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NODULATION WITH SUPERIMPOSED INFECTION IN LUNGS OF FOUNDRY GRINDERS AND BURNERS

Report of Four Unusual Cases

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THE ORIGIN of diffuse nodular shadows observed in roentgenograms of the chests of certain grinders and burners in the foundry and other industries has aroused considerable speculation in recent years. Those familiar with new developments in the field of occupational disease have become more cautious in diagnosing such roentgenograms, realizing that findings in numerous unrelated conditions may easily be mistaken for silicosis, especially when the person concerned had worked in an atmosphere which might have exposed him to dust. Unfortunately some general practitioners, industrial physicians and roentgenologists still insist on interpreting these patterns as first, second or third degree silicosis, regardless of the type of work or degree of exposure to respirable-sized particles of harmful dust to which an employee may have been subjected. The effect of such injudicious information is far reaching. It frequently results in unnecessary apprehension, financial loss and unjustified claims for disability.

In 1938 Sander and Enzer[1] described changes almost identical with silicosis in the pulmonary markings of electric arc welders whose occupations did not expose them to free silica but involved an atmospheric concentration of iron oxide sufficient to produce nodulation. Postmortem observations in 3 such cases demonstrated no evidence of silicotic fibrosis whatsoever. The changes in the lungs consisted solely of deposits of inert iron pigment in the lymphatics which were not productive of symptoms or disability. Reports from other sources in this country and abroad have confirmed these observations. McLaughlin, Grout, Barrie and Harding[2] in 1945 described similar findings in 4 silver finishers exposed to pure iron oxide dust from rouge. They found no fibrosis in the lungs and stated that a worker who has inhaled radiopaque dusts may have a roentgen picture of the lungs simulating

1. Enzer, N., and Sander, O. A.: Chronic Lung Changes in Electric Arc Welders, J. Indust. Hyg. & Toxicol. **20**:333-350 (May) 1938.

2. 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 **1**:337-341 (March 17) 1945.

early silicosis, miliary tuberculosis or other pathologic conditions and yet have no obvious physical disability. Pendergrass and Leopold,[3] also in 1945, reported 11 cases of siderosis in grinders resembling those observed by Sander and Enzer. Harding[4] in January 1945 portrayed roentgenographic stippling or fine nodulation of the lungs produced in rats by intratracheal injection of rouge (ferric oxide), which caused no detectable fibrosis over a period of eight months. Buckell, Garrad, Jupe, McLaughlin and Perry,[5] in 1946, performed roentgenographic examinations of the chests of 171 iron turners and grinders (138 men and 33 women) exposed to dust in iron turneries in England. Changes in the lungs in the form of reticulation due to iron oxide were present in 15 persons. Five of these persons had been working in this occupation for more than twenty years. The changes were not gross and few symptoms were noted. Only 1 man complained of shortness of breath, though 6 stated that they had some cough. Dust from rafter samples contained 37.1 per cent metallic iron and 23.3 per cent iron oxide. The total silica content was 5.4 per cent and the silicate residue 1.3 per cent.

In November 1945 my colleagues and I reported[6] atypical nodulation in 68 foundry grinders and burners, observed over a period of eleven years, whose roentgen patterns, clinical aspects and occupational exposure were inconsistent with the present conception of silicosis. In this group, unlike the cases described by Sander and Enzer, the men were known to have had some exposure to free silica, although repeated sampling of air-borne dust revealed the concentrations to be within safe limits. The composition of the dust before fractionation was as follows:

	Sample 1, Percentage	Sample 2A, Percentage
Total SiO_2	6.5	8.9
Free SiO_2 Quartz	3.1	3.9
Free SiO_2 Cristobalite	0.1	0.3
Free SiO_2 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 (titanium dioxide TiO_2)	trace	trace
Loss on ignition	6.2	3.2

3. Pendergrass, E. P., and Leopold, S. S.: Benign Pneumoconiosis, J. A. M. A. **127**:701-705 (March 24) 1945.

4. Harding, H. E.: Radiographic and Histological Appearances of the Rat Lung After Intratracheal Injection of Rouge (Ferric Oxide), Brit. J. Indust. Med. **2**:32-35 (Jan.) 1945.

5. Buckell, M.; Garrad, J.; Jupe, M. H.; McLaughlin, A. I. G., and Perry, K. M. A.: The Incidence of Siderosis in Iron Turners and Grinders, Brit. J. Indust. Med. **3**:78-82 (April) 1946.

6. Gardner, L. U.; Cranch, A. G.; Hamlin, L. E., and Sander, O. A.: Accurate Diagnosis of Silicosis, Bulletin 6, Transactions, Medical and Engineering Section, Industrial Hygiene Foundation, November 1945, pp. 15-20.

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7. Dayman, H.: Latent
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The high iron content of the samples of air, the relatively low percentage of free silica with negligible amounts of the most active forms cristobalite and tridymite, together with the lack of significant clinical findings, did not seem to constitute a definite hazard, certainly not enough to produce the rapidly developing nodulations observed in some employees' roentgenograms. If the markings were due to iron pigmentation, however, there appeared to be enough iron oxide present in finely divided form to cause it.

Early in 1945 we inaugurated an experimental study on the effect of air-borne grinding dust on laboratory animals under the direction of the late Dr. L. U. Gardner at the Saranac Laboratory, Saranac Lake, N. Y. An interim report after eight to ten months' exposure indicates that while faint diffuse dust pigmentation exists grossly in the lungs of guinea pigs and white rats, microscopically only scattered inactive dust cells appear without evidence of fibrosis. Roentgenograms of the chests of rabbits exposed to inhalation of dust for the ten month period were essentially normal. In animals infected experimentally with tuberculosis, the spread of the disease was not accelerated by the inhalation of this dust during an eight month period.

It is emphasized that these observations are only preliminary. The studies are continuing, and a complete report will be made after there has been sufficient exposure to demonstrate valid results. The tentative assumption that this dust causes reaction similar to that seen in exposures to other inert dusts is of definite interest in this presentation.

One of the well established facts about silicosis is its tendency to provide a fertile field for the development of tuberculosis. While this is undoubtedly true, some observers feel that in certain instances its importance may have been overemphasized. Dayman, however, in June 1946 published case reports on 4 persons as evidence that silicosis can exert a harmful effect on resistance to tuberculosis even when generalized pulmonary fibrosis due to free silica is so slight that evidence of it is meager or entirely lacking on technically satisfactory roentgenograms.

Observation of grinders and burners in the foundry industry under discussion reveals a very apparent lack of clinical symptoms and absence of conglomerate shadows in the roentgenogram. The incidence of tuberculosis is low and progression of infection, when it does appear, is not impressive. These employees seldom complain of shortness of breath, the cardinal symptom of silicosis, even though the roentgenogram reveals definite evenly distributed, fine nodulation. Stippling may appear after comparatively short periods of exposure, two to six years

7. Dayman, H.: Latent Silicosis and Tuberculosis, Am. Rev. Tuberc. **53**:554-559 (June) 1946.

in some cases, but when once established there is little change in subsequent roentgenograms in spite of the fact that the occupational environment has not changed appreciably.

Consideration of the evidence accumulated up to the present provides substantial reason for the belief that the roentgenographic observations in this group of workers represents siderosis and not, as it is still being diagnosed, silicosis.

The following cases are presented to support this view and to demonstrate the unusual course of superimposed infection in the presence of nodulation hitherto presumed to be silicotic.

REPORT OF CASES

CASE 1.—T. J. P. operates a grinding lathe in the machine section of the plant where large manganese steel castings ranging from 500 pounds (227 Kg.) to several tons in weight are ground sometimes to tolerance of 0.002 inch (0.0508 mm.). Vitrified abrasive wheels are used, and the point of contact is kept wet with water containing a soluble oil. The employee has worked on this particular job for thirty-one years without losing time except for a period of two weeks about twenty-three years ago, with what was diagnosed as pleurisy. Two years ago he had a hernia repaired and was away from work for two months. The operation was performed with the patient under local anesthesia, and no symptoms referable to his lungs occurred. Other than these two periods he has never lost a day's time because of illness. He states that he "feels like a million." His appetite is good and he has no discomfort following meals except occasional spells of mild indigestion.

Examination revealed a well developed, well nourished white man, 55 years old. He presented a healthful, robust appearance. His height was 6 feet 1 inch (185.4 cm.) and he weighed 220 pounds (99.8 Kg.). Blood pressure was 130 systolic and 90 diastolic. There was no evidence of disease of ear, nose or throat and no enlargement of the thyroid gland. Examination of the heart indicated no disease. The pulse rate was 80 per minute, regular and of good volume. The chest was symmetric, breath sounds were normal throughout and there was no other manifestation of disease. The remainder of the examination revealed no abnormality except for a rather large, easily reducible, recurrent inguinal hernia on the left side which appeared to be adequately controlled by a truss.

Roentgenograms of the chest were made for this worker in 1933, 1934, 1936, 1942, 1943, 1944, 1945 and 1946. The roentgenogram made in 1933 showed evidence of rather extensive nodulation throughout both pulmonary fields, with mottling, interpreted as tuberculous infection, involving the entire upper lobe of the right lung. The diagnosis at that time was first degree silicosis with active infection. A roentgenogram in 1934 was interpreted in a similar way with the addition of suggestive cavitation. In 1936 the roentgenogram showed considerable clearing of the condition in the upper lobe of the right lung, the dense mottling being replaced by hard linear shadows. By 1942 not much change was noted except that there seemed to be slightly more fibrosis of the infection with perhaps more accentuation of the nodulation. Subsequent roentgenograms, including stereoscopic views in 1946, demonstrated gradual clearing of the infection and replacement by a linear scar. This change occurred while the man was continuously subjected to the same dust exposure. A Vollmer patch test done recently

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CASE 2.—F. M. finishes
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Fig. 1 (case 1).—Serial
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resulted in a definite positive reaction. Three successive examinations of concentrated sputum were negative for acid-fast bacilli.

The course of the infection in this case is contrary to the usual progression of tuberculosis, assuming that the nodulation observed in the roentgenogram is due to silicosis. On the other hand, it is compatible with siderosis.

CASE 2.—F. M. finishes rough manganese steel castings weighing from 500 to 10,000 pounds (4,535 Kg.). The work is done with a swing frame grinder (fig. 2) and the employee has worked on this same job for the past thirty-four years. He has had no other occupation. He has no complaints and states that he feels well.

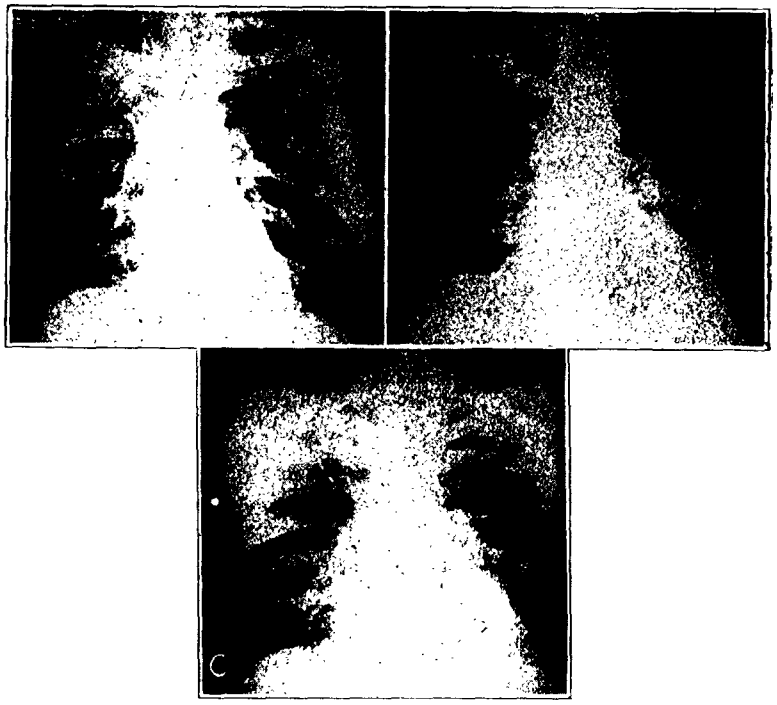

Fig. 1 (case 1).—Serial roentgenograms taken in 1934 (*A*), 1943 (*B*) and 1947 (*C*) showing extensive nodulation and clearing of infection in upper lobe of right lung with resultant linear scar.

Physical examination revealed a well developed white man of 64 years, 5 feet 10 inches (177.8 cm.) tall, weighing 170 pounds (77.1 Kg.). His temperature was 98.6, pulse rate at rest was 76 per minute, after exercise was 96 per minute and two minutes later was 76. The systolic blood pressure was 158 and the diastolic 80. There was some enlargement of the turbinal bones, also pyorrhea and dental caries. Examination of the heart and lungs revealed no abnormality. No other significant physical defects were noted except an enlarged inguinal ring on the right side and superficial varicosities on the left leg.

Roentgenograms of the chest were made in 1933, 1934, 1936, 1942, 1943, 1944, 1945 and 1946. Nodulation was evident in the first three of these and was diag-

nosed as uncomplicated silicosis. The 1936 roentgenogram suggests an area of beginning infection in the upper paravertebral area of the left lung. In the 1942 roentgenogram this was definite as a circumscribed density. Subsequent annual roentgenograms show no change except that possibly the shadows are slightly more dense and circumscribed. No change has occurred in the nodulation.

A Vollmer patch test was done recently which elicited a positive reaction. Concentrated sputum on three successive days was negative for acid-fast bacilli.

In this series of roentgenograms, a shadow strongly suggestive of developing tuberculous infection appeared on a background interpreted as silicotic and has remained constant over a period of ten years in spite of continuous exposure.

CASE 3.—P. J. H. worked in a coal mine for six years before coming to his present location. He was employed as a burner at this plant for thirteen years.

Fig. 2 (case 2).—Swing frame grinder in use on large manganese steel castings.

The operation consisted of burning off gates, fins and other projections on unfinished castings with an acetylene torch. On occasions he also did some welding on small surface defects. The castings were usually placed on the floor (fig. 4) so that the blast from the oxyacetylene torch stirred up accumulated dust along with fume from the operation itself. Because of the roentgen findings, he was put at outside work driving a truck and has not been exposed to dust for the past four years. He gives a history of pneumonia on two occasions, the last attack occurring in February 1942. In March 1943 he was operated on for an inguinal hernia on the left side and in February 1946 he suffered an acute infection of the respiratory tract, which cleared up without complications. He has gained weight and states that he feels better than he has for years.

Examination disclosed a white man of 60 years, 5 feet, 7½ inches (171 cm.) in height, weighing 153 pounds (69.4 Kg.). The systolic blood pressure was 165 and the diastolic was 90. His temperature was 98.6 F., his pulse rate 70 per

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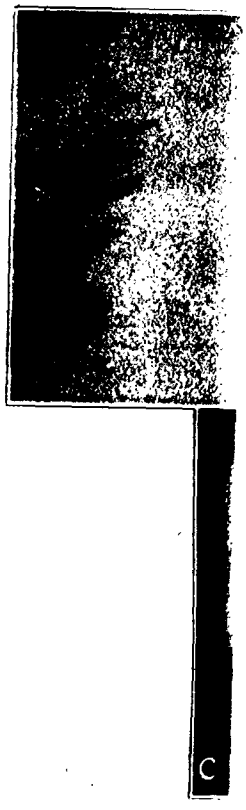

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minute and his respirations 14. The lower teeth were in poor condition but the upper teeth were replaced by a denturé. Examination of the heart revealed no evidence of disease. The breath sounds were roughened but otherwise the lungs were normal. The remainder of the physical examination showed no significant abnormalities.

Roentgenograms of the chest were made in 1934, 1942, 1943, 1944, 1945 and 1946. The 1934 roentgenogram showed a diffuse nodulation without evidence of infection. This was classified as first degree silicosis and was reclassified to second degree nodulation in 1942. Some mottling in the upper lobe of the right lung was noted at this time, and tuberculous infection was suspected. In 1943 the

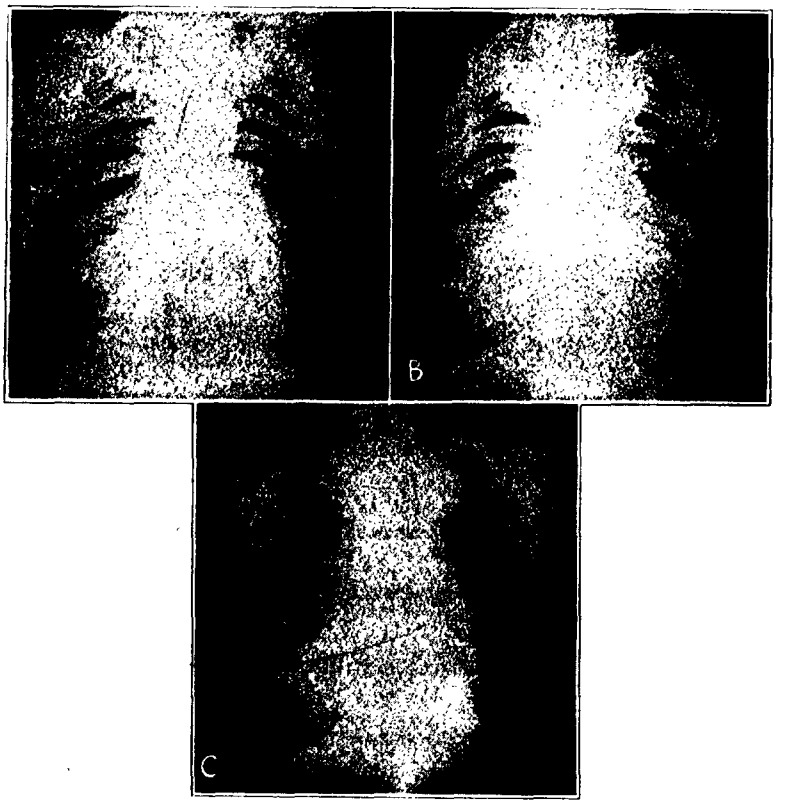

Fig. 3 (case 2).—Serial roentgenograms taken in 1936 (*A*), 1944 (*B*) and 1947 (*C*) showing nodulation and suggestive infection in paravertebral area of the upper lobe of the left lung which has remained constant over eleven years.

same condition was again observed and was rechecked with stereoscopic roentgenograms. Subsequent roentgenograms have shown no change except more organization of the infection.

Samples of sputum taken every other day for six occasions recently were all negative for acid-fast bacilli. A patch test and also two intradermal injections of old tuberculin (0.1 mg. and 1.0 mg.) gave negative results. The blood sedimentation rate was 2 mm. per hour. The Wassermann and Kahn reactions were also negative.

The similarity of the roentgenographic observations in this case and in the preceding one are rather remarkable. Both employees work in the same industry, although their specific jobs are different. They have been employed at separate locations which are over 1,000 miles (1,600 kilometers) apart, but the operations in both plants are the same, so that both men have had similar types of dust exposure. The negative reactions to the tests for tuberculosis in this case suggest that the shadows observed in the roentgenogram are not caused by the tubercle bacillus. This again emphasizes the need for careful evaluation of all the clinical data before making a positive diagnosis in any case

Fig. 4 (case 3).—Burner using torch to remove fins from casting. Note the blast from the torch which stirs up considerable dust from the floor.

demonstrating evidence of occupational fibrosis. The fact remains, however, that a condition suggestive of infection which developed on a nodular background has remained relatively stationary for the past four years, an event which is not consistent with the usual course of silicotuberculosis.

CASE 4.—J. W. works in a different plant from the men in the preceding cases. His job consists of grinding gray iron castings which are rather free from sand, so that his actual exposure to free silica has been negligible. There is considerable dust containing fair amounts of iron oxide in the atmosphere. This employee has been in the same location as a chipper and grinder for thirty-six years. At the time of his examination he stated that he did not "feel any too well" and com-

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Physical examination showed a white man of 63 years who did not appear ill. He was 6 feet 1½ inches (187 cm.) in height and weighed 175 pounds (79.4 Kg.). His blood pressure was 114 systolic and 64 diastolic. His temperature was 99 F., his pulse rate 68 and respiration rate 14 per minute. The pulse was regular and of good volume. It increased to 96 after exercise and returned to 72 after two minutes' rest. Examination of the chest showed no evidence of cardiac disease and the lungs were normal except for a small area of decreased resonance in the left infraclavicular space. There were no other abnormalities noted with the exception of small superficial, bilateral varicosities. The employee's weight of 175

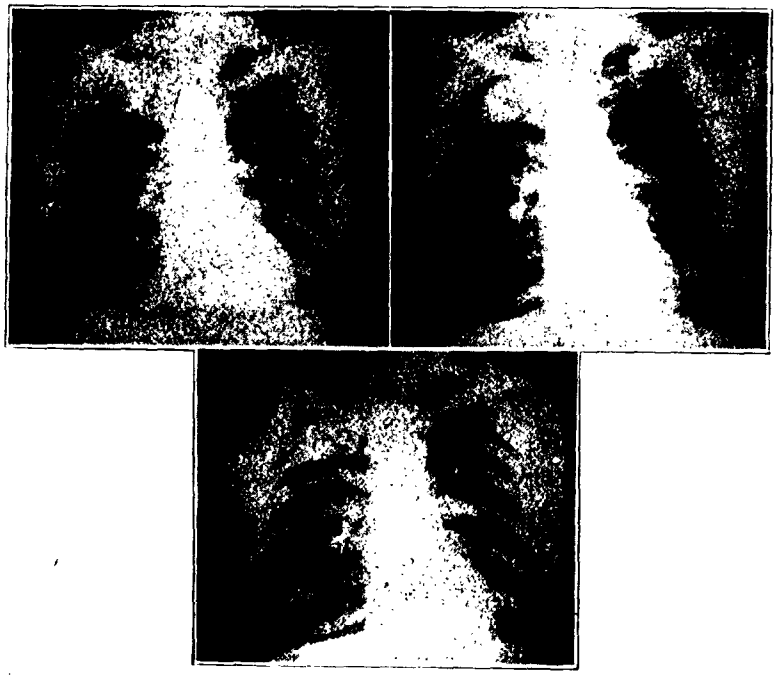

Fig. 5 (case 3).—Serial roentgenograms taken in 1942 (*A*), 1944 (*B*) and 1946 (*C*) showing infection in the upper lobe of the right lung superimposed on an extensive nodular background. The infection has shown no change in more than two years.

pounds at this examination, however, represents a loss of 10 pounds (4.5 Kg.) since 1944.

Roentgenograms of the chest were made in 1933, 1934, 1936, 1939, 1943, 1944, 1945, 1946 and 1947. In 1933 the roentgenogram was interpreted as first degree silicosis with infection, presumably tuberculous, in the upper third of the right lung. No pronounced change was noted in succeeding roentgenograms until 1939, when infection appeared in the upper lobe of the left lung. By 1943 the infection in the upper lobe of the right lung was more diffuse with a more characteristic appearance of pleural thickening, while the mottling in the upper lobe of the left lung suggested some increase in the pathologic process. Subsequent roentgenograms in 1945, 1946

and 1947 have shown no definite change except possibly some slight increase in density of the shadows previously noted.

As a result of the abnormalities noted in earlier roentgenograms, this employee was examined very thoroughly by several competent specialists, all of whom were agreed that the shadows in the roentgenograms represented tuberculous infection. The man was approached about entering a sanatorium and was strongly urged to to do, both by management and by his family physician. He stated that he felt quite well and did not want to enter a sanatorium and could see no adequate reason why he should. He has continued working under observation since that time and has been a steady, uncomplaining producer.

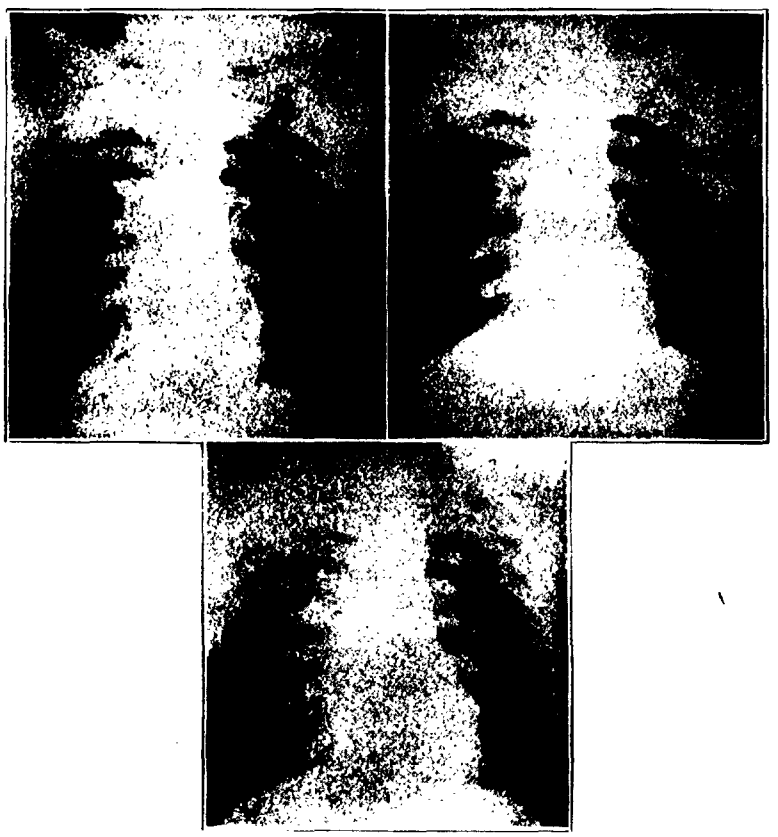

Fig. 6 (case 4).—Serial roentgenograms taken in 1936 (*A*), 1943 (*B*) and 1946 (*C*) showing infection in the upper lobe of the right lung which has developed in the presence of definite nodulation. There is also suggestive evidence of infection in roentgenogram *B* (1943) in the upper lobe of the left lung. There has been no appreciable change in the 1946 roentgenogram over the 1943 roentgenogram.

Recently a Mantoux tuberculin test elicited no reaction to first strength purified protein derivative, but a slight positive reaction was obtained with the purified protein derivative of second strength.

The roentgen observations in this case again failed to demonstrate the anticipated course of infection in the presence of silicosis.

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SUMMARY

Findings in the roentgenograms of the chests of 4 employees in the foundry industry are presented to demonstrate the unusual course of suggestive tuberculous infection in the presence of nodulation hitherto presumed to be due to silicosis. The progress of the disease is inconsistent with the usual picture of tuberculosis superimposed on silicosis, both from the clinical and from the roentgenographic aspects. Occupational exposure as demonstrated by industrial hygiene surveys in the plants where these roentgen patterns were produced does not appear to be adequate to produce the extensive nodulations observed but does seem to be sufficient to cause siderosis. The unorthodox behavior of both infection and nodulation, in spite of continuous exposure, substantiates the impression that the roentgenographic appearance is the result of the deposition of iron pigment (siderosis) rather than reaction in pulmonary tissue due to contact with free silica.