to the tank.

Costs of Control

Production of the atomic bomb posed some of the most spectacular industrial hygiene hazards in history. Safeguards were built into those plants and atomic bomb workers were protected from the insidious effects of crippling radiant energy and toxic atmospheric emanations. These precautions were an integral part of the problem of manufacture of the uranium for the bomb and illustrate a principle that is applicable to more commonplace problems in engineering control of occupational disease hazards. That is, that any hazardous industrial operation can be carried on in reasonable safety if preventive measures are properly engineered.

Usually, adequate control is moderate in cost, but sometimes the money expenditure is high. Control occasionally may require a fundamental change in operating methods. When the change takes the shape of a major project it should be engineered to incorporate all possible operating cost improvements at the same time to help justify the capital outlay.

One should not make the mistake of assuming that the cost of an exhaust system or other means of control is all loss. It may show a definite

economic return on the expenditure which makes it an investment. I like the example afforded in the ventilation for welding fumes in shipyards, which incidentally are innocuous fumes. Ross and Drinker report that:

> "For the average shipyard, the total annual cost of the ventilating program, including both labor and depreciation of equipment, is 1.5 percent of the total annual payroll of the welding department. Can the successful control of fumes increase the daily welding by 1.5 percent?—If a welder burns 17 pounds of rod a day under poor conditions, can he and will he burn an additional quarter pound of rod when the compartment is well ventilated? Yes, in fact he will burn considerably more. Welding superintendents have estimated that output in confined areas on the hulls increased by three to five pounds of rod per man after a good ventilation system was installed."

This is a tangible benefit, other examples of which can be found in other occupations.