

A study of chronic mercurialism in the hatters' fur-cutting industry / From the Division of Industrial Hygiene, Senior Surgeon R.R. Sayers, medical officer in charge. Medical studies by: Paul A. Neal, P.A. surgeon, Roy R. Jones, P.A. surgeon. Engineering studies by: J.J. Bloomfield, P.A. sanitary engineer, J.M. Dallaville, P.A. sanitary engineer. Statistical analysis by: Thomas I. Edwards, technical editor. Prepared by direction of the Surgeon General.

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**A STUDY OF CHRONIC
MERCURIALISM IN THE HATTERS'
FUR-CUTTING INDUSTRY**



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PREPARED BY DIRECTION OF THE SURGEON GENERAL



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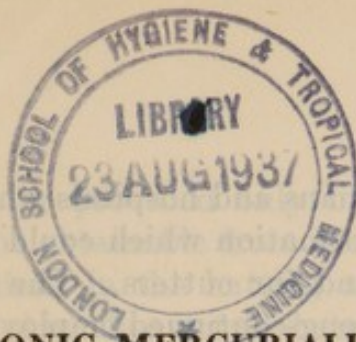
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A STUDY OF CHRONIC MERCURIALISM IN THE HATTERS' FUR-CUTTING INDUSTRY

INTRODUCTION

A study of conditions affecting the health of workers employed in the hatters' fur-cutting industry was begun in 1935 at the request of the N. R. A. code authority for that industry. At that time approximately 2,000 men and women in 36 factories were engaged in preparing the fur of rabbits and hares for the subsequent manufacture of felt hats. In one of the early stages in the treatment of the pelts (carroting) a mercury preparation is applied, and measurable quantities of mercury leave the fur as vapor and on dust particles at every succeeding stage in the manufacturing process. Hand labor is required at almost every stage and because many of the manufacturing processes are carried on in the same workroom, a large proportion of the workers are exposed to mercury vapor and fur dust.

The literature on the subject contains many statements concerning the dangers of mercurialism in the fur-cutting industry. In later sections of this paper the results of earlier studies on the health of hatters and fur cutters will be discussed in detail in connection with the presentation of similar data collected in this study. It may be useful, however, to note briefly the content of the principal papers dealing with the health of American fur cutters.

Freeman (14) traced an outbreak of mercurialism in New Jersey hat factories to the use of carroted fur containing excessive amounts of mercury and described the symptoms briefly. In 1891 Adler (7) published a clinical description of chronic mercurialism as he observed it in five male hatters who came to him for treatment. In 1878 Dennis (11) questioned 1,546 hatters employed in 28 factories in and near Newark, N. J., to ascertain the prevalence of tremor, sore mouth, and rheumatism, and to find out whether or not adequate ventilation was provided in the factory workrooms. The data he collected and published do not bear out his contention that the use of alcohol and tobacco was responsible for the cases of ill health he observed, for according to his figures (p. 84), the 75 persons who abstained from the use of both alcohol and tobacco were afflicted with tremor to the same extent (10 percent) as the 800 persons who used both. Mrs. Bates (9) inspected a number of hat factories in the vicinity of New York City in 1910. Her report was limited to the data she could

obtain from private physicians and hospitals who treated hatters and fur cutters, and to the information which could be obtained by questioning disabled hatters and fur cutters. The consensus of opinion of all concerned was that long-continued employment at certain occupations in the hatting industry produced the symptoms of chronic mercurialism in an undetermined proportion of the persons exposed, but if the affected men were transferred to occupations or industries which appeared to offer a lower mercury exposure the symptoms disappeared. Harris (15) in 1915 published the results of a study of the health of employees in the fur-cutting industry and allied trades in New York City. He was unable to make very thorough physical examinations of the 266 fur cutters he studied.

In 1921 Wright (24) made physical examinations of 100 male hatters and fur cutters who presented themselves voluntarily for examination at a special clinic set up in Danbury, Conn. Eight of these men were fur cutters. Wright's data clearly indicate the nature of the physical defects and disorders which may be found in persons employed in these industries, but they do not show how large a proportion of all the employees in the industry may have been so affected. No study of working conditions was made. At the same time, several other studies of the hatting and fur-cutting industries were made by members of the department of industrial hygiene of the Harvard School of Public Health, and in the series of published papers that resulted valuable contributions to the literature of the subject were made. Dr. Alice Hamilton contributed reviews (37, 38) of the literature; Minot (42) made quantitative chemical analyses of the amounts of mercury present in the material at several stages in the hat-making process which indicate there is a progressive loss of mercury during the course of manufacture; and Johnson (39) attempted, with only partial success, to find a substitute for mercury in the carroting process.

Physicians who have worked on the problem are not entirely in agreement concerning the characteristic symptoms of chronic mercurialism. Their lack of agreement is especially conspicuous with respect to the interpretation of laboratory tests on blood and urine. Incidentally, the characteristic symptoms of chronic mercurialism differ greatly from the well-known symptoms of acute mercurial poisoning, upon which there is more general agreement.

No satisfactory substitute for mercury nitrate in the carroting process has come into general use in this country in spite of more than a century of active research. Therefore, to a large extent the protection of the health of fur cutters depends upon removal of mercury vapor as completely as possible from the workrooms by effective application of engineering methods. Any solution of this problem presupposes an accurate knowledge of the nature of the working en-

environment which can be provided only by an engineering survey. Such information is not obtainable from the literature. Most of the data on health conditions in the hatting and fur-cutting industries are to be found in the older, less detailed studies, in which laboratory tests were not made. The physical examinations made by Wright on 100 men employed in 30 different factories probably cannot be regarded as a fair index of the health of workers in the industry as a whole, since persons who considered themselves to be in good health would not be as likely to present themselves for examination as persons who were aware they had physical defects.

In the present study, between February and May 1935, physical examinations, supplemented by roentgenological examinations and standard laboratory tests of blood and urine, were made on 529 men and women. This group constitutes 26.4 percent of the employed fur cutters in the United States. A complete record of each person's previous employment was also obtained. Engineering surveys were made (1) in all of the fur-cutting factories then in operation in this country to define the manufacturing processes in use; (2) to make measurements of mercury vapor concentration, dust counts, and other conditions of the working environments in the five plants selected for special study; and (3) to investigate the methods developed by the industry for controlling mercury and fur-dust exposure.

ENGINEERING STUDY

Methods and Instruments Used in the Study

At the time this study was conducted there were, in all, 36 plants in the United States engaged in the preparation of hatters' fur. Information obtained from these plants revealed that the industry employed approximately 2,000 persons. Since it was not feasible to examine every worker in the industry, it was necessary to make a selection of plants. Such a sampling procedure could be used provided certain information was available on each individual plant. Accordingly, a preliminary engineering survey was made in each of the 36 plants. This survey consisted of collecting data on industrial welfare facilities available to the workers, the general sanitation of the plant, and the processes and occupations involved in the preparation of hatters' fur. Information was obtained on facilities for conducting physical examinations, and the degree of cooperation to be expected from employers and employees in the conduct of the study, which influenced the selection of the plants for study. In this manner it was possible to choose five plants which represented both modern and old practice, and good, fair, or poor working conditions as judged by visual inspection. In addition, this preliminary survey served to give a fairly good concept of the entire industry.

Further preliminary steps in this study, prior to making actual measurements of the working environment, consisted of making sanitary and occupational surveys of the various workrooms in the five plants. Such preliminary surveys serve as a guide in the more detailed studies which follow. The sanitary survey, for example, lists the various facilities accessible to the worker in the working environment, while the occupational survey permits one to determine the nature of the work and the particular hazards associated with each occupation. The survey form reproduced in a later portion of this report served as a basis for recording the essential data on the sanitary and occupational phases of this study.

The preliminary survey of the industry showed that the major occupational hazards in need of further investigation were exposure to mercury vapor and dust.

The General Electric selenium sulphide detector (1) was used for the determination of mercury vapor. (See fig. 1.) This instrument was selected in preference to other devices for the detection of mercury vapor in air because of its portability, ruggedness, simplicity of operation, and because direct readings may be obtained in a short

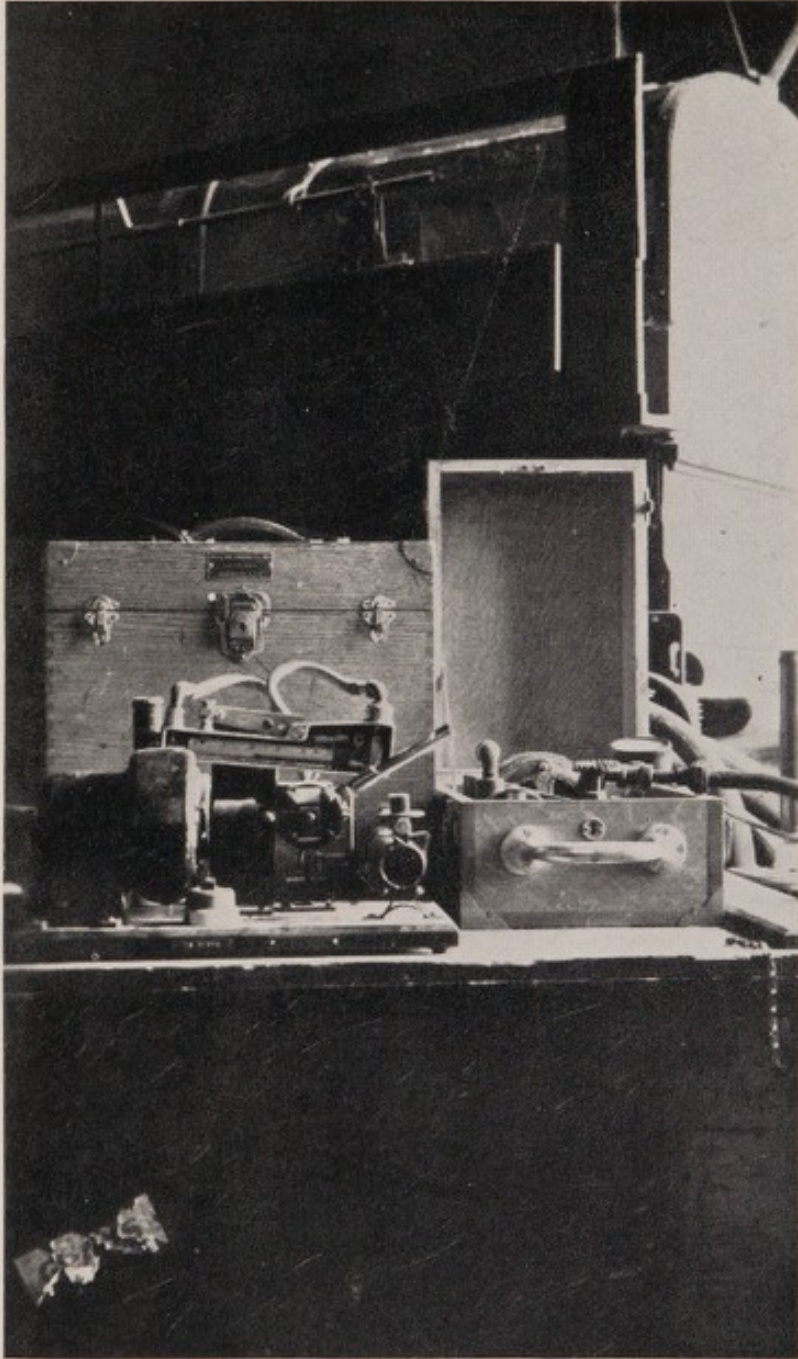
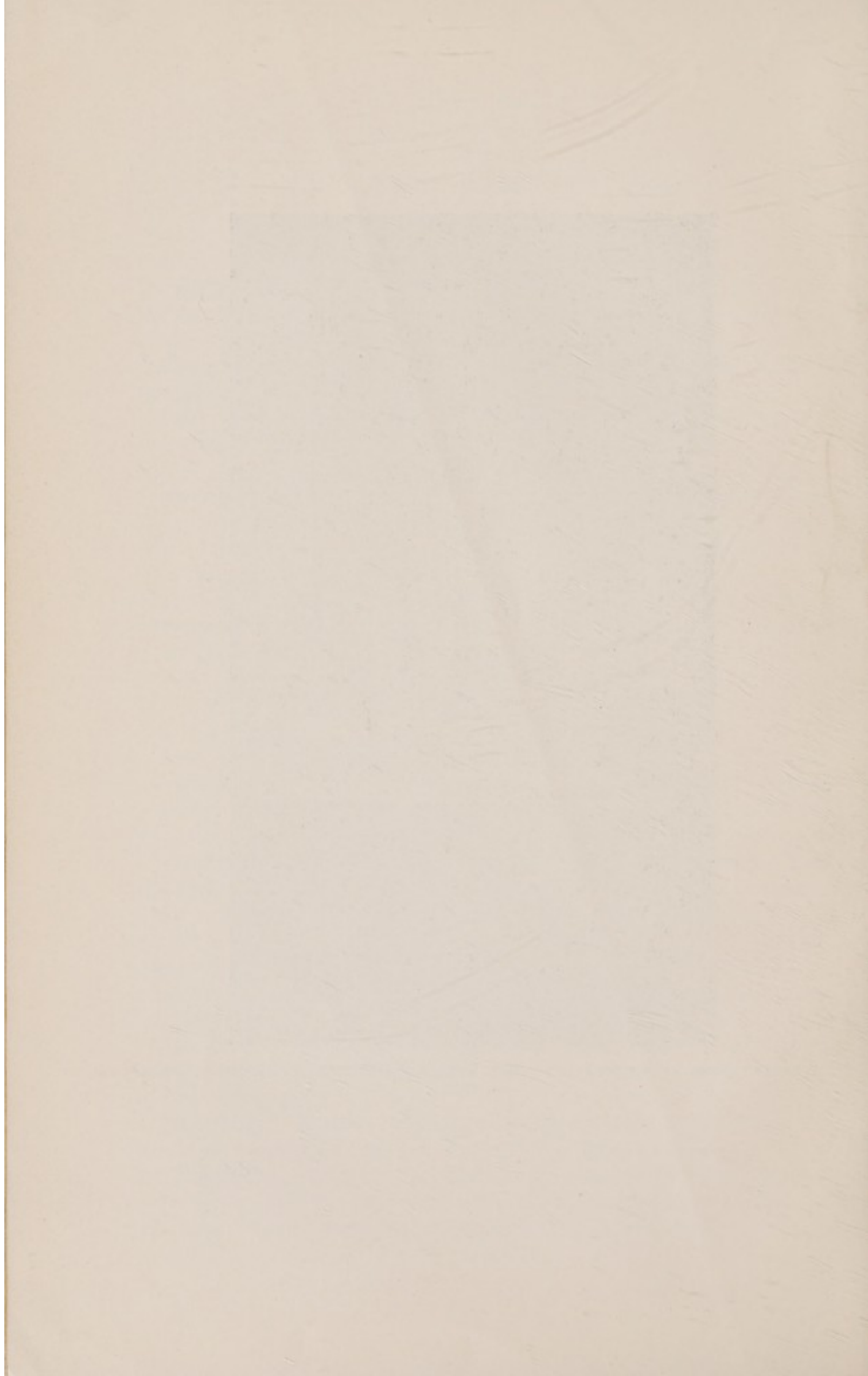


FIGURE 1.—INSTRUMENTS USED FOR THE DETERMINATION OF MERCURY VAPOR AND DUST.



time. It has been in use for some time for detecting minute amounts of mercury vapor in the air and has an extremely high sensitivity. In the present study, mercury-impregnated dust was excluded from the detector by placing a single-thickness Whatman paper thimble at the point where air enters the instrument. The dust-free air then passed into the device, was preheated to a temperature of 70° C., and then allowed to come in contact with paper coated with active selenium sulphide. When mercury vapor comes in contact with the paper it is blackened to a degree which is dependent on duration of exposure and the concentration of mercury. The amount of mercury vapor in the air can be determined by comparing the sample obtained with standards which accompany the instrument.

In order to determine the amount of mercury-impregnated dust in the air, samples were obtained with the impinger apparatus (3). Since it was found in preliminary observations that the mercury-coated fur was greasy, and hence difficult to wet, it was necessary to use a 25-percent alcohol and water mixture as a collecting medium. Samples thus obtained were shipped to the central laboratory in Washington, where they were analyzed by Associate Chemist F. H. Goldman by means of the electrolytic method described by Fraser (2).¹

The konimeter was employed for the determination of the amount of dust to which workers were exposed (5). In the control studies which followed, certain ventilation measurements were made on the exhaust systems employed. These readings were obtained with the Pitot tube.

¹ Since preliminary treatment of such samples is necessary before Fraser's method can be applied, a brief description of the procedure follows.

The sample was transferred to a 500 cc Kjeldahl flask, and the alcohol was boiled off very rapidly for 5 to 10 minutes. After cooling, 10 cc of concentrated sulphuric acid was added and then 4 g of potassium permanganate. The neck of the flask was washed down with water. The sample was allowed to digest at a temperature just under the boiling point for 2 hours. It was then decolorized with oxalic acid crystals (about 3 g are required), warming if necessary. Unless the solution is cold, it is better to add the oxalic acid in small amounts during this operation. The solution was next transferred from the Kjeldahl flask to a 250 cc glass-stoppered Erlenmeyer flask, 1 cc of 0.5 percent copper sulphate solution was added, and then H₂S was passed in for about one-half hour. The precipitate was allowed to stand overnight and then washed by centrifuging.

Chlorine gas was then passed into the centrifuge cup containing the copper and mercury sulphide precipitate after the addition of 5 cc of water. Solution was usually effected in 15 minutes, after which air was passed through to remove the chlorine.

This solution was transferred to a 50-cc beaker, 2 cc of saturated oxalic acid and 5 cc of saturated ammonium oxalate were added. The mercury was plated out using a pure gold cathode 1 by 3 cm and ¼ mm thick. The voltage was kept at 1.3-1.5 and the time was 18-24 hours. The anode was platinum. The gold electrode can be easily made in the laboratory. A piece of gold foil is cut to the specified dimensions and is welded to a platinum wire by heating wire and foil in position on an anvil with a Bunsen flame, finally tapping gently with a small hammer. Care must be taken not to melt the gold by excessive heating.

The electrode which has the mercury and copper plated out on it was washed in water, alcohol, and ether successively, and was then weighed on a micro-balance.

After weighing, it was placed in a Pyrex combustion tube through which a stream of hydrogen was passed. The tube was heated carefully and the mercury was driven off. After cooling, the electrode was again weighed and the mercury determined by difference.

Preparation of Hatters' Fur

The processes used in the manufacture of hatters' fur may be roughly divided into three parts: First, the preparation of the pelt; second, the carroting and drying of the fur; and third, the cutting or shearing of the hair from the skin. These constitute the basic steps in all hatters' fur establishments. Such differences as may be found to exist among various plants pertain chiefly to the degree to which some departments have been mechanized.

DESCRIPTION OF OPERATIONS AND OCCUPATIONS

Types of pelts used.—Practically all the hatters' fur used today is obtained from the pelts of rabbits or hares. The dry, raw pelts, turned inside out, are shipped in bales containing approximately 200 dozen. Most of these pelts are shipped from Great Britain, France, Australia, Belgium, and Russia. Relatively few pelts are produced in this country for the hatters' fur industry. Small amounts of furriers' waste or scraps of pelts from muskrats, squirrels, hares, etc., are also utilized. These yield felts with finer textures and are used in making high-grade felts.

Disinfecting.—As a rule, all the skins shipped are packed in naphthalene or other suitable preservative. In some instances, however, especially when scraps and inferior grade skins are used, it is necessary to eradicate worms which infest the hides. In such instances, the skins are placed in large containers into which hydrocyanic acid gas is introduced under pressure. The worms are killed after a short exposure to this gas. Arsenic, which was formerly widely used for the preservation of skins, no longer appears to be employed in baled pelts.

Drumming and cleaning.—The baled pelts are exceedingly dry and brittle, and must be carefully handled to avoid the loss of good skins through breakage. To condition the skins for the handling to which they will be subjected, as well as to clean them, they are placed in large revolving drums containing dampened sawdust and sand, which are rotated for approximately 60 minutes. The pelts are then transferred to cylindrical screens which are rotated to remove the sawdust and sand and to dry the pelts. (See fig. 2.)

Opening.—When the pelts have been conditioned, they are delivered to the openers, who mount each pelt on an upright wooden fork and cut off heads, tails, and legs, and slit the hide. This work is usually done by girls. (See fig. 3.)

Clipping.—The opened pelts are counted and sorted according to quality and color. They are then taken to the clippers for shearing the long coarse hairs which are undesirable. Clipping consists of placing the skins on a small iron rail which, when pushed forward,



FIGURE 2.—CLEANING SCREEN FOR PELTS RECEIVED FROM DRUMMER.

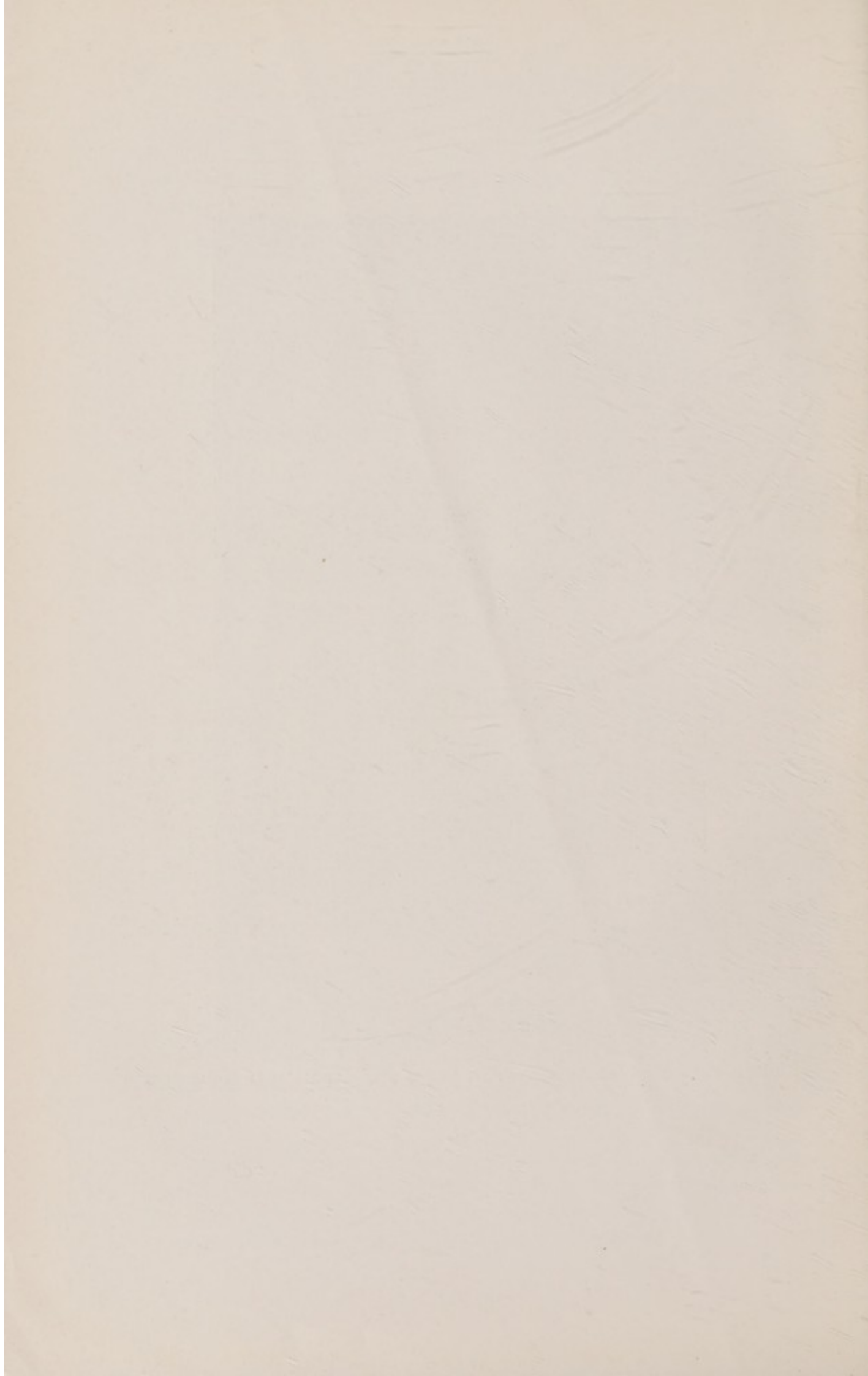




FIGURE 3.—OPENING PELTS.



FIGURE 4.—CLIPPING LONG HAIRS FROM RAW PELTS.



FIGURE 5.—HAND CARROTING OF HARE PELTS.

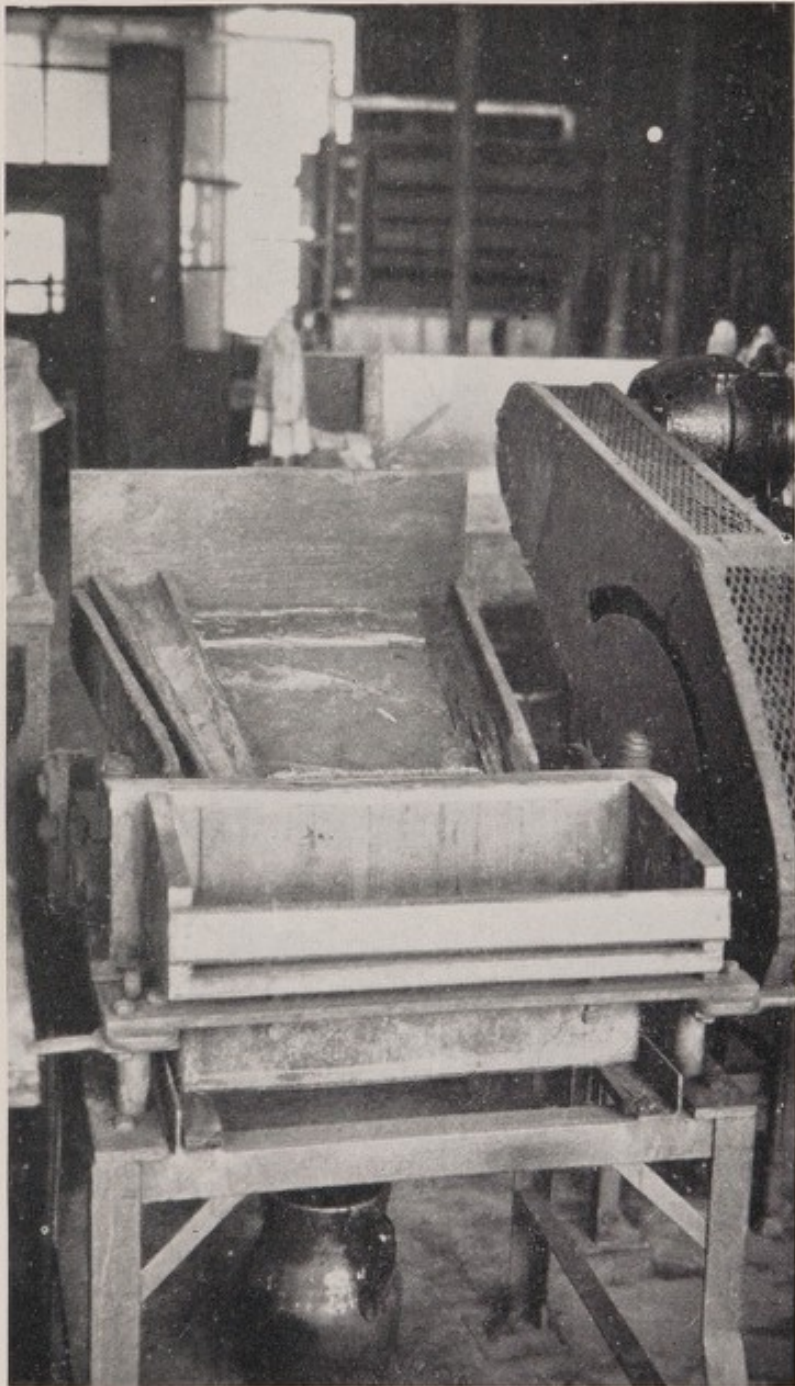


FIGURE 6.—EQUIPMENT USED FOR MECHANICAL APPLICATION OF CARROT.
The brush tips can be seen just above the forward dash board.

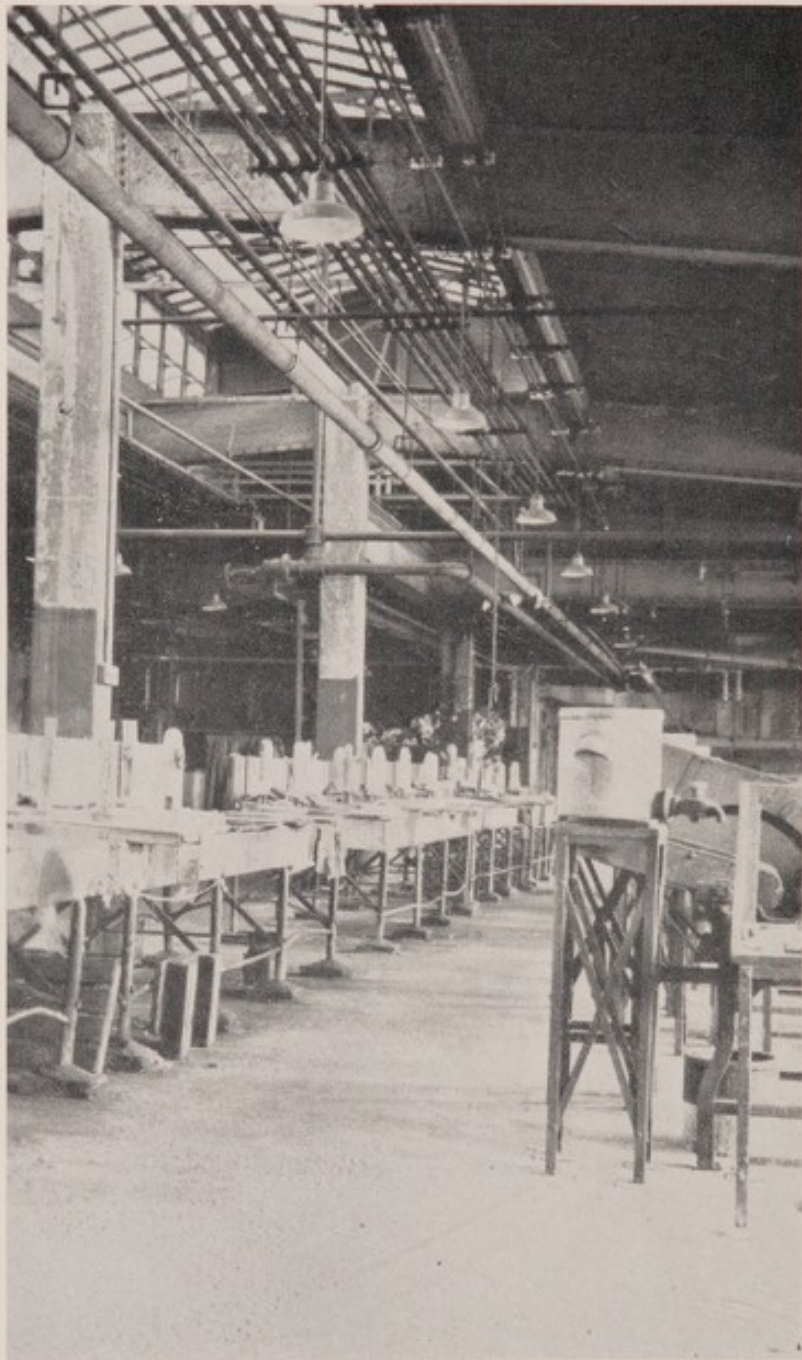


FIGURE 7.—MODERN CARROTING ROOM FOR BOTH HAND AND MACHINE CARROTING.

comes within a short distance of a revolving cutter. A vertical movement of the skin past the rail brings all the longer hairs within reach of the clipping blades. (See fig. 4.)

Clipping machines are exhausted, the air being drawn directly past the cutter which is approximately 6 to 8 inches in width, and conducted to a suitable collecting device, usually a cyclone. The hairs collected cannot be used for felting and are generally discarded as waste.

Carroting.—Up to the present point, the preparation of the fur has involved the handling of raw skins. Ordinarily cut fur or wool can be made into felt by wetting and applying pressure, but better felting can be secured by chemical treatment of the fur. Of the various chemicals used for this purpose, none has been found to be more generally suitable than mercury nitrate. The use of this compound for felting dates from the seventeenth century.

The application of mercury nitrate, or of any other chemical used in the treatment of raw fur, constitutes what is called carroting. This term arises from the carrot-yellow color of the treated skins which have been dried at temperatures approximating 200° F.

The application of mercury nitrate to the raw fur involves two important considerations. These may be considered in the following order: (1) Strength of carrot, and (2) method of application of the carrot. The strength of the carroting solution has a bearing on the type of felting sought, that is, whether a "fast" or "slow" felt is desired. Accordingly, the concentrated carrot (100 pounds nitric acid to 25 or 30 pounds of mercury) must be diluted to the necessary degree. An expert knowledge of the properties of various skins and of felting is essential in preparing and applying carrot of the proper strength.

With regard to the method of applying the carrot, either hand or mechanical methods are used. In the first method the carroter, protected by long rubber gloves, dips a brush into an earthenware bowl containing the carrot and deftly applies the substance to the fur. Not all the fur is treated with the carrot, but only the tips; likewise, too much carrot must not be applied. The method of hand carroting is shown in figure 5. The mechanical method of applying carrot consists of a revolving brush, about 10 inches in diameter and 18 inches in length which dips into an earthenware trough containing the carrot. The carroter, with hands protected, passes the fur side of the pelt over the brush. This method of applying the carrot is rapid, but requires considerable skill to prevent too much carrot being placed on the fur. The carrot is kept at a fixed level in the trough by means of a constant flow from a large earthenware crock.

The mechanical method of carroting fur produces a mist which causes considerable irritation to the carroter. He frequently brushes his face with his shoulders. The caustic mist appears to be the most

troublesome feature of carroting with mercury nitrate. Figure 6 illustrates the equipment used for mechanical application of the carrot.

In most plants, carroting is carried on in small, dark rooms. The mercury nitrate mist has a slightly pungent odor and attacks all exposed metal fixtures. The carroting room is usually damp and wet owing to the piling of carroted furs and the dripping which takes place in conveying the skins from the carroting benches to the drying rooms. In the more modern establishments, carroting is conducted in well-lighted rooms as may be seen by contrasting figures 5 and 7.

Spreading and drying.—The carroted fur may either be dried immediately or stored for a few hours in small humid compartments. Drying operations are of two types, depending upon the temperatures to which the skins are subjected. Temperatures of approximately 210°–240° F. produce what is known as a yellow carrot (Y. C.). This type of drying imparts a yellow, carrot color to the fur. Carroted skins are dried by spreading the carroted pelts on coarse screen trays which may be slid into steam-heated ovens. The trays alternate, one above the other, with steam coils. With yellow carrot furs, 20 to 30 minutes are required for completely drying the pelts. The moisture and gases are drawn off by exhaust systems. (See fig. 8.) Considerable smoke, due to the fat adhering to the skin, is produced.

When drying is done by natural means or by mechanical methods at temperatures below 140° F. a white carrot (W. C.) is produced. White carroting is generally used for white hare skins since no discoloration of the fur takes place. It is customary in white carrot drying to spread the carroted skins on trays in well-ventilated drying rooms or to suspend them from rafters in a manner similar to that illustrated in figure 9. Open air drying is also frequently resorted to. The mechanical method of drying consists of an oven with a special conveyor belt on which the skins are placed. The speed of the conveyor is regulated to assure perfect drying of the skins by the time they emerge from the oven.

The success of the carrot as an aid to felting is based on experience. Some plants have laboratories to control the felting properties of the fur to meet market demands but this is exceptional. Frequently the dryer foreman samples the carroted fur by tasting. This procedure is repeated many times each day and undoubtedly leads to the ingestion of considerable amounts of mercury.

Piling.—The dried pelts are exceedingly stiff and brittle. In order to soften them, they are piled in racks, fur to fur, and the exposed skin surface is wetted with a fine water spray. The piled fur is then pressed down with heavy planking and allowed to stand for indefinite periods. Figure 10 shows the manner in which the carroted and dried fur is piled.

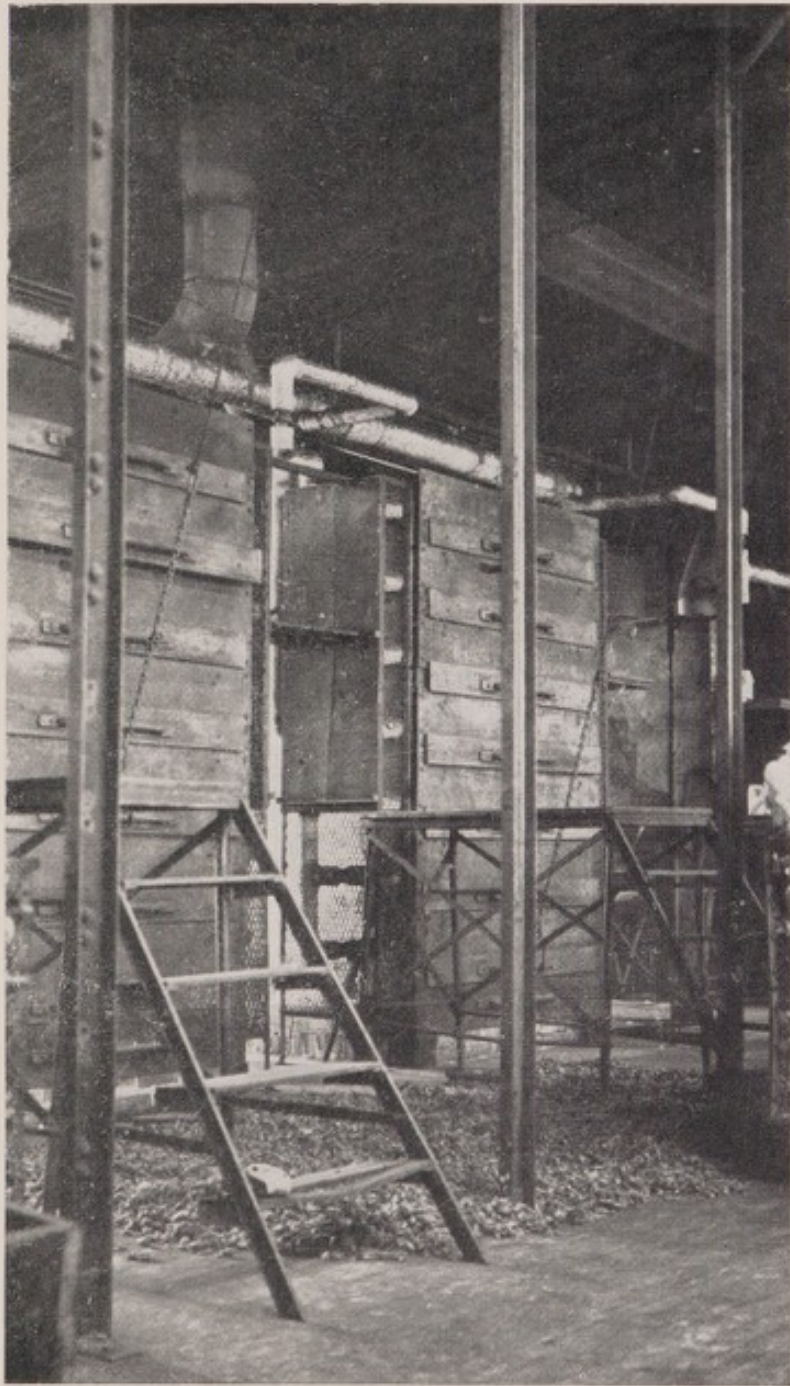


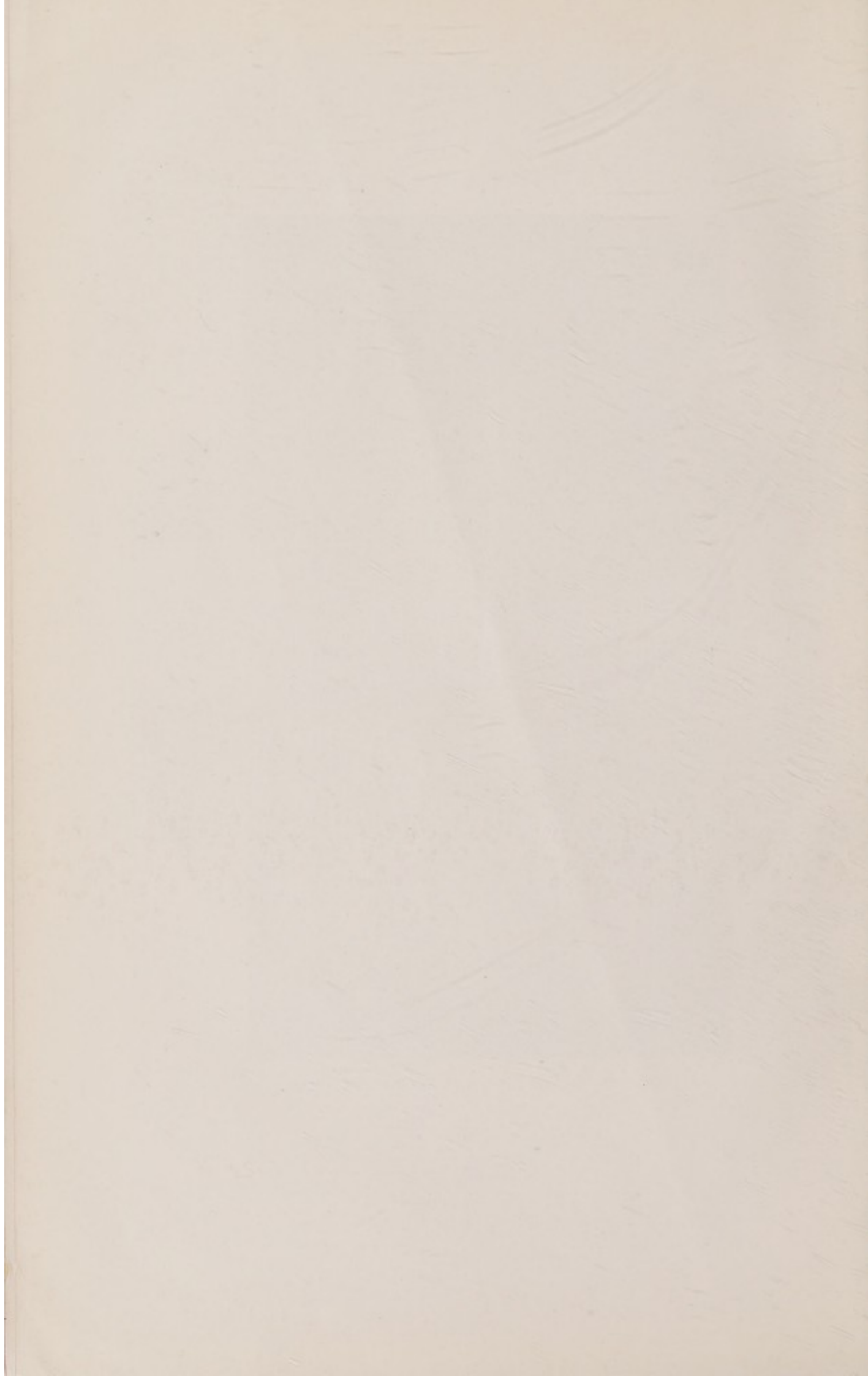
FIGURE 8.—YELLOW CARROT DRYING OVENS.



FIGURE 9.—ONE METHOD OF SPREADING FOR WHITE CARROT DRYING



FIGURE 10.—PILING OF DRIED CARROTED FURS.



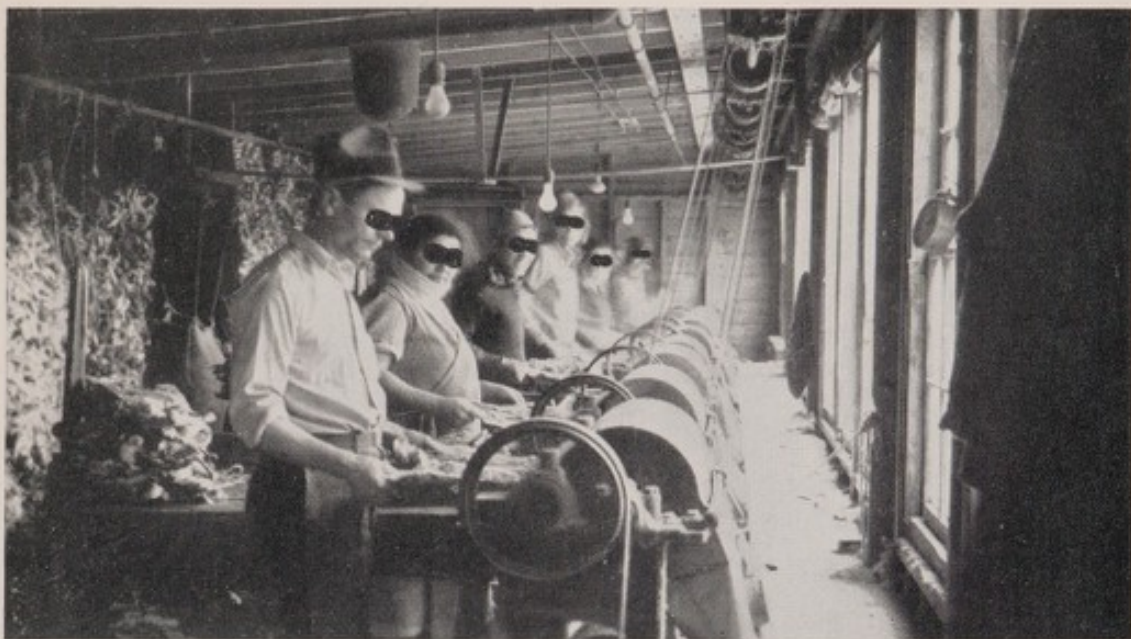


FIGURE 11.—BRUSHING CARROTED FURS.

Note method of exhausting.

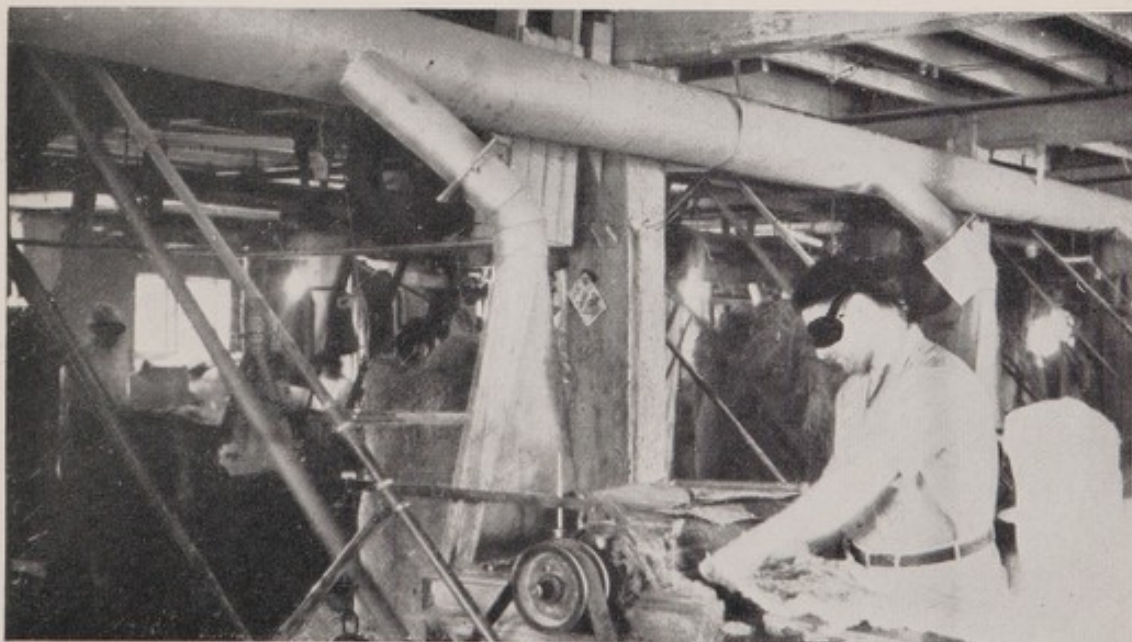


FIGURE 12.—CUTTER FEEDING BRUSHED CARROTED FUR INTO CUTTER.

Note exhaust.

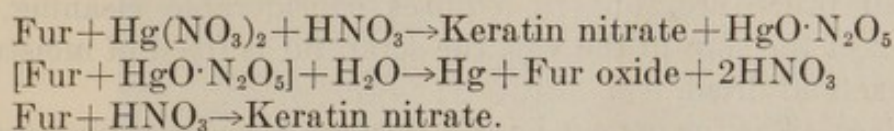


FIGURE 13.—SORTING OF CUT FUR.



FIGURE 14.—PACKING CUT AND SORTED FUR.

Exposure of workers to mercury vapor usually begins with the piling operations. The chemical reaction which takes place subsequent to the application of mercury nitrate to raw fur and which releases mercury vapor is not definitely known. It is believed, however, that the reaction is somewhat as follows:



The reaction is slow, but it is well known that more mercury vapor is given off as the carroted fur becomes older.

The action of mercury nitrate in altering the physical characteristics of fur is also not clearly understood. The general opinion prevails in the fur-cutting industry that the carroted hair tips are rendered flexible and thus, when matted together in the presence of moisture, they enmesh themselves, forming a firm felt.

Brushing.—The piled skins are sent as needed to the brushing department. After treatment with carrot, the fur is matted and irregular and must be smoothed. This is done by brushers who hold each skin against a stiff, revolving brush. The operation is usually repeated. Figure 11 shows the type of machines used for brushing.

Cutting and sorting.—Cutting and sorting constitute the third major step in the preparation of hatters' fur. The brushed pelts are taken to cutting machines which shear the fur from the skin. This work, usually done by men, consists in feeding pelts, one by one, to blades revolving at high speed which shear the fur and at the same time cut the skin into shreds (fig. 12). The sheared fur passes on a conveying belt, or on trays, to the sorters, who remove scraps of skin from the cut fur. Cutting operations produce large amounts of dust and consequently the floors must be swept frequently to remove the accumulated waste. The shredded skins drop into a compartment below the shearing knives and are collected in burlap bags and baled.

Sorting is a sedentary occupation employing girls. The work consists of manipulating the cut fur which has been placed on a flat tin tray and removing the scraps of skin which have been sheared by the cutter (fig. 13). The fur which has been freed of these scraps is placed in a paper bag and the waste is reclaimed by either of two methods described later in this report. Each sorter fills the bag assigned to her to a weight of 5 pounds. The bags are then tied up and sent to the storage room (fig. 14).

Reclaiming.—Small scraps of fur recovered either in the opening or sorting operations, or which have been purchased from furriers, are first chopped into small pieces and then treated in one of two ways. The pieces may be glued by pasters or stickers to strips of manila

paper, or else the skin to which the fur adheres may be digested by special methods in large vats. (See fig. 15.) If the fur has not been caroted, it may be caroted after gluing, and it may be dried, sheared, sorted, and otherwise handled in the same way as an ordinary pelt. Vat treatment of fur scraps involves less manipulation than the above-described procedure, but it requires considerable cleaning. After digestion of the skin in the vat, the scrap fur is freed of moisture in a centrifuge and dried.

Blowing.—The fur is next passed through a series of blowers, which act as elutriators and free the fur from gross material. These blowers consist of an automatic feeder and a rectangular compartment of two, four, six, or eight sections which contain revolving wire brushes. These brushes pass the fur from one compartment to the other by whipping the fur into suspension. The heavier matter which is not wanted drops to the bottom. The fur may be passed again through the same blower or through some other blower until the fur has been satisfactorily cleaned. Part of a four-section blower is illustrated in figure 16.

Blowing is one of the dustiest operations carried on in fur-cutting plants. Not only are caroted and uncaroted furs handled, but also cuttings from felt hats which have been shredded and are being reclaimed.

Storage and shipping.—All cut and blown fur is packed in 5-pound paper bags. Unless there is immediate turn-over, the fur is labeled and stored until required. Storage rooms are usually cool, humid, basement rooms, in which the temperature does not exceed 70° F. The manner of storing the cut fur is indicated in figure 17.

In shipping, the bags of fur are placed in wooden boxes. All fur is carefully graded and labeled. If the fur-cutting plant is an adjunct of a hat factory, the bags are sent, as required, in large open boxes mounted on dollies.

Superintendence.—Each department of a fur-cutting establishment is under the direct supervision of a foreman or forelady. As a rule, each worker is paid on a piece-work basis; this requires careful counting of furs and checking and inspection by supervisors. These, in turn, are responsible to the plant manager.

Engineers, machinists, electricians, grinders, and carpenters are employed in the large plants. Their duties consist in keeping the building and machinery in working condition. These occupations are generally under the direction of the plant manager.

GLOSSARY OF TERMS

Blower.—Operates machine used for removing coarse hair and grit.

Brusher.—Feeds caroted pelts, received from the piling room, through revolving brushes.

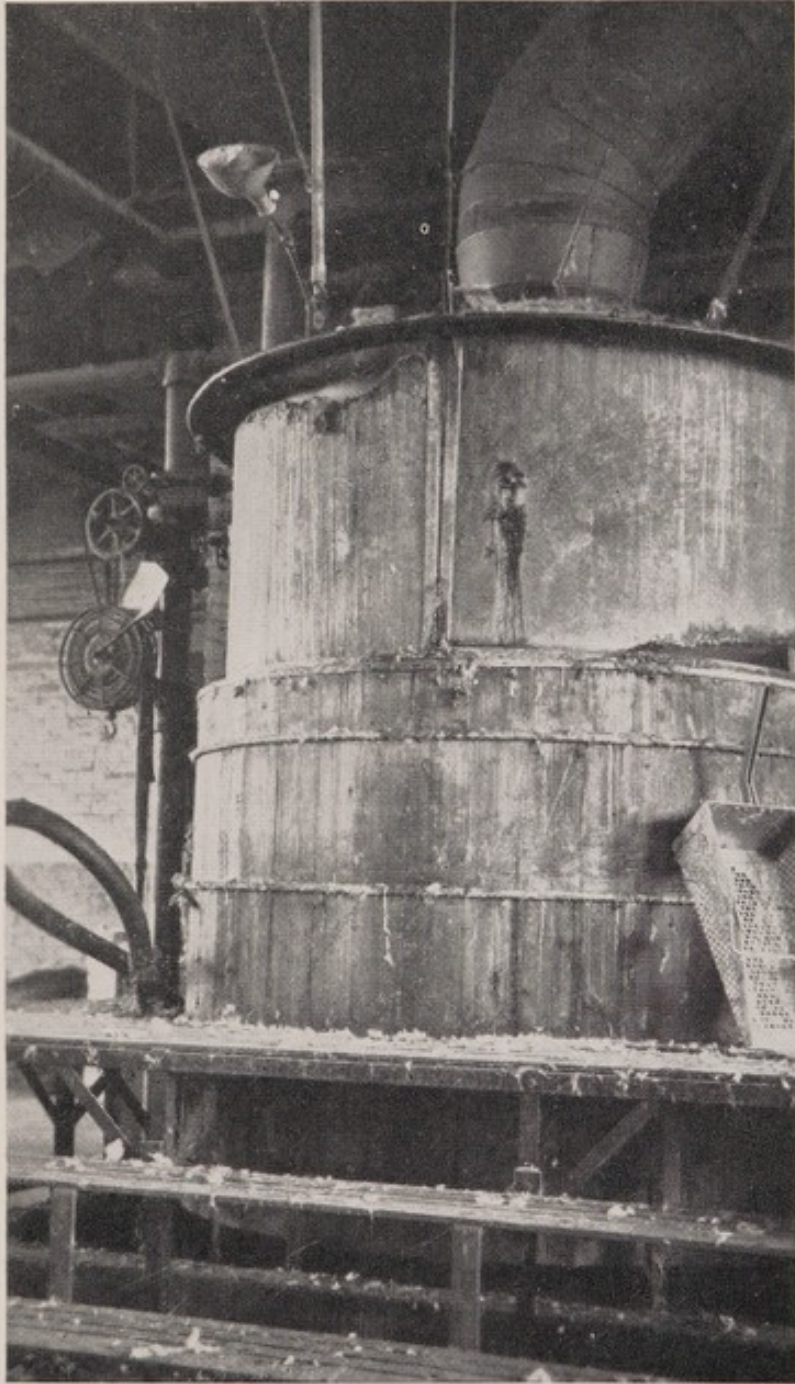


FIGURE 15.—SCRAP SKIN DIGESTION VAT.

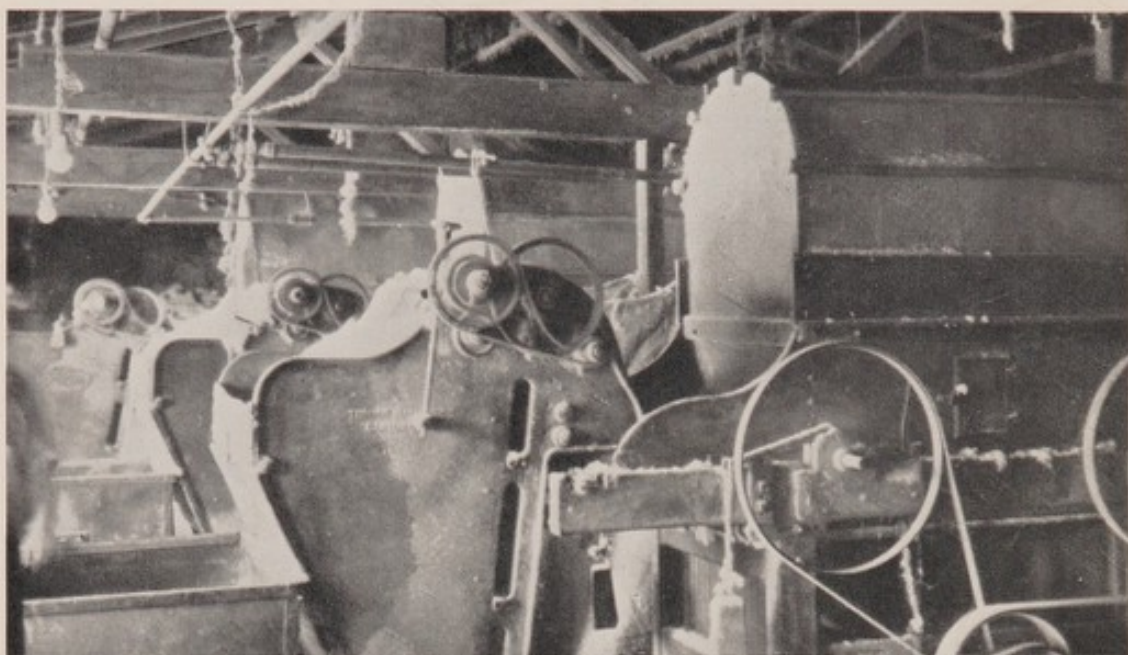


FIGURE 16.—FEED END OF FOUR-SECTION BLOWER.



FIGURE 17.—STORING CUT FUR.

- Carrot*.—A mixture of mercury nitrate and nitric acid.
- Carroter*.—Applies mercury nitrate, either manually or by means of a revolving brush, to the fur.
- Chopper*.—Operates machine for cutting scraps of skin received from openers, sorters, and furriers, preparatory to placing in digestion vat.
- Clipper*.—Feeds pelts to a revolving cutter which trims off long, undesirable hair.
- Drummer*.—Operates large drums containing damp sawdust and sand, in order to soften dry and brittle pelts and to clean them.
- General utility*.—Comprises machinists, electricians, carpenters, janitors, elevator men, and other maintenance workers.
- Grinder*.—Grinds and sharpens clipping- and cutting-machine blades.
- Opener*.—Removes heads, tails, and legs, and slits open the reversed pelts.
- Packer*.—Ties up sorted and blown fur in 5-pound bags.
- Paster*.—Glues small fur scraps to manila-paper sheets.
- Piler*.—Stores and moistens dried carroted skins.
- Shipper*.—Ships fur received from the packers or from the store-room.
- Skin sorter*.—Counts and grades pelts.
- Sorter*.—Removes scraps of skin which have been cut from the carroted pelt by the cutting machine.
- Spreader*.—Places the carroted pelts on drying trays.
- Sticker*.—Same as paster.
- Supervisory*.—Includes departmental foremen and foreladies, piece-work counters and checkers, and plant manager.
- White carrot (W. C.)*.—A term applied to fur treated with mercury nitrate and nitric acid and dried at room temperature, or temperature less than 140° F.
- Yellow carrot (Y. C.)*.—A term applied to fur treated with mercury nitrate and nitric acid and dried at temperatures of approximately 240° F.

Results of the Engineering Study

PRELIMINARY SURVEY

The majority of the 36 plants covered in the preliminary survey were housed in old frame buildings, many of them being establishments of the so-called back shop variety. Only a few of the plants could be considered as having been well planned from the standpoint of control of any existing occupational hazards.

Although insanitary conditions may not be directly associated with ill health, it has long been recognized that the elimination of sources of uncleanness in factories is conducive to the well-being and efficiency

of the workers. For this reason, the general sanitary conditions of the 36 plants were observed, and it was found that the sanitation in these plants was, on the whole, rather poor. An analysis of these data showed that 57 percent of the plants were in either a poor or bad state of sanitation, 33 percent fair, and the remaining 10 percent could be considered as having good or excellent sanitary conditions.

The data presented in table 1 show the number of factories employing specified numbers of workers. These figures are compared with data for other industries in the United States (4). The results show that there is a greater percentage of large plants in the hatters' fur-cutting industry than in other industries in the United States. For example, 55 percent of the 210,959 plants covered in the 1930 United States Census employed less than 10 persons, as contrasted with only 8.4 percent in the hatters' fur-cutting establishments. In fact, 20 percent of the 36 plants in the fur-cutting industry employed 100 or more persons, as contrasted with only half that percentage for a typical industrial area.

TABLE 1.—*Comparison of hatters' fur-cutting plants with other industrial establishments in the United States, according to number of workers*

Type of establishment	Number of plants	Percent of plants with less than stated number of workers							
		Less than 10	Less than 20	Less than 30	Less than 40	Less than 50	Less than 75	Less than 100	100 or more
All industries in the United States ¹	210,959	55.0	72.0	77.0	81.2	85.2	88.8	91.9	8.1
Typical industrial area ²	615	48.7	64.1	73.4	77.0	80.7	87.0	89.8	10.2
Hatters' fur-cutting industry.....	36	8.4	27.8	38.9	52.8	63.9	69.5	80.6	19.4

¹ Personal communication from U. S. Census, 1930.

² Public Health Bulletin No. 216.

A comparison of industrial-welfare provisions in the hatters' fur-cutting industry and plants in a typical industrial area is shown in table 2. It is apparent that such facilities as medical care, first aid, etc., are rather limited in the hatters' fur-cutting industry, as compared with the same type of service in the typical industrial area. For example, only 5.5 percent of the employees in the fur-cutting trades had the services of either a part- or full-time physician, as compared to 15.3 percent who received this type of service in the typical industrial area. When one takes into consideration the fact that even in the typical industrial area the welfare provisions are rather limited, as judged by present-day standards, it is then evident that the hatters' fur-cutting industry leaves much to be desired in providing those facilities which are known to have a bearing on industrial health.

TABLE 2.—*Comparison of industrial-welfare provisions between hatters' fur-cutting industry and industries in a typical industrial area*¹

Industry	Number of employees	Percent of persons with listed facility				
		Physician	Nurse	First-aid room	Sickness records	Sick-benefit association
Hatters' fur cutting.....	1,970	5.5	10.1	21.8	10.1	10.1
Typical industrial area ¹	28,686	15.3	34.1	48.5	40.0	29.4

¹ Public Health Bulletin No. 216: The Potential Problems of Industrial Hygiene in a Typical Industrial Area in the United States.

SANITARY AND OCCUPATIONAL SURVEYS

As a result of the preliminary study of the 36 plants, it was possible to select 5 factories for detailed investigation. As indicated earlier, the first step in an engineering study of this type is the making of a sanitary and occupational survey. The survey form which follows served as a basis for these preliminary steps. On the face of this form, certain data pertaining to general sanitary conditions, ventilation, illumination, and environmental conditions, as well as air-borne toxic substances, are recorded, while information on the various occupations and the particular activities and raw materials associated with these occupations is noted on the reverse (figs. 18 and 19).

Items 1 and 2, on the physical structure of the buildings, have already been discussed. Item 3, on ventilation, is treated in a later section of this paper.

With reference to item 4, namely, illumination, it is apparent that this type of preliminary survey does not call for actual measurement of the illumination in the workrooms. However, it has long been known that to secure the maximum average illumination over the working surfaces, the window-glass area should be as large as structural and architectural limitations will permit. Experience indicates that the glass area should not be less than 18 percent of the floor area for glass starting 3 feet above the floor; but the best practice is to exceed this minimum value, particularly if a portion of the sky is obstructed by adjacent buildings (6).

With such a standard in mind, the data shown in table 3 were prepared. An examination of this table shows that 87 percent of the workrooms had a window-space to floor-space ratio of less than 0.20; in other words, the glass area was less than 20 percent of the floor area in 87 percent of the rooms. These data are presented merely to indicate the fact that natural illumination in these factories could be greatly improved.

E-631

No. _____

Date _____

UNITED STATES PUBLIC HEALTH SERVICE
Office of Industrial Hygiene
and Sanitation

1. GENERAL				
Establishment				
Type of Bldg.			Bldg. No.	
Workroom			Location	
Size			Crowded	
2. GENERAL SANITARY CONDITIONS				
Refuse disposal	Sweeping service			
Cloak rooms				
Washing facilities				
Eating facilities				
Drinking water				
Toilet facilities- type & No.	Illumination	Ventilation	San. Cond.	Ample
Male				
Female				
3. VENTILATION				
Natural	Type			
Artificial	Type & No.			
4. ILLUMINATION				
Natural	General impression			
Window space	Maximum distance from window			
Ratio to floor space	Type of window			
Condition				
Artificial	General impression			
Type & No.	Condition			
Shadow or glare				
5. FUMES AND GASES				
6. DUSTY PROCESSES				
7. SPECIFIC POISONS				
8. EXPOSURE TO ABNORMAL TEMPS., DAMPNES, RADIATION, ETC.				

FIGURE 18.

TABLE 3.—Workrooms classified according to ratio of window space to floor space

Ratio	Less than 0.05	0.05 to 0.09	0.10 to 0.14	0.15 to 0.19	0.2 to 0.24	0.25 to 0.29	More than 0.30
Number of rooms in each class..	11	11	15	4	1	3	2
Percent of rooms in each class..	23.4	23.4	31.8	8.5	2.1	6.4	4.4

apparent from this study that practically all of the workrooms in the five plants under study were of ample size, only one room being found to provide less than 50 square feet per capita.

TABLE 4.—*Distribution of workrooms according to per capita space allotment*

Square feet floor space per capita	Less than 50	50 to 99	100 to 149	150 to 199	More than 200	Total
Number of rooms in each class.....	1	12	4	4	26	47

Table 5 gives the number of workers, by occupation, in the 36 plants of this industry and contrasts these data with similar information on the 5 plants studied in detail. It may be seen that 57 percent of the workers were males and that the occupation employing the greatest number of persons is that of sorting, 580 of the 2,004 persons being engaged in this occupation. A comparison of the last two columns of this table gives an indication of the representative nature of the five plants selected for this study. In nearly every instance the percentage of workers, by occupation, in the five plants compared well with the figures for the industry as a whole.

TABLE 5.—*Occupational analysis of the hatters' fur-cutting industry contrasted with data secured from 5 plants studied*

Occupation	Number of males in industry	Number of females in industry	Total number in industry	Percent of total in industry	Percent of total in 5 plants studied
Openers.....	24	133	157	7.9	5.5
Drummers and cleaners.....	57	0	57	2.8	2.0
Skin sorters.....	13	11	24	1.2	.9
Clippers.....	188	0	188	9.4	11.2
Carroters.....	180	2	182	9.1	7.3
Dryers and spreaders.....	52	45	97	4.8	7.0
Pilers.....	14	0	14	.7	1.6
Brushers.....	74	26	100	5.0	4.4
Pasters and stickers.....	0	42	42	2.1	
Cutters.....	145	2	147	7.3	8.6
Sorters.....	0	580	580	29.0	36.0
Packers.....	7	3	10	.5	.6
Shippers.....	22	0	22	1.1	2.0
General utility ¹	143	0	143	7.1	7.9
Blowers and choppers.....	135	0	135	6.7	5.0
Supervisors.....	60	8	68	3.4	(?)
Clerical.....	23	15	38	1.9	(?)
Total.....	1,137	867	2,004	100.0	100.0

¹ Includes machinists, blade grinders, carpenters, elevator men, etc.

² Included in general utility.

OCCUPATIONAL EXPOSURE TO MERCURY VAPOR AND DUST

Samples of mercury vapor and mercury-impregnated dust were obtained simultaneously for each occupation in each of the five plants studied. The results of the two separate analyses were added together in order to determine the total exposure to mercury for each occupation.

Table 6 shows the amounts of mercury to which workers in the various occupations were exposed and how much of the mercury exposure was due to mercury-impregnated dust and how much was due to mercury vapor.

Occupations have been listed in order of mercury exposure, shipping heading the list. Shippers, who are employed in storerooms housing thousands of pounds of mercury-treated fur, have an average exposure of 7.2 mg of mercury per 10 m³ of air. Their mercury exposure is almost entirely due to the mercury vapor which arises continually from mercury-treated fur, 93 percent of their mercury exposure being due to mercury vapor. Pilers have the next highest exposure, 5.4 mg per 10 m³, and again their mercury exposure is largely due to mercury vapor. Like shippers, pilers are obliged to work in inadequately ventilated rooms in which large quantities of mercury-treated pelts are stored.

Blowers also have a high mercury exposure, 74 percent of which is due to mercury vapor. They work with mercury-treated fur under conditions which are favorable for the release of mercury vapor, and they are also exposed to large amounts of dust, as table 7 shows. Cutting and sorting are usually carried on in the same rooms and present almost the same mercury exposure, most of which is due to mercury vapor.

In the occupations with low total mercury exposure, mercury-impregnated dust constitutes a larger part of the total. Moreover, three of these occupations, clipping, drumming, and skin sorting, do not involve the handling of mercury-treated fur, and the mercury-impregnated dust and mercury vapor to which they are exposed must have come from other operations carried on elsewhere in the same workroom.

These data clearly show that the greatest part of the mercury to which fur cutters are exposed is present in the form of mercury vapor and that a comparatively minor part is due to mercury-impregnated dust.

The literature on mercurialism among hatters' fur workers contains many statements concerning the severity of the hazard among car-roters. The present study indicated that carroters were exposed to relatively small amounts of mercury, the findings as shown in table 6, averaging only 0.8 mg in 10 m³ of air.

In this connection, it may be well to point out a second phenomenon observed in this study. Following the preliminary survey made in the 36 plants, the first thought was that the small "back shop" type of plant, with its extremely insanitary conditions, would be the one in which considerably mercury exposure would be found. However, quantitative studies indicated that these small plants had relatively small amounts of mercury vapor and dust in the air, as compared

with the larger plants. This finding may be explained by the fact that the small plants do not allow stock to accumulate but work intermittently as orders are received. For this reason, very little mercury is handled from day to day, and practically no treated furs are allowed to accumulate in the factories. On the other hand, in the larger plants, considerable quantities of mercury are being used, and hundreds of thousands of treated skins and vast quantities of treated fur are continually present in the factory. In addition, large amounts of treated and cut fur stock are allowed to stand about in the various workrooms, often in those rooms where there would otherwise be no mercury exposure, such as those in which preliminary processes are conducted, as in the case of openers and drummers. The remedy for this situation is quite apparent, since by the simple practice of segregation it would be possible to eliminate exposure to mercury for those workers whose tasks do not entail the handling of any mercury compounds or treated stock.

The exposure of workers to mercury compounds in the hatters' fur-cutting industry was found to vary from a trace to a maximum of 10.4 mg per 10 m³ in the air of the stockrooms. The effect of such exposures is discussed in the report dealing with the medical phases of the study.

TABLE 6.—Occupational exposure of fur cutters to mercury dust and vapor in 5 plants

Occupation	Number of samples (total) †	Number of workers	Average exposure to mercury in milligrams per 10 cubic meters of air			
			Dust	Vapor	Total dust and vapor	Percent total as vapor
Shippers.....	12	11	0.5	6.7	7.2	93
Pilers.....	8	9	.3	5.1	5.4	94
Blowers.....	26	24	1.2	3.4	4.6	74
Cutters.....	26	47	.6	3.4	4.0	85
Sorters.....	52	197	.5	3.4	3.9	87
Blown-fur packers.....	2	3	.4	3.4	3.8	89
Brushers.....	16	24	.8	2.3	3.1	74
Fur choppers.....	2	2	.2	2.6	2.8	93
Drummers.....	8	11	.2	2.3	2.5	92
Yellow-carrot dryers.....	6	6	.5	1.5	2.0	75
Clippers.....	18	61	.6	.9	1.5	60
Chopped-fur blowers.....	4	2	.5	.8	1.3	61
Skin sorters.....	6	5	.2	1.0	1.2	83
White-carrot dryers or spreaders.....	22	32	.6	.6	1.2	50
Carroters.....	26	40	.6	.2	.8	25
Openers.....	4	30	.3	.4	.7	57
Miscellaneous (office, machinists, etc.).....	10	43	.2	.4	.6	67
Total.....	248	547	-----	-----	-----	-----

† Equal number of dust and vapor samples taken for each occupation.

The present study of mercurialism among hatters' fur workers afforded an opportunity to determine the effects of inhalation of organic dusts on workers. For that reason, determinations of dust concentrations were made with the konimeter. This instrument was used in preference to the standard impinger method, because the nature of the dust precluded the use of the latter device.

Table 7 presents the results of 112 determinations of the dust exposure among hatters' fur workers. Drummers had the highest exposure, 16 million particles per cubic foot of air. Blowers were exposed to 9.4 million particles, and shippers were exposed to 1.8 million particles per cubic foot. Judged according to present-day standards of dustiness, it may be concluded, on the basis of the dust results alone, that the dust exposure of hatters' fur workers is not high enough to be inimical to health.

TABLE 7.—Average dust counts prevailing in various occupations in the fur-cutting industry, based on konimeter samples

Occupation	Number of samples	Millions of particles per cubic foot	Occupation	Number of samples	Millions of particles per cubic foot
Drummers.....	4	15.9	Carroters.....	13	4.0
Blowers.....	8	9.4	Clippers.....	6	3.1
Sorters.....	31	7.1	Spreaders.....	4	2.3
Cutters.....	18	7.0	Shippers.....	4	1.8
Openers.....	6	6.3			
Packers.....	2	4.5	Total.....	112	.....
Brushers.....	16	4.2			

The Control of Dust and Mercury Vapor

Three methods are employed at the present time in the hatters' fur industry for the control of mercury vapor and fur dust. These are (1) segregation, (2) local exhaust ventilation, and (3) general natural ventilation.

SEGREGATION

As might be expected, segregation has a definite application to the operations in the fur-cutting establishment which are concerned with the handling of raw, untreated pelts, namely, openers, drummers, skin sorters, and clippers. Complete segregation of these occupations would free 21.3 percent of the fur workers from mercury exposure. Table 8 illustrates how exposure to mercury may be decreased by segregating drummers and clippers from other occupations.

TABLE 8.—Exposure of hatters' fur workers to mercury vapor and treated fur dust under controlled and uncontrolled conditions

Occupation	Total mercury exposure in milligrams per 10 cubic meters		Method of control
	Uncontrolled	Controlled	
Drummers.....	2.5	0.6	Segregation.
Clippers.....	1.5	.7	Do.
Brushers.....	3.1	1.2	Local exhaust ventilation.
Cutters.....	4.0	1.8	Do.
Sorters ¹	3.8	1.7	Do.
Blowers.....	4.6	.7	Do.
Pilers.....	5.4	Trace	Good natural ventilation.
Storage workers and shippers.....	7.2	Trace	Do.

¹ Depend on exhausts installed on cutting machines.

LOCAL EXHAUST VENTILATION

No data are available relative to the air movements required for the control of mercury vapor and fur dust by local exhaust systems. In fact, machines used by brushers, cutters, and blowers have been exhausted chiefly to eliminate the nuisance caused by the dust generated by these occupations, and even in these instances efficiency has generally been based on visual judgment of the degree of improvement secured. However, the presence of exhaust systems, as may be seen by reference to table 8, decreases the mercury exposure considerably.

Brushers.—The method of control used on brushing machines is illustrated in figure 11. The exhaust opening is located directly behind the revolving brush, and the air is drawn upward from the front portion of the machine, which is open. An average of 300 cubic feet of air per minute per machine was found to produce the improvement indicated in table 8. The reduction shown in this table was obtained in a plant in which more brushes were operated than in the plants without control. This fact also implies the presence of more caroted skins in the brushing department, which are continuously giving off mercury vapor.

Cutters.—As has been pointed out, cutting machines produce large amounts of dust due to vibration of the equipment and to the fan action of the cutting blades. Not only are cutters exposed to this dust, but sorters also, who work in the same room. Thus, as may be seen from table 5, 36.3 percent of the workers in the industry are exposed to dust created by this operation alone. Persons employed in these occupations are, moreover, exposed to mercury vapor emitted by the large quantities of caroted skins and cut fur which are constantly present. The reduction of the amount of mercury present in the air, both as a vapor and as a constituent of dust, as a result of exhaust ventilation, is clearly shown in table 8.

The manner of exhausting cutting machines is illustrated in figures 12 and 20, the latter representing schematically the dimensions of the hood used. It will be noted in figure 12 that the hood is located immediately behind the cutting blades and draws air upward from the waste hopper below the machine. Of the 16 cutting machines equipped with exhaust hoods which were studied, it was found that they handled an average of 383 cubic feet of air per minute. This value was exceeded considerably on some machines located close to the exhaust fans, but the increased air flows apparently did not interfere with the cutting operations.

Blowers.—Tables 7 and 8 indicate that blowers have high mercury vapor and dust exposures. This condition is due to the presence of large amounts of treated fur and to the nature of the work done by blowing machines.



FIGURE 21.—AMERICAN-TYPE BLOWING MACHINES WITH VENTILATION ON.

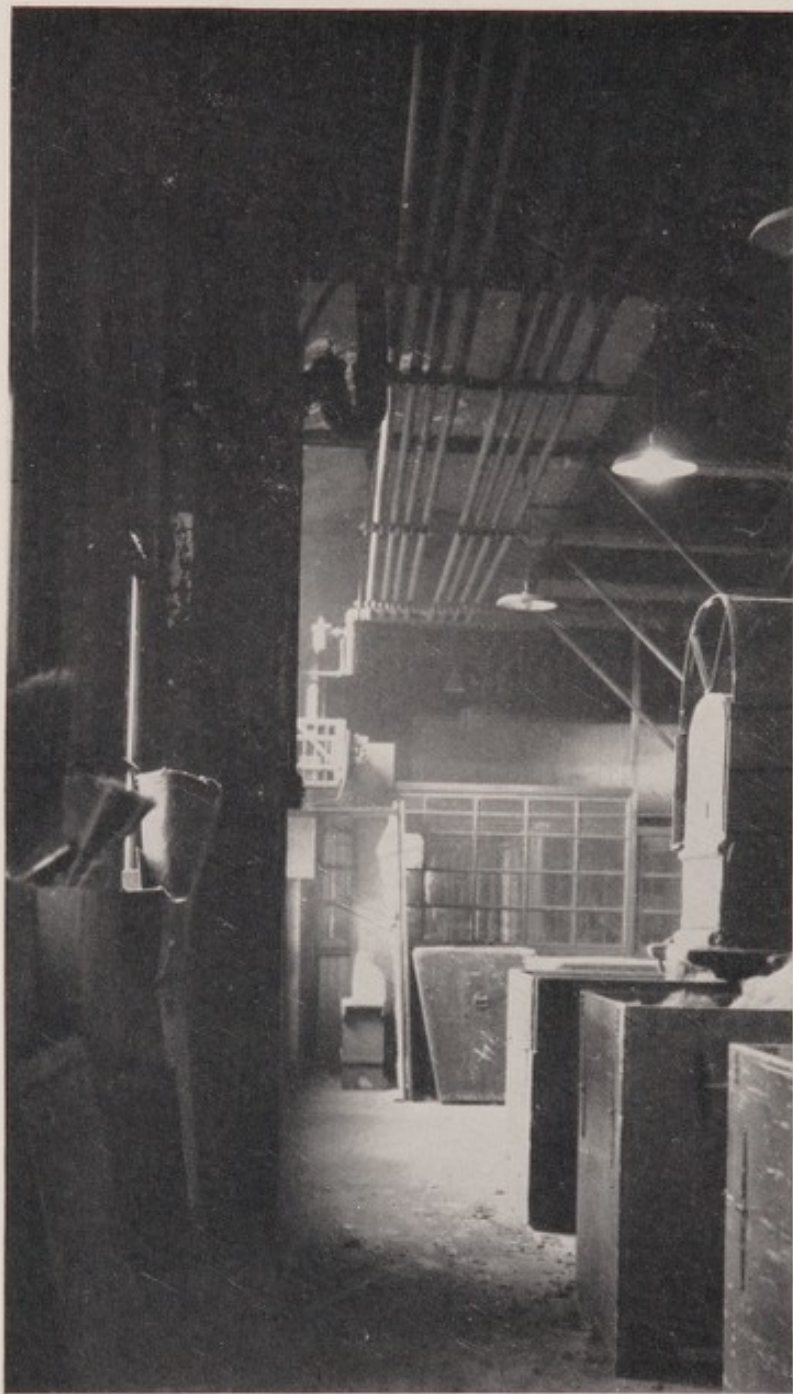
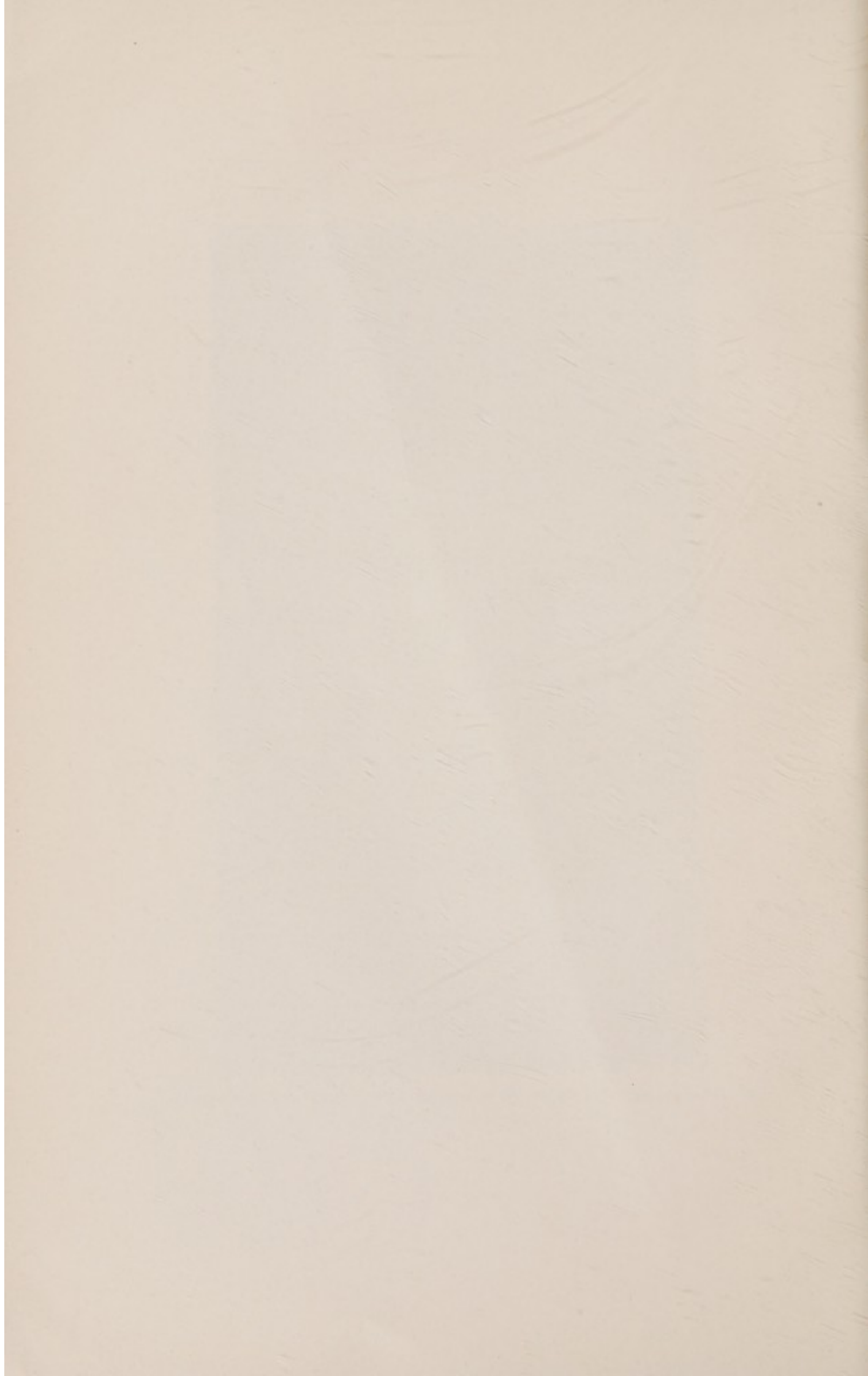


FIGURE 22.—SAME AS FIGURE 21 WITH VENTILATION OFF.
Note presence of dust.



FIGURE 24.—HOODS USED ON GERMAN-TYPE BLOWING MACHINES.



Two forms of blowers are used in the hatters' fur industry, designated as American type and German type, according to the country in which they are manufactured. Both types of blowers are similar in operation but differ in construction. American blowers are equipped with semicircular screened tops which permit much dust to escape, while the German type is constructed with a flat top having small screened openings near the feeder end.

To control the dust generated by the American-type blowers, an almost semicircular hood concentric with the screened top of the blower is used. This hood is constructed of varnished cloth in order to reduce the weight of the blower top, which must be removed periodically. An adapter is fitted to the feeder end of the hood and connected to an exhaust leader. Air is thus drawn from the open end across the screened top of the blower and thence to the exhaust system. Figures 21 and 22 illustrate the effectiveness of these hoods. Figure 22 shows the presence of dust in the air after 30 minutes' operation with the exhaust system sbut off, while figure 21 shows the same view with the system in operation. Detailed dimensions of the hood used are presented in figure 23.

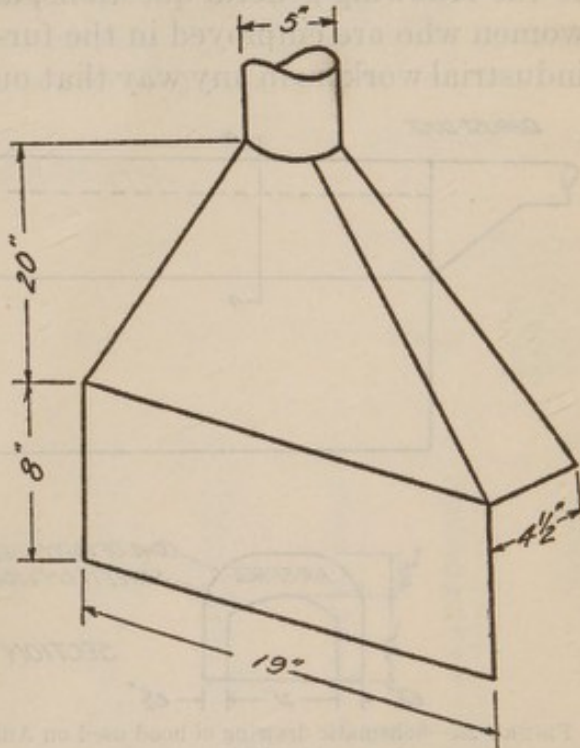


FIGURE 20.—Schematic drawing of cutting machine hood.

Ventilation studies made on two two-section and seven six-section American-type blowers gave the following results:

	<i>Cubic feet per minute</i>
Average air flow for 2-section blower.....	1, 840
Average air flow for 6-section blower.....	2, 330

The control used in German-type blowers consists of a 45 by 40 by 10-inch hood with a 10-inch flanged apron attached. (See fig. 24.) The data secured from ventilation tests in two series of German-type blowers gave average air flows ranging from 835 to 1,362 cubic feet per minute. Dust and vapor removal was found to be more effective with the higher air flows.

GENERAL NATURAL VENTILATION

This method of control was found in piling rooms and fur-storage basements. Because, as has been pointed out, the storage of large amounts of treated fur produces large amounts of mercury vapor, it is essential that adequate air changes be provided. Good natural

ventilation was found to be effective in one piling room and one storage room studied. In these instances, outdoor air was forced to sweep through the rooms for 12 hours each day. Natural ventilation, however, must not be considered as adequate in every instance, unless there is a continuous positive movement of fresh air.

MEDICAL STUDY

Objectives

The medical section of this report is intended to supply answers to the following general questions, among others: (1) Do the men and women who are employed in the fur-cutting industry differ from other industrial workers in any way that ought to be taken into consideration

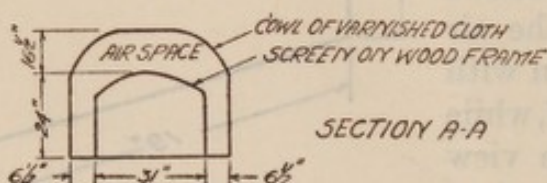
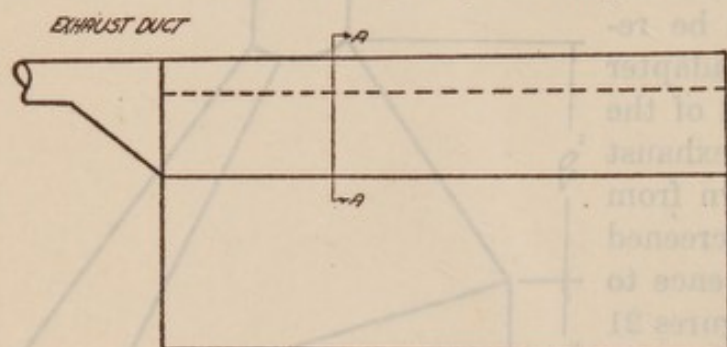


FIGURE 23.—Schematic drawing of hood used on American type blowing machines.

in making comparisons of health conditions in the fur-cutting industry and other industries? (2) What types of physical defects and diseases were found, and how many people were affected? (3) Is ill health, in any of its manifestations, more prevalent in this industry than it is in other industries? (4) Does mercury exposure have any relation to the occurrence of the physical disorders that are found more frequently in the fur-cutting industry than in other industries? (5) How many cases of chronic mercurialism were found, and what relation do these cases have to mercury exposure and to other conditions of the working environment?

General Descriptive Data

Age distribution (table 9) is important because many diseases and defects become more frequent with advancing age, regardless of industrial health hazards. Table 10 indicates how long these fur cutters have been employed in the industry, exposed to whatever health hazards it may offer. Table 11 shows the national origins of these employees and their parents; it is presented because standards of living, diet, and the extent to which hygienic measures are practiced in the home (all of which have a profound influence on health) vary greatly in different groups of recent immigrants.²

² Of a total of 547 employees in 5 representative fur-cutting plants, 529 were given a medical examination. Of the 18 employees not examined, 17 were office and clerical workers and 1 man was excluded because he had been employed for a long time in the hatting industry and for only a few months in the fur-cutting industry.

The age distributions of the male and female fur cutters studied are shown in table 9, where, for comparison, the percentage age distribution of 10,143 male industrial workers employed in 10 industries which have been studied by the Public Health Service (25) has been presented. The male fur cutters are an older group of individuals, on the average, than the larger group of male industrial workers. For instance, among the fur cutters only 36.6 percent were under 35 years of age, but in the other industries 54.5 percent were in this age group. As is often the case in industrial groups, the female fur cutters were younger than the male fur cutters, having an average age of 34.0 years, as compared with 39.0 for the male fur cutters. The average age of the 10,143 male industrial workers was 35.3 years.

TABLE 9.—Age distribution of fur cutters compared with age distribution of 10,143 male industrial workers

Age	Percentage		Number		Percentage age distribution of 10,143 male industrial workers ¹
	Male	Female	Male	Female	
Total.....	100.0	100.0	298	231	100.0
Under 20 years.....	4.7	6.9	14	16	4.9
20 to 24 years.....	9.1	16.9	27	39	14.0
25 to 29 years.....	11.1	19.5	33	45	18.3
30 to 34 years.....	11.8	10.0	35	23	17.3
35 to 39 years.....	16.4	18.6	49	43	15.5
40 to 44 years.....	16.4	13.4	49	31	11.2
45 to 49 years.....	11.4	6.5	34	15	8.1
50 to 54 years.....	10.7	3.9	32	9	5.1
55 to 59 years.....	3.7	1.3	11	3	3.0
60 to 64 years.....	1.7	2.6	5	6	1.6
65 to 69 years.....	1.3	.4	4	1	.7
70 years and over.....	1.7	0	5	-----	.3

¹ Public Health Service Bulletin 162.

TABLE 10.—Classification of fur cutters according to duration of employment

Duration of employment	Percentage		Number	
	Male	Female	Male	Female
Total.....	100.0	100.0	298	231
Less than 1 year.....	3.7	7.4	11	17
1 to 4.9 years.....	30.5	34.6	91	80
5 to 9.9 years.....	21.8	36.4	65	84
10 to 14.9 years.....	15.8	12.1	47	28
15 to 19.9 years.....	12.4	6.9	37	16
20 to 24.9 years.....	7.7	1.7	23	4
25 to 29.9 years.....	4.4	.9	13	2
30 to 34.9 years.....	1.3	0	4	-----
35 to 39.9 years.....	.7	0	2	-----
40 to 44.9 years.....	.7	0	2	-----
45 years and over.....	1.0	0	3	-----

Labor turn-over is not great in the fur-cutting industry. In comparison with 10 other industries in which studies have been made by the Public Health Service (25), the proportion of males employed in

the fur-cutting industry for 10 years or more (45.6 percent) is exceeded by 5 other industries—cigar, pottery, glass, post office, and foundry.

It is noteworthy that a large proportion (410 or 77.5 percent) of the fur cutters examined in the course of this study were born in other countries and of the 119 fur cutters who were born in this country 97 were the offspring of immigrant parents. It appears that this has been characteristic of the fur-cutting industry in this country for a long time. Mrs. Bates (9) noted a similar situation in 1910, and in

TABLE 11.—*Classification of employed fur cutters according to the country in which they and their parents were born*

Country	American-born—parents born in country specified	Foreign-born—born in country specified	Total
Total, all countries.....	119	410	529
Italy.....	30	172	202
Syria.....	23	86	109
Portugal.....	4	49	53
United States.....	22	.....	22
Canada (French-Canadian).....	7	11	18
Czechoslovakia.....	8	9	17
Poland.....	7	10	17
Greece.....	1	12	13
Germany.....	4	8	12
Austria-Hungary.....	7	3	10
South America and Central America.....	.....	8	8
France.....	4	3	7
Spain.....	1	6	7
Russia.....	.....	7	7
British Isles.....	.....	6	6
Lithuania.....	1	4	5
Other countries.....	.....	16	16

1915 Harris wrote that fur cutters employed in New York City were "mainly Poles and Italians." Wright (24) in 1921 observed that 74 of the 100 men he studied were either foreign-born or had foreign-born parents. According to Wright, most of these men or their parents had come from Ireland, Austria-Hungary, Czechoslovakia, Poland, Italy, Syria, or Germany.

Most of the Italians and Americans of Italian parentage were employed in one of the five factories studied. Most of them had come from Sicily and southern Italy.

The proportion of illiteracy was high among fur cutters. In order to detect tremors of the hand each person was asked to write his or her name, but 117 persons, or 22.1 percent, were unable to do so because of lack of education.

Medical Findings

In presenting the results of the medical examination, data for males and for females have been presented separately whenever striking sex differences were observed. Throughout the tables two groups of individuals have been kept separate; the first group consisting of the

43 persons who, because they had fine intention tremors and a combination of certain other symptoms (to be discussed more fully in a later section of this report), were diagnosed as having chronic mercurialism, and a second group consisting of 486 persons who did not present these symptoms.

The persons who were not diagnosed as affected by mercury exposure cannot properly be called a control group. Every employee in the five factories studied was exposed to measurable concentrations of mercury vapor and fur dust, and it was not possible to make a medical study on another group of people similar to these 529 people in age distribution, economic status, etc., and differing from them only in freedom from exposure to mercury. It is probable that a number of subclinical cases of chronic mercurialism are included in the group which was not diagnosed as mercury-affected.

PROCEDURE IN MAKING MEDICAL EXAMINATIONS

In this study the physical examinations were conducted in rooms or portions of rooms provided by the factory management. They were examined during the working day, one or two at a time, as they were sent in by the foreman. Both physicians assigned to the study examined each person. A nurse was present and assisted in the examination of all female employees. Most of the routine laboratory examinations of blood and urine specimens were made in a field laboratory.

Because mercury exposure often tends to produce a characteristic type of nervousness and irritability it was necessary to exercise considerable care in conducting the physical examination to make the subject feel at ease. For this reason, and also in order to obtain an appraisal of the extent to which the individual under observation may have been afflicted by such nervous disturbances, the preliminary part of the examination, including the taking of the occupational history and the recording of past and present medical complaints, was often prolonged as much as possible.

OCCUPATIONAL HISTORY

In recording the occupational history of each worker an effort was made to include: (1) His present occupation and the length of time he had been engaged in it; (2) every type of work he may have performed in the fur-cutting industry and the length of time he was so employed; (3) a record of all the occupations in other industries he may have worked at from the time he first began to work; and (4) an estimate of the total time he was employed. As a result it is possible to say that, insofar as it can be ascertained from their own statements, none of these employees had previously worked in an industry other

than the hatting trades in which it is known that workmen are exposed to appreciable quantities of mercury.

Thirty persons had previously worked in hat factories. Only 11 persons employed as fur cutters at the time of examination had been employed as hatters within the last 5 years. Five of these 30 persons were diagnosed as having chronic mercurialism; 1 person had been

Case No. 000

CASE RECORD

Plant John Doe Mfg. Co. Date May 1, 1936 Present Occupation Blower
 Name Richard Doe Age 52 Sex Male Marital Status (M) S. W. D.
 Age began work 13 Years worked 39 Racial Stock Portuguese

Occupational History				
Specific Occupation	Industry	Yrs. in		Remarks
		Fur cut	Other	
Present	Blower	Fur cutting	5	
Prev. - 1	Section Hand	Railroad		1/2
" 2	Blower	Fur cutting	3	
" 3	Section Hand	Railroad		2
" 4	Laborer	Street		2
" 5	Clerk	Warehouse		1 1/2
" 6	Weaver	Wool		6
Seasonal employ. during occupation specified.		2 1/2 years	idle	

Past Medical History (Record dates on positive history)

Intimate contact with TB. (Relationship)	No	Tuberculosis	No
Pneumonia	No	Colitis	No
Pleurisy	No	Constipation	No
Dis. Colds	H. No C. No	Abdominal Colic	No
Dis. of Nose	No	Sinuses	Normal
Dis. of Joints	No		
Dis. of the Nervous System	Shakes most of the time for past year		
Dis. of the Urinary System	No		
Dis. of the Skin	No		
Other diseases or operations	Contused wounds, 1934, from fall.		

Present Medical History (Record dates of Onset)

Weakness	No	Loss of Appetite	No	Loss of Weight	Slight
Sore mouth	No				
Digestive Disturbances	No				
Aural Disturbances	No	Nasal Disturbances	No		
Eye Symptoms	No	Headache	No		
Psychic Disturbances	No				
Tremor	Marked	Fatigue	No		
Palpitation	No	Cough	No		
Skin Trouble	No	Edema	No		
Miscellaneous	No				

Habits

Sleeping	Able to sleep only 3-4 hours nightly	Tobacco	20 cigarettes daily
Eating	Normal	Alcohol	None since shakes
Questions for	Menstr. period Reg. — Irreg. —	Dysmen.	—
Faeces.	No. of Children Living — Dead —	Miscarriages	—

FIGURE 25.

employed one-sixth year as a hatter, 8 years ago; a second, one-half year as a hatter, 4½ years ago; a third, 1 year as a hatter, 38 years ago; a fourth, 2 years as a hatter, 6¾ years ago; and the fifth, 11½ years as a hatter, 10 years ago. These figures are representative of the other ex-hatters. It does not appear that previous employment in the hatting industry influenced the results of this study appreciably.

PAST MEDICAL HISTORY

During the physical examination each person was asked whether or not he had ever had certain diseases or defects which other investigators have reported to be associated with chronic mercurialism. As far as

Physical Examination

Blushes easily;

General Appearance: Trembles. Height 64 ins. Present wt. 135 Usual 140

Scleral vessels

Eyes: Conjunctiva injected Pulillary react. R Norm. L Norm. Misc. R Normal
Vision R -20/30 L -20/30 Tremor of Lids. R Norm. L Norm. Signs. L Normal

Cerumen accumulation

Ears: Est. canal R ^ L ^ Drum membranes R L Not visible
Hearing, (whispered voice), R -20/20 L -20/20

Nose: Mucus Mem. Norm. Perforated Sept. No Sept. dev. R. No L. No
Mouthbreather No

Throat: Tonsils ~~absent~~ Norm. Diseased R No L No Tongue No tremor
Gums: Inflam. No Mercury line Blue line on gingival margins
Mucus mem. mouth Discoloration No Inflam No

Teeth: O, indicates absent., X, decayed (U) 8-7-6-5-4-3-2-1-1-2-3-4-5-6-7-8
/, " repaired., —, black (L) 8-7-6-5-4-3-2-1-1-2-3-4-5-6-7-8

Glands: Thyroid Not palpable Parotids Normal
Of neck Cervical Normal Sub-ling. Normal Sub-max. Normal
Epitroch Normal Axillary Normal Inguinal Normal

Blood Pressure: Syst. 126 Diast. 90 Pulse press 36

Pulse: Quality Norm. Before exer. 84 Trembles so much it is difficult to take pulse
After exer. After 2 min. rest

Respiration: Before exer. 16 Not exercised because of tremor
After exer. After 2 min. rest

Chest:

Inspection	Normal	Head shakes when standing in Rhomberg position. Unable to light cigarette because of tremor of hands. Lips tremble when he attempts to light cigarette but do not tremble when no attempt is made to light it. Unable to pick cigarette from floor due to tremor. Trembles more when he laughs or is annoyed, or when a stranger (nurse) approaches.
Palpation	Normal	
Percussion	Normal	
Auscultation	Normal	
Heart	Normal	

Abdomen: Normal

Extremities: Severe intention tremor of fingers, forearms, and arms.

Skin: Large scar on scalp from lacerated wound, 10 years ago.

Nervous Reactions:

Psychogenic Timid to point of wincing. Extremely apprehensive; is easily angered and easily depressed.

Vegetative Blushes deeply; perspires freely
Moderate bilateral exaggeration

Peripheral: Knee jerks R ^ L ^ Romberg Normal Paralysis No,
Tremor
Speech Hesitancy; blurring of words

Remarks:

Signature Could not write because of tremor. Examined by R.R.J. and P.A.N.

FIGURE 26.

past medical history is concerned there was little to distinguish these fur cutters from other industrial workers. Although stomatitis has frequently been observed and reported by physicians who have made physical examinations on hatters and hatters' fur cutters, only five persons were found who were able to recall attacks of ulcerative inflammation of the mouth, and none of these five was in the mercury-affected group.

Laboratory

Urine: Single specimen Twenty four hours ✓ Amount

Gross examination.

Color *Straw* Reaction *acid* Spec. gr. *1.016*
 Albumin *fine trace* Sugar *None* Quant. Chlorides *1.06*
 Urobilin *None* Hematoporphyrin *None*

Micro. examination

Negative findings

Casts *Type* Epith. cells Bact.
 Pus cells Red blood cells

Blood:

Hb. est. (Dare) *95* Color index *.85*
 Red cell count *6.00* White cell count *6500* Platelet est. *normal.*
 Stipples per 100,000 *none* Reticulocytes *0.4* Per cent.
 Anisocytosis *no* Poikilocytosis *no* Achromasia *no* Nuc. Rbc. *no*

Differential W. C. C.

Neutrophils *56.0*
 Lymphocytes *38.0*
 Monocytes *6.0*
 Eosinoph *0*
 Basophil *0*

Wassermann reaction *Negative*
 Blood Kahn reaction *Negative*

Chemistry: Blood

Non-protein nitrogen *28.6* Blood sugar *95*
 Urea nitrogen *not tested* Blood calcium *10.3*
 Creatinine *1.4* Chlorides *347*

Spectroscopic examination of urine for mercury: Amount *.64 mg* per 1000 cc.

Occupational Summary

Classification - *blower*

Occupational dust exposure - *9.4 million particles per cu. ft.*

Present mercury exposure - *3.2 mg per 10 cubic meters*

X-Ray of Chest

No evidence of gross pathology (Due to tremor, it was impossible for patient to stand still).

Diagnosis

Severe chronic mercurialism

FIGURE 27.

TABLE 12.—Number and percentage of employed fur cutters reporting a past history of certain diseases and physical defects

Past medical history	Percentage		Number	
	Chronic mercurialism	No diagnosis of chronic mercurialism	Chronic mercurialism	No diagnosis of chronic mercurialism
Total.....	100.0	100.0	43	486
Diseases of nervous system.....	30.2	4.1	13	20
Operations requiring hospitalization.....	20.9	29.1	9	142
Diseases of digestive system.....	16.3	13.8	7	67
Disabling colds.....	14.0	11.5	6	58
Diseases of urinary system.....	4.6	4.3	2	21
Pneumonia.....	4.6	6.8	2	33
Stomatitis.....	0	1.0		5

With respect to nervous diseases, the fur cutters made more frequent mention of past attacks of nervous and mental disorders than industrial workers generally do in examinations of this kind. It is apparent from table 12 that the rate is considerably higher among the group with other symptoms of chronic mercurialism than it is among the nonaffected group. In this, and in the other diseases and defects listed in table 12 the differences in rates between males and females are statistically insignificant.

The proportion of persons who reported past attacks of digestive or urinary disturbances is not high in comparison with employees of other industries. Among apparently healthy brass founders (30) 17 percent reported digestive disturbances. The proportion of people who had ever had operations requiring hospitalization does not seem to be excessively high, in view of their age.

The proportion of fur cutters who reported that they had ever had pneumonia, namely 6.6 percent, seems to be fairly low. The incidence of pneumonia was no higher among persons who had a tremor than it was among those who had had no tremor. Similar considerations enable one to dismiss disabling colds from consideration as a possible consequence of exposure to mercury vapor and fur dust. Diseases of the sinuses, joints, or skin, were so few in number that they were not significant.

PRESENT MEDICAL HISTORY

When one comes to the disorders present at the time of the examination of which the afflicted persons were aware, the differences between groups affected and not affected by mercury exposure and also between fur cutters and other industrial employees become more pronounced.

TABLE 13.—*Number and percentage of employed fur cutters who complained of certain conditions present at the time of examination*

Present complaint	Percentage		Number	
	Chronic mercurialism	No diagnosis of chronic mercurialism	Chronic mercurialism	No diagnosis of chronic mercurialism
Total.....	100.0	100.0	43	486
Psychic disturbances.....	37.2	4.3	16	21
Digestive disturbances.....	23.3	7.4	10	36
Insomnia.....	20.9	5.8	9	28
Loss of appetite.....	16.3	3.3	7	16
Tremor.....	14.0	.8	6	4
Admittedly excessive use of alcohol.....	11.6	10.3	5	50
Loss of weight.....	11.6	1.9	5	9
Sore mouth.....	9.3	1.6	4	8
Weakness.....	4.7	2.3	2	11

In table 13, as in table 12, the most conspicuous difference between the two groups concerns the functioning of the nervous system. More than a third (37.2 percent) of the affected fur cutters were aware that they had nervous disorders that interfered with their activities. These persons complained, for example (without being prompted or urged), that they were excessively timid and easily embarrassed in the presence of strangers, that it was hard for them to get along with their families or with their fellow employees, and that they were very easily angered. This type of disorder has attracted the attention of everyone who has studied the hatting and fur-cutting industries and many striking examples of the extreme forms of this disorder are on record. Indeed, it is probable that the colloquial phrase, "mad as a hatter" may have been coined to describe this condition.

An interesting characteristic of mercurial tremor is that only 6 of the 43 persons in whose hands or face fine intention tremors were detectable were aware they had the "shakes." In its early stages mercurial tremor does not interfere greatly with the execution of movements that have been practiced so long that they have become habitual. Four persons who did not have a detectable tremor at the time of the examination nevertheless complained of this condition. It may be that these represent subclinical cases of mercurialism. It must be remembered that an absence of short duration from mercury exposure will arrest mild cases of mercurial tremor.

A large proportion of the persons who had other symptoms of chronic mercurialism complained of digestive disturbances present at the time of examination. The percentage of nonaffected persons who complained of digestive disturbances was no greater than one would expect to find in the general population. Complaints of insomnia, loss of appetite, and loss of weight were also more frequently noted in persons who had tremor and other symptoms than in nonaffected persons. Many persons complained they had two or more of these disturbances. Other physicians have mentioned these conditions in discussing chronic mercurialism, and although they are not the most important symptoms, nevertheless, they deserve attention. Weakness, which has also been regarded as a consequence of mercury exposure, was not a complaint of many persons.

Twelve people, four of whom were poisoned, complained of sore mouth, but none of them had the severe ulcerative form of stomatitis that is described in the older literature on chronic mercurialism. The number of people, however, who had oral pathology of other types was rather high; this will be discussed more fully in a later section.

Specific inquiry concerning the possible presence of a number of other pathological conditions was made of each person examined.

None of these conditions occurred with sufficient frequency to warrant inclusion in the tables.

PHYSICAL EXAMINATION

After the data obtainable by questioning had been recorded, the subject's height and weight were measured, and an examination of eyes, ears, nose, and throat was made. Special attention was given to the mouth because of the frequency with which oral pathology is mentioned in the literature of chronic mercurialism. Blood pressure was measured with a standard mercury sphygmomanometer with the subject in a sitting position. Pulse rate and respiratory rate were recorded. The subject was stripped to the waist, and the condition of the skin and the presence or absence of occupational stigmata was noted. The chest examination consisted of inspection, palpation, percussion, and auscultation of the heart and lung fields. A roentgenographic examination of the chest was made, including fluoroscopy and the preparation of a flat film for subsequent study. Special care was exercised in making the neurological study.

Blood samples for microscopic study and for hemoglobin determination were taken from an ear lobe or from a finger tip. Blood samples (6 to 10 cc) for chemical analyses were drawn from the median basilic vein. Samples of blood serum were inactivated by heating at 56° C. for 20 minutes, and were mailed either to the National Institute of Health or to the Connecticut State Department of Health for Kahn and Wassermann tests.

Each person was given a container in which he was asked to bring a 24-hour sample of urine. On this sample, in addition to the standard chemical and microscopic tests, quantitative spectrographic estimations of mercury content were made.

Pallor.—A slight or moderate degree of pallor was observed more frequently in individuals with the symptoms of mercurialism than in other persons (18.6 per cent as compared with 1.2 percent). Since pallor is often associated with a decrease in the number of red-blood cells and a decreased hemoglobin content of the blood, it seemed to be of interest to see whether this was true of these individuals. Blood drawn from the nine males with pallor (seven of whom were diagnosed as having chronic mercurialism) had an average red-cell count of 4.45 ± 0.10 million per mm^3 which is definitely lower than the average value for the 260 males not affected by mercury exposure, 4.93 ± 0.02 . Likewise, the hemoglobin content of the blood of these nine males with pallor (76.3 ± 0.96 percent) is much lower than the average value for all the males in the study (82.2 ± 0.3). Only one man had an abnormally high reticulocyte and stippled-cell count; all others were within normal limits of variation. Similar relations hold for the red-cell count and hemoglobin content of blood samples taken from the five

TABLE 14.—Summary of the results of physical examination of 529 fur cutters

Impairment	Percentage		Number	
	Chronic mercurialism	No diagnosis of chronic mercurialism	Chronic mercurialism	No diagnosis of chronic mercurialism
Total number of persons.....	8.1	91.9	43	486
Pallor.....	18.6	1.2	8	6
Eyes:				
Defective vision.....	29.4	11.1	¹ 10	² 46
Conjunctiva inflamed.....	20.9	9.0	9	44
Conjunctiva jaundiced.....	2.3	2.3	1	11
Ears:				
Otitis media.....	2.3	.8	1	4
Perforated eardrum.....	4.6	3.5	2	17
Defective hearing.....	4.6	3.5	2	17
Nose: Simple inflammation of nasal mucous membrane.....	53.5	33.1	23	161
Mouth and throat:				
Gingivitis (including pyorrhea).....	46.5	36.6	20	178
Dry, white discoloration of mucous membranes.....	37.2	25.5	16	124
Dry coppery discoloration of mucous membranes.....	11.6	4.7	5	23
Extensive dental repair.....	25.6	16.9	11	82
Dental caries.....	16.3	16.0	7	78
6 or more teeth missing.....	32.6	3.9	14	19
All teeth missing.....	9.3	1.4	4	7
Chronic tonsillitis.....	4.7	6.8	2	33
Excessive salivary flow.....	14.0	.8	6	4
Dark line on gums.....	16.3		7	0
Mercurial stomatitis.....			0	0
Glands:				
Enlarged thyroid gland.....	14.0	10.3	6	50
Enlarged cervical glands.....		.2	0	1
Enlarged epitrochlear glands.....	7.0	3.3	3	16
Enlarged axillary glands.....		1.0	0	5
Enlarged submaxillary glands.....		.6	0	3
General adenopathy.....		3.5	0	17
Heart: Valvular heart disease.....		1.0	0	5
Lungs:				
Persistent coarse rales.....	7.0	1.2	3	6
Fine moist rales.....			0	0
Nervous system:				
Fine intention tremor of any part of body.....	100.0		43	0
Fine intention tremor of fingers.....	79.1		34	0
Fine intention tremor of eyelids.....	62.8		27	0
Fine intention tremor of tongue.....	46.5	0	20	0
Fine intention tremor of other members.....	25.6		11	0
Fine intention tremor as shown by shaky signature.....	37.2		16	?
Psychic irritability.....	79.1	1.0	34	5
Speech defect.....	18.6	.4	8	2
Exaggerated knee jerk.....	20.9	4.3	9	21
Positive Romberg test.....	2.3	.4	1	2
Dermatographia.....	11.6	.8	5	4
Blushes abnormally.....	25.6	.2	11	1
Excessive perspiration.....	11.6	.2	5	1

¹34 persons tested.²419 persons tested.

women with pallor. These 14 persons with pallor had, on the average, a greater exposure to mercury than most of their fellow-workers; their average length of employment in the fur-cutting industry was 11.6 years, and their average exposure to mercury vapor was 2.7 mg per 10 m³.

Vision.—The vision of 453 of the employees was tested, using Snellens' chart. Sixty-one persons, 10 of them having symptoms of chronic mercurialism, had defective vision (20/50 or less in each eye or 20/70 in one eye and 20/30 or less in the other). The possibility that defective vision may be a consequence of mercury exposure is important enough to warrant a careful ophthalmological study. These data,

collected under unsatisfactory conditions, are not adequate to answer this question definitely.

Conjunctiva.—All of the cases of inflamed conjunctiva were of the relatively mild, noninfective type, resembling the inflammation produced by irritation. It is difficult, if not impossible, to trace the cause of this inflammation to a specific irritant present in measurable amount in the working environment. The two occupational groups in which inflamed conjunctiva was most common, namely, blowers and drummers, are the occupational groups exposed to the highest dust concentrations, as shown in table 8. Eight of the 15 blowers and 4 of the 10 drummers were so affected. The blowers are exposed to high concentrations of mercury and the drummers to low concentrations, as table 6 shows. From this alone one might be led to conclude that dust was responsible for this condition. Nevertheless, if the other occupational groups are arranged in order of dust concentration, the incidence of inflamed conjunctiva does not vary in any regular way with dust exposure. Moreover, the incidence of this disorder was nearly as high among the carroters as it was among the blowers and drummers, 12 out of 40 being affected. The carroters are exposed to small amounts of mercury vapor and dust, but they are also exposed to acid fumes arising from the carrotting solution. No definite relation to mercury exposure is discernible.

The proportion of individuals with jaundiced conjunctiva is no greater than in nonindustrial populations, and none of the cases observed was of a severe type.

Hearing.—Each employee was given an otoscopic examination, and his ability to hear the examiner's whispered voice at different distances was noted. The hearing tests were made in noisy places, and caution should be exercised in their interpretation. The percentage of fur cutters found to have chronic otitis media, as indicated by evidence of pus exudation or characteristic changes of the eardrum was 0.8, and the percentage with perforated eardrum was 3.5. Sydenstricker and Britten (46) reported (p. 88) that the incidence of otitis media in 100,924 white males was 0.96 percent and the percentage of men with perforated eardrum was 0.88.

Nose.—Upon examination with the nasal speculum a large proportion of the fur cutters were found to have simple inflammation of the nasal mucous membranes. Although comparable data on other populations are not available the proportion of people with this type of inflammation appears to be unusually high. Persons who had tremor and other symptoms were affected to a greater degree than persons who did not have these symptoms. The data of table 7 were used to find out whether high atmospheric dust concentration was associated with a high incidence of inflammation of nasal mucous membranes, but no definite correlation could be found.

Oral cavity.—Oral pathology has been so frequently discussed as a consequence of long-continued exposure to mercury vapor that it deserves special consideration. When mercury vapor is administered as a therapeutic agent in the treatment of syphilis it is well known that gingivitis and increased salivary flow result from heavy or long-continued dosage. Fraser, Melville, and Stehle (13) produced gingivitis in dogs by exposure to mercury vapor. Among fur cutters, the incidence of pathological conditions of the mouth is uniformly higher among persons with tremor and allied symptoms than among other persons.

Several generalizations on the subject of oral pathology may be made before discussing the individual disorders in detail. (1) None of the severer forms of pathology that have occasionally been attributed to chronic mercurialism (such as ulcerative mercurial stomatitis, the loss of large numbers of teeth, and severe degrees of pyorrhea) were observed in these fur cutters. (2) It is obvious that the general living conditions of these individuals, and possibly the extent to which they practiced oral and dental hygiene, may have a great deal to do with the occurrence of these conditions. Since many of these people are fairly recent immigrants, it is likely that they may have differed in both respects from the populations for whom data on mouth pathology are available, and this makes it doubly difficult to assess the part mercury may have played in producing these disorders. (3) In the case of pathological conditions that are as diversely described and interpreted as these, it is not surprising to find great differences in the incidence of these conditions in the published reports of different physicians. Consequently, it is difficult to decide what the incidence of these conditions in a "normal" population might be. (4) Many of the conditions listed in table 14 as disorders of the mouth and throat represent different degrees of damage to the oral cavity which may be merely stages in a general pathological process.

Gingivitis (including both pyorrhea and gum inflammation in which pus exudation was not demonstrable) was somewhat more prevalent among persons with chronic mercurialism than it was among persons who were not so diagnosed. In view of the importance attached to gingivitis as a symptom of chronic mercurialism by other investigators a study of the relation to age and mercury exposure was made.

A tabulation of the percentage of men and women in different age groups who had gingivitis is presented as table 15 which shows that the incidence of gingivitis increases with advancing age. Although the percentage of males with gingivitis is slightly higher (40.3) than the percentage of females (35.1) the only age groups in which the rates for males differ greatly from the rates for females are the ones in which the number of individuals is small. It is in the age groups

between 30 and 50 years that the incidence of gingivitis in the mercury-affected group is higher than the average for those age groups.

TABLE 15.—*Incidence of gingivitis at different ages*

Age	Males			Females		
	Number in age group	Number with gingivitis	Percent with gingivitis	Number in age group	Number with gingivitis	Percent with gingivitis
Under 20 years.....	14	1	7.1	16	4	25.0
20 to 29.....	60	13	21.7	84	21	25.0
30 to 39.....	84	30	35.7	66	21	31.8
40 to 49.....	83	42	50.6	46	25	54.3
50 to 59.....	43	26	60.5	12	7	58.3
60 to 69.....	9	5	55.6	7	3	42.9
Over 70.....	5	3	60.0	0	0	0
Total.....	298	120	40.3	231	81	35.1

Sydenstricker and Britten (47) have published similar data for 100,924 white males, holders of life-insurance policies. If one adds their figures (p. 123) for the number of persons diagnosed as having pyorrhea and slightly infected gums, groups their data by 10-year groups instead of 5-year groups, and divides by the population of these age groups, rates of incidence are obtained which are about half as high as the rates for male fur cutters in the corresponding age groups. The 100,924 insurance policyholders and these 529 fur cutters differ so greatly in education, employment, and economic status that it would be unwarranted to assume that the difference in incidence of gingivitis could be due to mercury exposure alone.

The incidence of gingivitis appears to have no direct relation to the degree of mercury exposure. The number of cases of gingivitis was tabulated as in table 28, classified according to length of employment and mercury-vapor concentration. The incidence of gingivitis was no greater in groups of people with a high mercury-vapor exposure (over 2.5 mg per 10 m³) than it was for groups of people with a low mercury-vapor exposure who were employed for the same length of time.

All of the forms of dental pathology listed in table 14, with the exception of caries, also were more prevalent among mercury-affected than among nonaffected persons.

There is no real difference between the incidence of chronic tonsillitis (as characterized by enlargement, redness, presence of caseous material or pus in the tonsillar crypts) between persons who had the symptoms of chronic mercurialism and persons who did not have these symptoms. In comparison with other industrial groups it does not appear that these rates are at all excessive. Comparisons of this kind are made difficult by the differences in diagnostic standards employed by different examining physicians.

Two kinds of discolorations of the oral and nasal cavities were observed, one of them white and one of them a rich coppery color. Both types were dry and glistening and, when present, usually extended over the entire oral mucous membrane as far as the upper portion of the pharynx and the vestibular portion of the nasal mucous membrane. The coppery discoloration has been mentioned frequently by writers on chronic mercurialism and it has been illustrated in color by Baader and Holstein (8); the white discoloration has been less frequently discussed. These conditions were found most frequently in persons exposed to a combination of high mercury-vapor concentrations and large amounts of fur dust, among blowers, and blown-fur packers for instance. These conditions were also associated with tremor and allied symptoms.

Six men and one woman, all of whom had fine intention tremors, had dark lines on their gums closely resembling the Burtonian line of lead poisoning. This line, which has been noted and variously described by almost every physician who has published an account of chronic mercurialism, appeared as a narrow, irregular row of closely set, bluish-black dots running roughly parallel to the gingival margins. The colored plate published by Baader and Holstein (8, Abb. 8) is a fairly accurate representation of the condition observed in these fur cutters with but two exceptions: No lines of this kind were observed on the buccal portion of the lips, and the advanced stage of dental pathology there represented was not characteristic of these seven cases. The individuals in whose mouths dark lines were found had no more and no less than the usual number and degree of pathological conditions of the mouth. Four of these persons (three of them blowers) were working in air containing more than 2.5 mg of mercury vapor per 10 m³ at the time of the study, which represents more than an average exposure to mercury, as table 27 shows. The shortest length of employment in the fur-cutting industry resulting in a dark line on the gums was 2½ years.

Excessive salivary flow, long considered to be a cardinal symptom of chronic mercurialism, was observed in 10 fur cutters, all but 3 of whom were working in atmospheres containing more than 2.5 mg of mercury vapor per 10 m³ of air. No case of excessive salivary flow was observed in persons exposed to less than 1.0 mg per 10 m³. Six of these 10 persons had fine intention tremor. No cases of ulcerative stomatitis, which has been regarded by some writers as a symptom of chronic mercurialism, were found. Tylecote (22) also did not observe any cases of ulcerative stomatitis in the 20 cases he reported.

Glands.—No cases of generalized glandular enlargement were found. Likewise, considering one group of glands at a time, there was no type of glandular enlargement that was consistently associated with mercurialism.

Thyroid.—There was no discernible relation between thyroid enlargement and duration of employment in the fur-cutting industry, either in men or in women. Examinations to ascertain the presence of thyroid enlargement were made in accordance with the procedure recommended by Olesen (44) which takes into account small deviations from normality. The rates for men (8.1 percent) and for women (13.9 percent), based on all of the 298 men and 231 women examined are not particularly high, taking into account such comparative data as are available. The absence of an unusual prevalence of enlarged thyroid is of importance because of a possibility that the tremor observed in this study might have been caused by a thyroid disturbance instead of mercury exposure. Only 6 of the 43 people afflicted with tremor had enlarged thyroids, a proportion only a little higher than among persons who did not have tremor. Four of these poisoned cases were 1+ and two were 2+ according to Olesen's classification.

Heart.—Only 5 cases of chronic valvular heart disease were found among the 529 fur cutters (0.94 percent), and all of these were fully compensated. The incidence of valvular heart defects is lower than in the 10,143 male industrial workers discussed by Britten and Thompson (25); of whom 3.6 percent had defects of the mitral, aortic, or tricuspid valves (p. 112); and it is also lower than the incidence of valvular heart defects in the 100,924 white males discussed (p. 88) by Sydenstricker and Britten (46).

Chest.—In the older medical literature dealing with the fur cutting industry the belief has been frequently expressed that pulmonary tuberculosis was more prevalent than usual in this industry. Also, since large amounts of fur dust (see table 7) are in suspension in the air of the workrooms, it seemed desirable to ascertain whether lung pathology was present which could be attributed to dust exposure. Accordingly, each person was subjected to a fluoroscopic chest examination and a flat X-ray film was made for subsequent study.

Roentgenological findings indicative of active pulmonary tuberculosis were not observed in any of the individuals studied. There was no indication that exposure to fur dust had resulted in any detectable lung pathology. This is in keeping with the previously reported findings (29) of the Public Health Service that exposure to organic dusts alone does not result in pneumoconioses. Only two men were found whose lungs exhibited fibrotic changes symptomatic of pneumoconiosis. Upon questioning these men about their previous employment it was found that both men had been employed in an industry in which they were exposed to inorganic dust for a sufficient time to have caused the fibrotic changes which were noted.

Tremor.—In the differential diagnosis of mercurial tremor the possibility that the tremor may have been due to multiple sclerosis, paralysis agitans, exophthalmic goiter, chronic alcoholism, or senility

was considered. These possibilities can be excluded because the other symptoms of these conditions were absent in the 43 individuals who were considered to have mercurial tremor. Thus, these individuals did not have the diminished abdominal reflexes, nystagmus, or bladder symptoms characteristic of multiple sclerosis. Paralysis agitans is accompanied by a characteristic masklike expression, and its tremor is not wholly an intention tremor. The absence of a direct relationship between thyroid enlargement and tremor has already been discussed and that circumstance, together with the absence of exophthalmia and other characteristic signs eliminates the possibility that the tremor may have been due to exophthalmic goiter. The tremor due to senility rarely begins before the age of 70. The tremor associated with chronic alcoholism is finer and more regular than the mercurial tremor. Biondi (10) has discussed the differences between the tremors associated with these conditions in detail.

Fine intention tremor has a two-fold significance. It is not only pathognomonic of chronic mercurialism but, in its advanced stages, it becomes disabling. There is general agreement on the characteristics of mercurial tremor. As it was observed in 43 fur cutters, it is a fine intention tremor, that is to say, it is a rhythmical, trembling movement of slight amplitude, 5 to 8 movements per second, which increases in extent when the subject attempts voluntary movements. When present, the tremor affected both sides of the body to an equal degree. It was most frequently observed in the hands and fingers. Next, in order of frequency, came tremors of the eyelids, tongue, arms, cheeks, lips, forehead, head, and legs. Only one case was observed in which the entire body was affected.

Specimens of handwriting of four persons who had different degrees of fine intention tremors are presented in figure 28 which illustrates certain characteristics of mercurial tremor. One feature is the exaggeration of the tremor at the moment the subject begins to make a movement requiring close attention. An inspection of the samples of handwriting (fig. 28) shows that in all four specimens the capital letter (the first letter the subject wrote) is much more shakily written than almost any other letter; in the name "Joseph", for instance, the upper loop of the initial letter "J" is the only imperfection in an otherwise steady signature. In this individual, tremors were detectable only in the hands and eyelids. The specimens at the upper right and lower left of the figure were written by persons with more advanced stages of mercurial tremor. It may be necessary to note that it is not the crudity of formation of letters that is under discussion here; it is the involuntary, wavering movements of the pencil point from side to side as the letters were written, and the diminution of the unsteadiness as the writer proceeded. The person who wrote the word "February" in the lower right-hand corner had the most

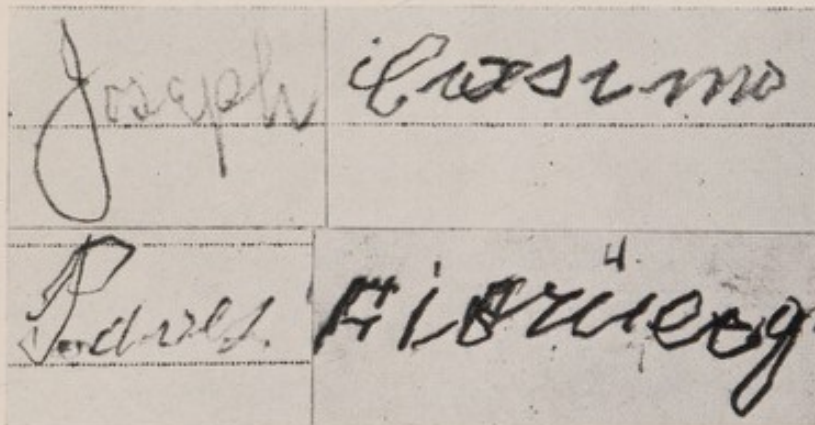
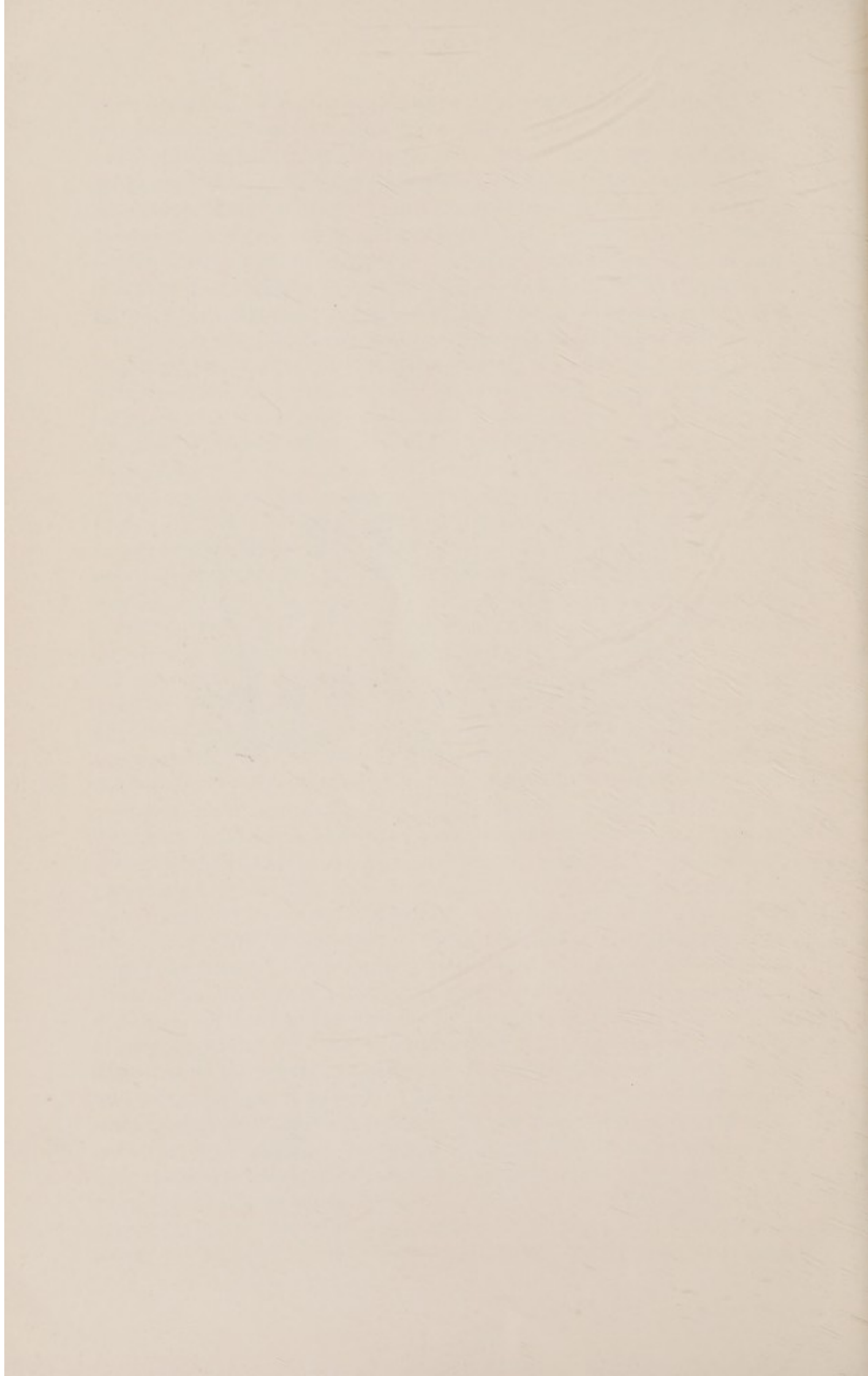


FIGURE 28.—SPECIMENS OF HANDWRITING OF PERSONS WHO HAD FINE INTENTION
TREMOR.
Natural size.



advanced stage of tremor of any of the four. He became discouraged and stopped several times during the writing of this one word, but each time he was persuaded to continue until he had finished.

Psychic disturbances.—A diagnosis of psychic irritability was made when an individual had several of the following characteristics in abnormally exaggerated degree; irascible temper, discouragement without cause, feeling of depression or despondency, excessive embarrassment in the presence of strangers, timidity, a desire for solitude, anxiety, excitability, inability to take orders, or a strong feeling of self-consciousness.

The difficulties in making appraisals of this kind are so obvious that they need no discussion. Any of these characteristics can be found in individuals who have had no known mercury exposure whatsoever, and psychiatric literature is filled with discussions of the various causes of disturbed mental states such as these. Four facts can be adduced to show that these disturbances actually are a consequence of exposure to mercury: (1) These disorders are closely connected with other symptoms of chronic mercurialism; 79 percent of the people who had fine intention tremor had psychic disturbances also, and only five persons who did not have discernible mercurial tremor had mental disturbances of this degree. This kind of relationship will be more fully discussed in connection with the data of table 27. Moreover, there was a direct parallelism between the degree of severity of tremor and the degree of deviation of the individual from normal standards of behavior, the advanced stages of tremor usually being accompanied by the most abnormal psychological states. (2) These phenomena have been noted by almost every writer on chronic mercurialism in modern times. Indeed, certain physicians have gone so far as to regard psychic disturbances as the earliest and most characteristic symptoms of chronic mercurialism resulting from exposure to low concentrations of mercury. (3) Disorders of this kind have been reported to be prevalent in industries which manufacture or make use of mercury, but which differ from each other in most other respects. (4) There is a close relation between mercury exposure and the occurrence of psychic disturbances. Without attempting to make allowances for duration of exposure because of the relatively small number of cases with which we have to deal, the following data may prove to be instructive: Of the 107 workers exposed to less than 1.0 mg mercury vapor per 10 m³, 4 (or 3.7 percent) had psychic disturbances; of the 278 persons exposed to more than 1.0 but less than 2.4 mg per 10 m³, 10 (or 3.6 percent) were so affected; of the 144 persons exposed to more than 2.5 mg per 10 m³, 25 (or 17.4 percent) had psychic disturbances.

A distinctive type of speech defect was found frequently among persons with tremor and allied symptoms. This defect, often referred

to as scanning speech, is characterized by a slight or moderate slurring of words, hesitancy in beginning sentences, and a kind of difficulty in pronunciation that is quite different from the difficulties encountered in speaking an unfamiliar language. Six cases occurred in the persons diagnosed as having moderate or severe chronic mercurialism, and four of these cases had a tremor of the tongue which may have contributed to the speech defect. Eight persons, upon questioning, said they had not had this impairment of speech before beginning work in the hatting trades. Two cases occurring among nonaffected people, however, had been present since childhood.

Knee jerk.—Exaggerated knee jerk was found about five times as frequently among persons with chronic mercurialism as it was among other persons, and this difference is statistically significant. In a study of garment workers carried out by the Public Health Service (28) 8 percent of 1,958 males were considered to have exaggerated patellar reflexes; this is a little higher proportion than the value for persons who did not have tremor (4.3 percent) but it is much lower than the percentage value for the persons who had tremor (20.9). Several physicians have mentioned exaggerated knee jerk as a consequence of mercury exposure, among them Adler (7), Tylecote (22), and Jacobsohn (16). Four-fifths of the persons with exaggerated knee jerk were working at the time of examination in atmospheres containing more than 1 mg of mercury per 10 m³ of air. When this condition accompanied fine intention tremor, the tremor was usually more pronounced, and affected a greater portion of the body than when exaggerated knee jerk was absent.

Vasomotor disorders.—Red, stable dermatographia, excessive perspiration, and abnormal readiness to blush are particularly common among persons who were exposed to the higher mercury vapor concentrations, and among persons who had the symptoms of chronic mercurialism. Among 138 employees of a mercury smelting plant, most of whom were suffering from mercurialism, Weger (23) observed dermatographia in 79 percent, hyperhidrosis in 56 percent, and other vasomotor disturbances in 38 percent of the men examined. Incidentally, 35 percent of these men had mercurial tremor. Disorders of this kind present in the degree in which they may be observed in persons exposed to mercury, are uncommon in industrial populations.

Structural, anatomical defects such as hernia, varicose veins, ankylosed joints, muscular atrophies, and missing members were found so infrequently that there seemed to be no need to tabulate them.

BLOOD PRESSURE

The data on blood pressure have been presented in table 16 and in figure 24 in the form of average values for males and females of certain age groups. The average blood pressure values for a large number of

male industrial workers examined in the course of 10 earlier surveys carried out by the Public Health Service (25) have been plotted in figure 29 for purposes of comparison.

TABLE 16.—Average blood pressures for male and female fur cutters, classified by age

Age group	Males				Females			
	Number tested	Blood pressure, mm Hg			Number tested	Blood pressure, mm Hg		
		Systolic	Diastolic	Pulse pressure		Systolic	Diastolic	Pulse pressure
Under 20.....	14	125.3	81.1	44.3	17	122.0	78.1	43.4
20 to 29.....	56	125.2	80.1	45.1	82	126.2	82.0	42.6
30 to 39.....	82	127.0	83.5	44.3	67	132.2	86.3	47.7
40 to 49.....	81	135.6	86.6	49.4	43	151.4	93.1	58.0
50 to 59.....	41	143.5	91.3	52.2	12	159.9	92.3	67.8
60 to 69.....	10	151.0	89.4	61.6	6	188.0	108.3	79.7
Over 70.....	5	141.0	78.4	62.6	-----	-----	-----	-----

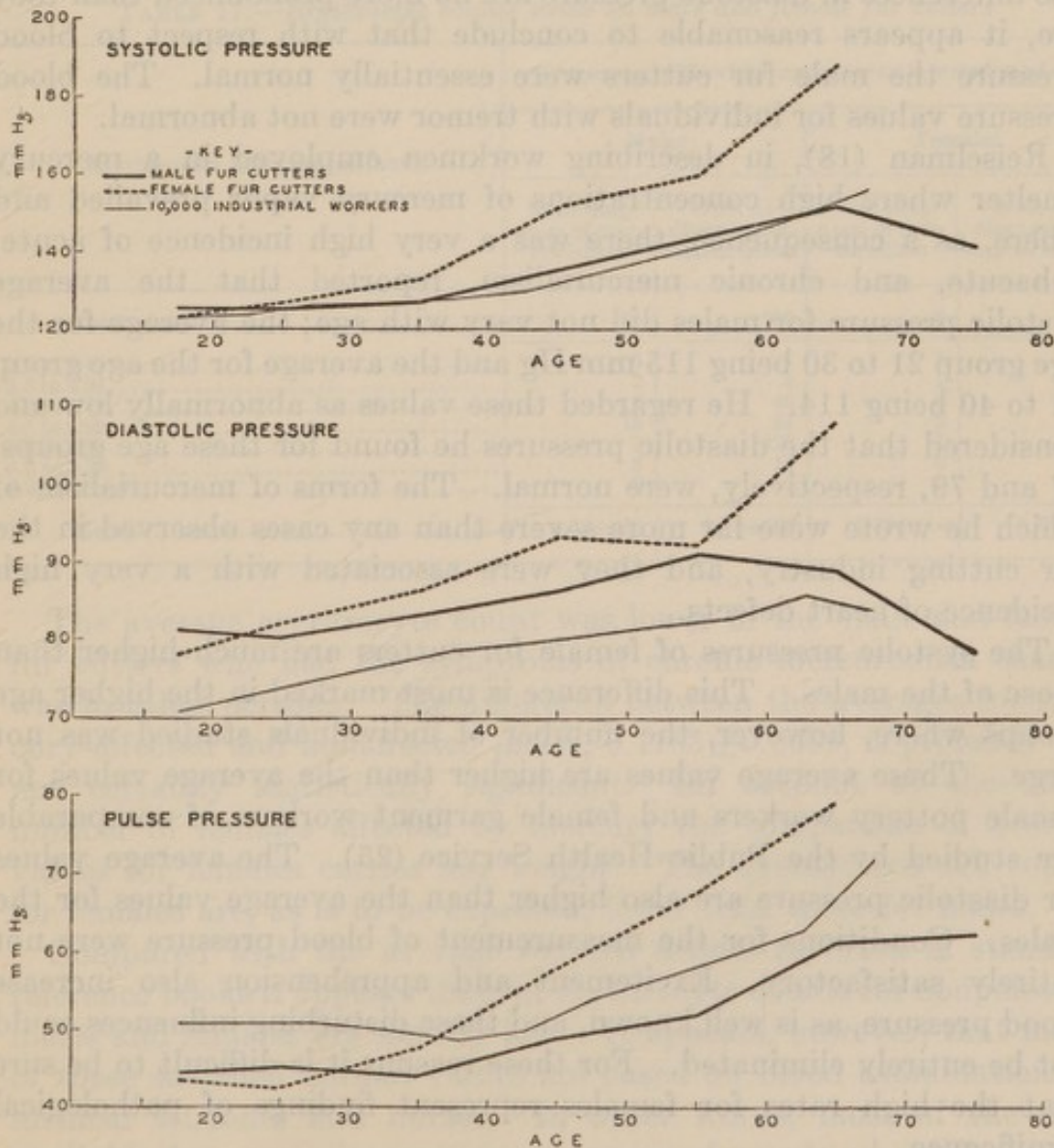


FIGURE 29.

All of these values show an increase with advancing age, as is to be expected. There is a very close correspondence between the average systolic pressure for male fur cutters and the average systolic pressure for other male industrial workers of comparable age. The relatively low systolic and diastolic pressures for the five male fur cutters aged 70 and more is of doubtful significance, and any interpretation must necessarily be speculative in nature. The average diastolic pressures of the fur cutters are consistently higher than those of the comparison group for all ages, and as a consequence the values for pulse pressure are lower than the values for other male industrial workers. There is a possibility that this difference may be due to a difference in the technique employed by the two physicians who examined the fur cutters. Accepting the values as they stand, it does not appear that many individuals had abnormally high diastolic pressures. Since the systolic pressures of the two groups are in good agreement, and since the differences in diastolic pressure are no more pronounced than they are, it appears reasonable to conclude that with respect to blood pressure the male fur cutters were essentially normal. The blood pressure values for individuals with tremor were not abnormal.

Reiselman (18), in describing workmen employed in a mercury smelter where high concentrations of mercury vapor prevailed and where, as a consequence, there was a very high incidence of acute, subacute, and chronic mercurialism, reported that the average systolic pressure for males did not vary with age; the average for the age group 21 to 30 being 115 mm Hg and the average for the age group 31 to 40 being 114. He regarded these values as abnormally low and considered that the diastolic pressures he found for these age groups, 77 and 79, respectively, were normal. The forms of mercurialism of which he wrote were far more severe than any cases observed in the fur cutting industry, and they were associated with a very high incidence of heart defects.

The systolic pressures of female fur cutters are much higher than those of the males. This difference is most marked in the higher age groups where, however, the number of individuals studied was not large. These average values are higher than the average values for female pottery workers and female garment workers of comparable age studied by the Public Health Service (25). The average values for diastolic pressure are also higher than the average values for the males. Conditions for the measurement of blood pressure were not entirely satisfactory. Excitement and apprehension also increase blood pressure, as is well known, and these disturbing influences could not be entirely eliminated. For these reasons it is difficult to be sure that the high rates for females represent findings of pathological significance.

The subject of high blood pressure will be referred to again in a later section in connection with the discussion of evidences of kidney pathology.

BLOOD PICTURE

Erythrocytes.—An important question which these data were collected to answer is: Do the hematological findings provide any evidence that mercury exposure caused a large-scale destruction of red blood cells? Three kinds of data bearing on this point are presented here: (1) Total number of erythrocytes, (2) concentration of hemoglobin, and (3) cytological evidence of the presence of juvenile stages of erythrocytes which, if present in large numbers, would indicate that regeneration of red cells was actively in progress.

Erythrocyte counts for male and female fur cutters have been presented in table 17.

TABLE 17.—*Erythrocyte counts made on male and female fur cutters*

Erythrocytes (millions per mm ³)	Frequency with which certain counts were found in—			
	Males		Females	
	With diagnosis of mercurialism	With no diagnosis of mercurialism	With diagnosis of mercurialism	With no diagnosis of mercurialism
Total tested.....	34	260	8	224
3.0 to 3.49.....	0	1	1	4
3.5 to 3.99.....	2	2	1	6
4.0 to 4.49.....	7	40	3	47
4.5 to 4.99.....	15	81	2	103
5.0 to 5.49.....	7	120	1	56
5.5 to 5.99.....	3	14	0	8
6.0 and over.....	0	2	0	0
Mean.....	4.78±.06	4.96±.02	4.31±.14	4.75±.02

The average erythrocyte count was lower in the male and female fur cutters who had the symptoms of chronic mercurialism than it was in other persons. The difference between the averages for mercury-affected and nonaffected males, 0.1763 ± 0.0609 , is probably but not certainly statistically significant. On account of the small number of females affected by mercury the comparison of average values for females carries less weight. The average red cell counts for females are, as is to be expected, lower than those for males.

Compared with the average red cell counts reported in standard reference books it appears that the erythrocyte counts for nonpoisoned males and females are slightly low. It appears, however, that many of these so-called normal values are based on blood examinations of medical students and nurses. In other words, most of the data available for comparison represent groups of people who differ in age and nutritional status from industrial populations. Consequently,

it appears that close comparison of these data with data representative of nonindustrial populations may be inadvisable and this precaution probably applies to many of the hematological data presented here.

Hemoglobin estimations were made with the Dare hemoglobinometer. These data have been presented in the form of frequency tables in table 18.

TABLE 18.—*Hemoglobin percentages found in blood of male and female fur cutters (Dare colorimeter)*

Hemoglobin percentage (Dare scale)	Frequencies with which certain percentage values were found in—			
	Males—		Females—	
	With diagnosis of mercurialism	With no diagnosis of mercurialism	With diagnosis of mercurialism	With no diagnosis of mercurialism
Total tested.....	34	260	8	223
Under 60.....		1		1
60 to 64.....		2		7
65 to 69.....	2	11		7
70 to 74.....	4	27	2	29
75 to 79.....	10	42	1	58
80 to 84.....	10	89	4	74
85 to 89.....	5	46		36
90 to 94.....	1	26		10
95 to 99.....	2	11		1
100 to 105.....		1	1	
Average.....	80.9±0.8	82.4±0.4	81.8±2.1	80.0±0.3

A difference in hemoglobin content between males and females is to be expected, and the average values, in themselves, are not markedly low. The difference between mercury-affected and nonaffected males, 1.4810 ± 0.9279 , is not statistically significant.

TABLE 19.—*Reticulocyte counts, expressed as percentages of total erythrocyte counts*

Reticulocytes percentage	Frequency with which these percentages were found in—			
	Males—		Females—	
	With diagnosis of mercurialism	With no diagnosis of mercurialism	With diagnosis of mercurialism	With no diagnosis of mercurialism
Total tested.....	34	256	8	220
0 to 0.19.....	2	21		3
0.2 to 0.39.....	3	20	2	20
0.4 to 0.59.....	6	57	3	52
0.6 to 0.79.....	8	62	1	47
0.8 to 0.99.....	3	40		29
1.0 to 1.19.....	3	17		25
1.2 to 1.39.....	2	13		15
1.4 to 1.59.....	2	10		13
1.6 to 1.79.....	1	5		2
1.8 to 1.99.....	1	4		1
2.0 and over.....	3	7	2	13
Mean.....	1.03±.10	.79±.02	1.72±.65	.95±.04

The color index averaged 0.881 ± 0.002 for mercury-affected males, 0.854 ± 0.006 for other males; 0.904 ± 0.009 for mercury-affected females, and 0.871 ± 0.003 for other females.

Determinations of the percentage of reticulocytes have been of value in the study of lead poisoning in indicating whether or not the proportion of newly formed red blood cells was so great as to indicate unusually high rates of erythrocyte formation. Although more data are needed to establish the normal range of reticulocyte counts definitely, 1.2 percent may be regarded as the upper limit found in normally healthy individuals.

The reticulocyte percentage is normally higher in females than in males. The difference between mercury-affected and nonaffected males, 0.2370 ± 0.1074 , is possibly, but not certainly, statistically significant. The mean values for both groups seem to be higher than normal. It is possible that this finding may be evidence of subclinical mercury absorption.

Other cytological data were collected which have a bearing on the question of destruction of red blood cells and their replacement. Estimates of the relative abundance of stippled cells were made; none were found in the blood of 77 percent of the males or 72 percent of the females; very few individuals had numbers of stippled cells of pathological significance, and there were no indications that stippling was associated with the symptoms of chronic mercurialism. Similar statements may be made for blood platelet estimations. Observations on occurrence of anisocytosis, and achromasia do not indicate that they are at all closely linked with mercury exposure or the symptoms of chronic mercurialism. In all these respects these findings are in agreement with those of Dunajewsky and Peissachowitsch (12) who examined blood taken from 138 men, most of whom were suffering from acute, subacute, or chronic mercurialism. It appears that cytological observations, with the possible exception of the reticulocyte count, had little diagnostic value as far as chronic mercurialism is concerned in this study.

Leucocytes.—Some of the leucocyte counts presented in table 20 may appear to be dangerously high unless one bears in mind that most of these individuals had been exercising actively and many of them had eaten food just before the blood sample was taken. It was a regular occurrence in certain factories for vendors to go through the workrooms and sell pastries to the employees, who ate them during pauses in the work. Normally there is a rise in the leucocyte count after eating due to an increase in lymphocytes and this may explain, partially at least, some of the high values.

TABLE 20.—*Leucocyte counts made on male and female fur cutters*

Leucocytes	Frequency with which these counts were found in—	
	Males	Females
5,000 to 5,999.....	10	11
6,000 to 6,999.....	52	27
7,000 to 7,999.....	72	73
8,000 to 8,999.....	90	65
9,000 to 9,999.....	40	22
10,000 to 10,999.....	11	18
11,000 to 11,999.....	10	7
12,000 to 12,999.....	6	1
13,000 to 13,999.....	0	1
14,000 to 14,999.....	2	3
Total tested.....	293	228
Mean.....	8,233.0±55.3	8,263.0±71.5
Standard deviation.....	1,407	1,600

No relation could be found between mercury exposure and the leucocyte count. Persons with the symptoms of chronic mercurialism had almost the same total leucocyte count as persons who did not have these symptoms.

The percentages of lymphocytes found in the blood of these fur cutters are slightly higher than usual and the percentages of neutrophils are correspondingly lower than usual. Although the interpretation of these differences is complicated by several circumstances which could not be controlled, it does not appear that these differences are necessarily the result of mercury absorption. The fact that the monocyte percentages are within normal limits substantiates this view.

TABLE 21.—*Total leucocyte count and differential leucocyte count of poisoned and nonpoisoned male and female fur cutters*

	Num-ber of per-sons	Total leuco-cyte count	Differential leucocyte count (expressed as percentages of total leucocyte count)				
			Neutrophils	Lympho-cytes	Monocytes	Eosino-phils	Basophils
Males:							
Nonaffected.....	260	8,276±65	55.54±0.42	35.65±0.42	7.83±0.18	1.79±0.05	0.65±0.03
Affected by mer- cury.....	34	8,176±179	54.12±1.03	37.35±.93	8.16±.48	1.62±.09	.76±.07
Females:							
Nonaffected.....	220	8,281±72	53.43±.44	38.95±.44	7.07±.12	1.39±.04	.73±.03
Affected by mer- cury.....	8	7,750±332	52.50±3.37	38.75±2.91	7.50±.73	1.61±.04	.69±.11

These findings are in accordance with those of Dunajewsky and Peissachowitsch (12), and of Matussevic and Frumina (17), who reported that lymphocytosis was the most distinctive blood finding in individuals who were exposed to mercury vapor. The difference between mercury-affected and nonaffected male fur cutters 1.698 ± 1.022 ,

is not statistically significant. When lymphocyte percentages were classified according to length of exposure and to the amount of exposure to mercury (as in table 29) no relation to mercury exposure was discernible. There was no variation of the lymphocyte count with age in either males or females. In order to decide whether there is a definite relationship between mercury exposure and increase in lymphocytes it would be desirable to supplement these findings by examinations of the blood of a number of persons before and after beginning work in an industry in which workmen are exposed to mercury vapor, making all examinations at proper intervals after partaking of food.

The nonprotein nitrogen, creatinin, and sugar contents of the blood were determined by the methods of Folin and Wu and serum calcium was measured by the titration method of Tisdall. Most of these values fall within normal limits and there seems to be no need to present them here.

RESULTS OF CHEMICAL AND MICROSCOPIC EXAMINATION OF URINE

All urine examinations were made on 24-hour specimens of urine within a few hours after they were received at the field laboratory. A tabulation of the results of these tests is presented as table 22.

Albumin.—Tests for the presence of albumin in urine were made by the sulphosalicylic acid method described by Kingsbury, Clark, Williams, and Post (40) and by Blatherwick (35). Albumin was found in the urine of 82 of the 281 males tested (29.2 percent) and of 52 of the 224 females tested (23.2 percent). This is a higher incidence of albuminuria than Sydenstricker and Britten (46) reported for 100,924 white males, namely, 21.7 percent. It is also a higher incidence of albuminuria than Blatherwick (35) reported for about 13,000 employees of a life insurance company (10.7 percent) who were tested by the same method. There was, however, little difference between the percentage of mercury-affected and nonaffected males with albuminuria, as table 22 shows. By the use of standard suspensions, rough quantitative determinations of the amount of albumin present were made and the percentages of persons with different amounts of albumin in their urine have been tabulated. Slight and moderate degrees of albuminuria are most frequent and the severe forms are relatively infrequent. In later sections of this paper, albuminuria and its relation to other urinary findings will be discussed. Reisman (18) did not consider that albuminuria was a consequence of mercury exposure, but Matussevic and Frumina (17) reported that the percentage of workmen whose urine contained albumin was higher in industries in which mercury was used than in industries where it was not used.

Sugar.—Sugar was found in the urine of only 1.6 percent of the males, a low rate of incidence. Although the percentage of females with glycosuria is higher than the percentage value for the males, again there is no suggestion of a deleterious effect of mercury exposure.

Urinary pigments.—Urobilin, considered by some to be indicative of impaired liver function and wholesale destruction of red blood cells, was present in the urine of only nine men and five women. Hematoporphyrin was also present in the urine of only a few individuals, three men and one woman. This very low incidence is significant because it is another indication that destruction of red blood cells is not going on at a rapid rate in the group as a whole. This deduction is in accordance with the interpretation of the hematological data discussed in the foregoing section of this report.

Blood and pus cells.—Microscopic examination of the urinary sediments thrown down by centrifuging indicated that the percentage of persons whose urine contained fine granular casts, leucocytes, or erythrocytes was about as high among persons who were not affected by mercury exposure as among persons who were. The data on occurrence of leucocytes and erythrocytes in the urine have not been tabulated because of the possibility that in some specimens these cells may have decomposed during the 24-hour period in which the samples were collected. Study of the data indicated that the percentages of males whose urine contained leucocytes or erythrocytes were about the same as the values reported for the 100,924 male policyholders (46) or for the 40 normal males examined during a study of lead poisoning (26).

Casts.—The difference between the percentage of mercury-affected males whose urine contained fine granular casts, namely, 24.2 percent, and the corresponding percentage for nonaffected males, 14.5 percent, is possibly but not certainly statistically significant. These figures are much higher than the values reported by Sydenstricker and Britten (46) for 100,924 white males, namely, 8.2 percent, and they are also higher than the rate found on examination of 40 men, 7.5 percent, in the course of an earlier study of the Public Health Service (26).

Kidney pathology.—As a means of finding out how many individuals were suffering from advanced stages of kidney disease a tabulation was made of individuals whose urine contained both albumin and fine granular casts, whose systolic pressure exceeded 150 mm of mercury, and who had more than 35 mg of nonprotein nitrogen per 100 cc in their blood. Ten men and eleven women had all four of these conditions. There was no evidence that their condition was in any way related to mercury exposure; their exposure to mercury vapor was no greater than the average, only 3 persons of the 21 had chronic mercurialism, and only 6 of the 20 whose urine was tested spectrographically had mercury in their urine.

TABLE 22.—Percentage of persons whose urine contained substances or bodies indicative of kidney pathology

	Males		Females	
	Diagnosis of chronic mercurialism	No diagnosis of chronic mercurialism	Diagnosis of chronic mercurialism	No diagnosis of chronic mercurialism
Total number of persons.....	34	247	8	217
Chemical tests:				
Albumin:				
Slight trace, less than 0.01 percent.....	20.6	16.2	0	8.8
Moderate amount, 0.01 to 0.03 percent.....	11.7	10.9	14.3	12.0
Marked amount, over 0.03 percent.....	0	1.6	0	2.8
Sugar.....	0	1.6	0	4.7
Urobilin.....	6.2	2.9	0	2.3
Hematoporphyrin.....	0	1.2	0	0.5
Microscopic tests:				
Fine granular casts.....	24.2	14.5	0	12.5

MERCURY IN THE URINE

The method of quantitative spectrographic analysis was based on Nitchie and Standen's (43) modification of Gerlach and Schweitzer's homologous pair technique.³

The number and percentage of male and female fur cutters whose urine contained mercury is presented in table 23, where they are further classified according to the concentration of mercury found. Reiselman (18) found measurable amounts of mercury in every one of 22 samples of urine and 14 samples of feces from unselected employees of a mercury smelter. His analytical methods are not specified. The average concentration of mercury in urine was 0.76 ± 0.9 mg per l; individual measurements ranged from .06 to 2.90 mg per l. In their working environment the smelter employees breathed air that apparently was almost completely saturated with mercury vapor.

³ In this method a known amount of an element (in this case thallium) not originally present in the material to be analyzed is added to serve as an internal standard. Essentially, the procedure consisted in adding 0.1 cc of a 0.07 percent solution of Tl_2SO_4 to 0.9 cc of urine. By means of a pipette 0.1 cc of this mixture was introduced into a $\frac{1}{8}$ -inch hole drilled to a depth of $\frac{3}{8}$ -inch in the end of a special spectrographic graphite electrode which upon test had been found to be free from mercury and thallium. Before use these electrodes were burned in an arc at 15 amperes for $\frac{1}{2}$ to 1 minute which had the desirable effect of making the graphite more porous. After introduction of the sample the electrodes were dried at $46^\circ C.$ for 2 hours and were then burned in a direct-current arc at 15 amperes for 25 seconds. The spectrum was photographed on an Eastman no. 33 plate with a Hilger E3 quartz spectograph. The densities on the photographic plate of the Hg line at 2537A and of the Tl line at 2580A were measured with a Bausch & Lomb density comparator. Slight variations in photographic technique and in the physical conditions of the arc were unavoidable in different tests, but if the density of the Hg line is always referred to the density of the Tl line (which thus serves as an internal standard) the possibility of an error being introduced into the mercury determination is minimized, for the thallium line should be as much altered as the mercury line. The apparatus was calibrated by testing samples of normal, Hg-free urine to which known amounts of mercury had been added, which were then treated in the same way that test samples were treated. Below concentrations of 0.1 mg per l the density of the line could not be measured with the comparator but the presence of mercury could be ascertained in concentrations as low as 0.01 mg per l.

A spectrographic method such as this gives no indication, of course, of the chemical state in which mercury exists in the urine.

TABLE 23.—*Number and percentage of male and female fur cutters whose urine contained mercury*

Concentration of mercury, mg per l	Percentage		Number	
	Males	Females	Males	Females
Total tested.....	100.0	100.0	266	222
Mercury absent.....	69.9	58.6	186	130
0.01 to 0.39.....	11.3	25.2	30	56
0.4 to 0.79.....	16.2	14.9	43	33
0.8 to 1.19.....	2.2	1.3	6	3
1.2 and over.....	.4	0	1	0

Mercury was found more frequently in the urine of women than in the urine of men, and the difference is statistically significant. These data do not provide any explanation for this difference. A tabulation of the incidence of mercury in the urine of males and females classified according to age indicated that about the same proportion of people in each age group had mercury in their urine.

One might expect to find the highest concentrations of urinary mercury in individuals who were exposed to the highest concentrations of mercury vapor in the atmosphere, but an examination of the data shows that such a trend is not at all clearly marked. These data have been tabulated in various ways, with both coarse and fine groupings of the values, and the arrangement followed in table 24 appears to display the data as clearly as any other method of tabulation.

TABLE 24.—*Relation of atmospheric mercury concentration to concentration of mercury in urine*

Concentration of mercury in urine, mg per l	Atmospheric mercury concentration, mg per 10 m ³			Total
	Less than 2	2-3.9	4 and over	
Total tested.....	347	104	37	488
Less than 0.01.....	237	54	25	316
0.01 to 0.39.....	64	19	3	86
0.4 and over.....	46	31	9	86

Statistical probability tests indicate that there is a significant association between atmospheric mercury concentration and urinary mercury concentration. It is not pronounced enough, however, to warrant a definite statement concerning the relation of these two variables. Perhaps if the total quantity of mercury present in a 24-hour sample of urine had been calculated instead of the concentration, a more definite relation might have been found. The volume of some urine specimens was so small, however, that they could not be regarded as 24-hour specimens, and this precludes discussion of the total daily urinary excretion of mercury. Fraser, Melville, and Stehle (13)

found that the quantity of mercury in the urine of dogs exposed to controlled dosages of mercury vapor varied greatly from day to day.

It is difficult to draw very definite conclusions concerning the relation of the presence of mercury in the urine to chronic mercurialism. Basing the discussion on males only, because only a very few women had symptoms of chronic mercurialism, the relevant data have been summarized in table 25. The urine of four of the six females affected by mercury who were tested contained mercury.

TABLE 25.—*Relation of urinary mercury to chronic mercurialism among male fur cutters*

Diagnosis	Number of males with—			Percentage with mercury in urine
	Mercury in urine	No mercury in urine	Total	
Total.....	80	186	266	.....
Mercurialism.....	14	19	33	42.4
Essentially normal.....	66	167	233	28.3

Statistical test of the data of table 25 shows that the difference between the percentage of mercury-affected males whose urine contained mercury and the percentage of nonaffected males whose urine contained mercury is possibly, but not certainly, significant.

If the presence of mercury in the urine were an important symptom of chronic mercurialism, then the persons with the most pronounced symptoms of chronic mercurialism should exhibit this characteristic in pronounced degree. However, this does not appear to be the case. Analyses were made of the urine of nine of the ten persons who had the most advanced symptoms of chronic mercurialism. Only three of these nine individuals had mercury in their urine.

There was no indication that the presence of mercury in the urine was associated with kidney pathology as evidenced by the presence in the urine of any of the abnormal urinary constituents listed in table 26. Reference to table 26, which is arranged to bring out the relationship between the presence or absence of mercury and the occurrence of albumin or fine granular casts, shows that these evidences of kidney damage were of no more frequent occurrence when mercury was present than they were when mercury was absent.

TABLE 26.—*Percentage of persons whose urine contained certain substances or bodies indicative of kidney pathology, classified according to the presence or absence of mercury in the urine*

	Mercury present	Mercury absent
Albumin.....	26.2	26.3
Fine granular casts.....	14.5	11.7

From this evidence it appears that the presence of mercury in the urine can be regarded only as proof of mercury absorption.

SYMPTOMATOLOGY OF CHRONIC MERCURIALISM

The most important physical impairments observed in this study have been listed in order of prevalence in the first three columns of table 27.

TABLE 27.—Number of persons who had certain pairs of impairments, compared with the number who might be expected to have these pairs of defects on the basis of chance alone¹

Impairment	Persons affected		Fine intention tremor		Physic disturbance		Exaggerated knee jerk		Vasomotor disturbances		Digestive disturbances	
	Number	Percent of total examined	Observed	Calculated	Observed	Calculated	Observed	Calculated	Observed	Calculated	Observed	Calculated
Fine intention tremor.....	43	8.1			34	3.2	9	2.4	10	4.3	10	3.7
Psychic disturbance.....	39	7.4	34	3.2			6	2.2	22	4.5	8	3.4
Exaggerated knee jerk.....	30	5.7	9	2.4	6	2.2			12	3.5	3	2.6
Vasomotor disturbance.....	61	11.5	10	4.9	22	4.5	12	3.5			8	5.3
Digestive disturbance.....	46	8.7	10	3.7	8	3.4	3	2.6	8	5.3		
Inflamed nasal mucous membrane.....	212	40.1	23	17.2	18	15.6	19	12.0	32	24.4	23	18.4
Discolored oral mucous membrane.....	191	36.1	29	15.5	23	14.1	15	10.8	29	22.0	24	16.6
Gingivitis.....	201	38.0	23	16.3	19	14.8	13	11.4	25	23.2	16	17.5
Inflamed conjunctiva.....	53	10.0	9	4.3	6	3.9	5	3.0	6	6.1	4	4.6
Insomnia (present complaint).....	37	7.0	9	3.0	10	2.7	2	2.1	5	4.3	9	3.2
Loss of appetite (present complaint).....	23	4.4	7	1.9	6	1.7	2	1.3	4	2.6	8	2.0
Loss of weight (present complaint).....	14	2.6	5	1.1	5	1.0	1	.8	3	1.6	5	1.2
Past history of nervous disease.....	33	6.2	13	2.7	12	2.4	7	1.9	13	3.8	8	2.9
Present complaint of sore mouth.....	12	2.3	4	1.0	3	.9	1	.7	1	1.4	1	1.0
Present history of tremor.....	10	1.9	6	.8	5	.7	3	.6	8	1.2	3	.9
Present complaint of psychic disturbance.....	37	6.9	16	3.0	15	3.9	4	2.9	10	4.3	10	3.2

¹ Where the differences between observed and calculated values are statistically significant the observed values are printed in bold-face type. Unless otherwise stated, the impairments listed were observed by the examining physicians during the physical examination.

These data are largely self-explanatory, especially since they have already been discussed in earlier sections of this paper. They are presented here to indicate the principal symptoms taken into consideration in making a diagnosis of chronic mercurialism.

Not every case of mercurialism presented all of these symptoms. For example, of the 43 persons who had fine-intention tremor (which was regarded as the most important diagnostic sign of chronic mercurialism), only 22 had vasomotor disturbances (dermatographia, excessive perspiration, or abnormal readiness to blush). Of these 22, 6 had psychic disturbances. Of these six persons, three had an exaggerated knee jerk. Only one person had tremor, vasomotor disturbances, psychic disturbances, exaggerated knee jerk and digestive disorders. Other tabulations of the data are possible, but the result, in general, is the same; the number of persons who had more than three or four of these symptoms is small. Nevertheless, it must not be supposed that these symptoms are entirely independent of

each other in their occurrence. On the contrary they are found together much more frequently than would be expected on the basis of chance alone. To illustrate this point, by making use of the percentage values of table 27, it is possible to calculate the probable number of persons who would have any 2, 3, 4, or 5 symptoms. Instead of the observed values of 22, 6, 3, and 1 for the numbers of persons having the symptoms listed above, one would expect 5.1, 0.36, 0.02, and 0.002 if it were merely a matter of chance that a person had more than one symptom.

Table 27 shows the number of persons who had particular pairs of symptoms. For each pair of symptoms a calculation has been made of the probable number of persons who would be expected to have these symptoms on the basis of chance alone. Where the differences between the observed and calculated values are statistically significant ⁴ the observed values are printed in bold-face type.

The data in table 27 show that fine-intention tremor accompanied other physical impairments far more frequently than one would expect on the basis of chance alone. No other impairment was so frequently associated with so many other disorders and defects as fine-intention tremor and this is one of the reasons why it was regarded as the most important symptom in establishing the diagnosis.

Psychic disturbances also accompanied many other impairments to an unusual degree, and this is important in showing that the mental disturbances described in an earlier section of this report are part of the symptom complex referred to here as chronic mercurialism.

Vasomotor disturbances and exaggerated knee jerk are also significantly associated with a number of other impairments, although not to the same extent as fine-intention tremor and psychic disturbances.

It is interesting to note that a complaint of digestive disorders present at the time of examination also was significantly associated with complaints of other kinds—insomnia, loss of weight, and loss of appetite. Digestive disturbances are not highly associated with the disorders that were found upon physical examinations, with the exception of fine-intention tremor and psychic disturbances.

Abnormalities of the mucous membranes are not significantly associated with many other disorders listed in table 27. This is a reasonable finding, since there are seldom very direct causal relationships between these abnormalities of the mucous membranes and other disorders listed in table 27.

Wright (24, p. 301) treated his data in a similar way but he did not make probability tests. Of the 43 hatters and fur cutters he diagnosed as having chronic mercurialism, "fourteen cases presented two

⁴ The discrepancy between the observed and calculated values was considered to be statistically significant when the difference was three times as great as the probable error of the calculated value.

of the symptoms, usually tremor and psychic disturbance; twenty cases presented three of the symptoms, usually tremor, psychic irritability, and gingivitis; eight presented four of the symptoms; and one case presented tremor, psychic irritability, salivation, gingivitis, and a blue line."

INFLUENCE OF MERCURY VAPOR CONCENTRATION ON THE OCCURRENCE
OF CHRONIC MERCURIALISM

Every employee in the five fur-cutting factories studied, including the office employees, was exposed to measurable concentrations of mercury vapor. Quantitative measurements made with the Nordlander instrument described in an earlier section of this report showed the presence of from 0.6 to 10.4 mg of mercury vapor per 10 m³ of air in the atmosphere of the workrooms. It may be helpful in studying these data on mercury vapor concentration to bear in mind that air fully saturated with mercury vapor at 20° C. (68° F.) would contain 131.8 mg of mercury vapor per 10 m³. The extent to which the concentration of mercury vapor is dependent upon the nature of the manufacturing process carried on in a particular workroom has been shown in table 6, and the extent to which it can be reduced by the application of appropriate engineering methods has already been discussed.

TABLE 28.—Percentages of persons exposed to different concentrations of mercury vapor who were found to have chronic mercurialism

Concentration of mercury vapor mg per 10m ³	Number of persons exposed to the specified mercury vapor concentration	Number of persons diagnosed as having mercurialism	Percentage of exposed population diagnosed as having mercurialism
Total.....	529	43	-----
0 to 0.9.....	107	6	5.6
1.0 to 1.9.....	270	11	4.1
2.0 to 2.9.....	12	1	8.3
3.0 to 3.9.....	96	16	16.7
4.0 to 4.9.....	28	6	21.4
5.0 to 5.9.....	10	-----	0
6.0 to 6.9.....	-----	-----	-----
7.0 to 7.9.....	6	3	50.0

The number of employees exposed to high mercury concentrations is relatively small; most of them (71.3 percent) were exposed to less than 2 mg per 10 m³. Cases presenting the symptoms of chronic mercurialism were found over the entire range of mercury concentrations observed in these plants. All but one of the cases found in the lower mercury vapor concentrations were diagnosed as mild in nature and two of the three cases observed in men exposed to more than 7 mg per 10 m³ were diagnosed as severe, but in the intermediate range the severity of the case was not always proportional to the

mercury vapor concentration. This is only to be expected, since the duration of exposure to mercury vapor has not been taken into account. The numbers of persons who were diagnosed as having chronic mercurialism have been entered in table 28 and the percentages of each of the exposure groups who were so affected have also been presented in the last column of table 28. The steady increase of the percentage of mercury-affected persons with increasing mercury concentration is clearly marked. This relationship is important because it is one of several arguments, which, taken together, prove that mercury exposure is the cause of the condition referred to in this report as chronic mercurialism.

The numbers of people exposed to some of the ranges of mercury vapor concentration listed in table 28 are small, and on that account the reliability of some of the percentage values is open to question. In view of the logical importance of the relationship between mercury exposure and incidence of chronic mercurialism it appeared to be advisable to group the data into two large classes, rather than eight small ones; one class including all persons exposed to less than 2.5 mg per 10 m³ and the other including all persons having a greater mercury exposure. Selection of 2.5 mg per 10 m³ is not only natural and convenient as reference to table 28 will show, but from an engineering viewpoint it is also a significant dividing point because the manufacturing processes which expose workers to mercury concentrations in excess of 2.5 mg per 10 m³ are the processes in which application of relatively simple control measures will materially reduce the mercury hazard. The data thus grouped have been presented in table 29, where they have also been subdivided according to the duration of employment in the occupations within the fur-cutting industry each individual was following at the time of the study.

The coarser grouping used in table 29 makes the relationship of mercury exposure to the incidence of chronic mercurialism even more striking. The incidence of mercurialism is 3.7 times greater in the higher range of mercury vapor concentrations than it is in the lower concentrations, and the difference is statistically significant.

It will be noted that no cases of chronic mercurialism were observed in persons who had been employed for less than 2 years. It must not be inferred, however, that this length of time necessarily constitutes a safe period of exposure because 60 of the 75 persons who had been employed less than 2 years were engaged in occupations which exposed them to less than 2.5 mg mercury per 10 m³, a range of mercury vapor concentration that does not produce a very high rate of incidence (4.7 percent) of chronic mercurialism irrespective of the length of exposure.

It may seem surprising that the percentage of persons with chronic mercurialism was not found to increase with length of exposure. It

must be remembered that this condition may become disabling, and if a person were obliged to quit his job because of disability resulting from mercurialism he could not be included in a survey of this kind. The data of table 28 showing the incidence of chronic mercurialism must be regarded for this reason as minimal estimates. The actual rates are almost certainly higher than these values.

TABLE 29.—*Incidence of chronic mercurialism in fur cutters employed for different lengths of time who were exposed to concentrations of mercury vapor above and below 2.5 mg per 10 m³*

PERCENTAGE OF PERSONS DIAGNOSED AS HAVING MERCURIALISM

Mercury vapor concentration mg per 10 m ³	Years in present occupation				
	Less than 2	2-4.9	5-9.9	10 and over	Total
Under 2.5.....	0	5.6	5.0	6.0	4.7
2.5 and over.....	0	22.8	20.0	16.7	17.4

NUMBER OF PERSONS DIAGNOSED AS HAVING MERCURIALISM

Mercury vapor concentration mg per 10 m ³	Years in present occupation				
	Less than 2	2-4.9	5-9.9	10 and over	Total
Total.....		15	13	15	43
Under 2.5.....		7	5	6	18
2.5 and over.....		8	8	9	25

NUMBER OF PERSONS EXPOSED

Mercury vapor concentration mg per 10 m ³	Years in present occupation				
	Less than 2	2-4.9	5-9.9	10 and over	Total
Total.....	75	159	141	154	529
Under 2.5.....	60	124	101	100	385
2.5 and over.....	15	35	40	54	144

INCIDENCE OF CHRONIC MERCURIALISM IN DIFFERENT OCCUPATIONS

Various occupations within the fur-cutting industry offer different degrees of exposure to mercury vapor and there are corresponding differences in the proportion of individuals on whom a diagnosis of chronic mercurialism was made.

Cases of chronic mercurialism were found among persons engaged in 10 occupations; the percentage of affected persons engaged in each occupation has been calculated, and the occupations have been listed accordingly. It will be noticed that the two occupational groups in which the incidence of chronic mercurialism is highest, blowers and

shippers, are the two groups exposed to the highest mercury-vapor concentrations. The occupations in which a smaller proportion of persons were diagnosed as affected by mercury exposure are occupations in which the mercury exposure is relatively low. This relationship cannot be expected to hold strictly because the factor of duration of exposure has not been taken into account. The number of persons employed in each occupation was too small to permit an analysis of this kind for each occupation.

TABLE 30.—*Incidence of chronic mercurialism in various occupations within the fur-cutting industry*

Occupation	Cases of chronic mercurialism		Number of persons employed in occupation	Average mercury exposure, mg per 10 m ³
	Percent	Number		
Total, all occupations.....	8	43	529	
Blowers.....	73	11	15	4.6
Shippers.....	50	3	6	7.2
Brushers.....	14	3	22	1.2-3.1
Blown fur packers.....	11	1	9	3.8
Yellow carrot dryer.....	11	1	9	2.0
Cutters.....	10	5	48	1.8-4.0
Clippers.....	9	5	56	.7-1.5
Spreaders.....	7	2	29	.9-1.2
Sorters.....	4	8	178	1.7-3.8
Miscellaneous.....	8	4	47	.6

Two of the four mercury-affected persons classified under the heading "miscellaneous" had been employed in the fur-cutting industry for over 25 years, and presumably had developed chronic mercurialism when they were employed in a different occupation from the one they were engaged in at the time of the study. Considering the group as a whole, however, these changes of occupation were not numerous; 416 of the 529 persons had been employed in the same occupation ever since they had begun to work in the fur-cutting industry.

Occupational stigmata.—It is interesting to note that no case of chronic mercurialism was found among any of the 40 carroters employed in these factories. Carroting has often been assumed to be a hazardous occupation. The older literature contains many references to the hazard of mercurialism to which carroters are exposed and special attention has been given by engineers to the design of machines which would make hand labor unnecessary in this process. There are other disorders, however, to which the carroters alone appear to be subjected. One, which has attracted the attention of other physicians, is a black mottling of the enamel of the teeth observed in 20 carroters. It appears as a conglomeration of small, irregular, black dots which cannot be scraped off. Only a few other employees had black teeth, and all of these persons worked near the carroters.

The formation of these blackened areas has been attributed to the acid spray arising during the carroting process. Carroters' finger and thumb nails were brown or black. Nine carroters had chronic bursitis, with callus formation over the metacarpophalangeal joint of the index finger where the straps securing the brush to the hand passed over the knuckle. All these conditions were so characteristic of carroters that their occupation could usually be guessed from these signs alone.

Mention should be made of characteristic calluses observed on the hands and forearms of cutters and openers. Because cutters rest their forearms on the table while feeding pelts to the cutting machine the upper third or upper half of the extensor surface of the forearms was red, dry, and indurated. Seven cutters were so affected. In one case there was a small, subcutaneous, circumscribed, soft mass in this area simulating a chronic bursitis. Two openers had thick calluses on the flexor surface of the right index finger caused by the knife used in opening skins.

INFLUENCE OF FUR DUST ON HEALTH

The data on atmospheric dust concentrations presented in table 7 were used in an attempt to find out whether or not a direct relation existed between dust exposure and certain disorders of the respiratory tract and the mucous membranes. The occupational groups were arranged in order of their dustiness and the percentages of the workers in each occupation who were afflicted with a specific disorder were tabulated and plotted in the same order. Dust concentration and incidence of these physical defects did not vary concomitantly when inflamed conjunctiva, inflamed nasal mucous membranes, gingivitis, discolored oral mucous membranes, and lung pathology demonstrable by the standard methods of physical examination or with X-ray equipment were studied in this way. One occupational group, however, the blowers, had a high incidence of each of these disorders. Besides being exposed to high dust concentrations the blowers are also exposed to high concentrations of mercury vapor, as shown in table 30.

HEALTH OF WOMEN IN THE FUR-CUTTING INDUSTRY

Two occupations, the opening of the pelts and the sorting of cut fur are carried on almost exclusively by women, and a third occupation, skin sorting, is also carried on largely by women, as table 5 shows. In the five fur-cutting factories studied, 92.3 percent of the women are employed in these three occupations. Opening the pelts and sorting of skins, in which 40 women (17.1 percent) are engaged, precede the application of the carroting solution containing mercury

compounds, and consequently the only mercury exposure these women are subjected to is the inhalation of mercury vapor arising from fur being processed elsewhere in the same workroom. In the sorting of cut fur, on the contrary, mercury vapor in rather high concentration (1.7 to 3.8 mg per 10 m³ of air, according to the factory in which measurements were made) is released from the mercury-treated fur that passes continuously on conveyor belts in front of the sorters. All of the eight women who had cases of chronic mercurialism were employed as sorters. The average length of their employment in the fur-cutting industry was 9.6 years (rather more than the average) and all but one of the women had continued in the same occupation since beginning work in the industry.

A nurse assisted in the physical examination of the women and asked each woman about the possible occurrence of menstrual disturbances and miscarriages, which some investigators report are aggravated by exposure to mercury. There were 23 women (10 percent) who reported menstrual disturbances, but none of the 8 women with chronic mercurialism were included in this group. Meaker (41) and Sturgis (45) have published data on the occurrence of menstrual disorders among female industrial workers, using definitions and methods of collecting their data that differed fundamentally from the ones employed in this study. They reported that 5.5 and 4.4 percent, respectively, of the women they studied were seriously handicapped by menstrual disorders. Miscarriages were reported by 16 women employed as fur cutters. There were 179 married women in the group, and basing the percentage on that number rather than on the total number of women, the proportion of women reporting miscarriages is 9 percent which is not high. Likewise, Harris in 1915 (15) noted no particular susceptibility to disturbances of menstruation or of pregnancy among 90 women employed in a fur-cutting factory.

INCIDENCE OF SYPHILIS AMONG FUR CUTTERS

The incidence of syphilis in this group of fur cutters appears to be rather low. Kahn or Wassermann tests (and in all but 27 cases both) were made on blood samples taken from the median basilic veins of 439 persons. Although it was not possible to make tests on blood samples from all 529 persons there is no reason to suppose that an undue proportion of syphilitic persons escaped test. In only four or five cases was it impossible to obtain a blood sample for test. Of the 439 blood samples received in good condition at the laboratories of the National Institute of Health and the Connecticut State Department of Health, three were anticomplementary to the cholesterinized antigen used in the Wassermann test, and for this reason they have not been included in the calculation of percentage values.

Seven blood specimens gave both Wassermann and Kahn reactions of 1 plus or more; of these seven samples, five were graded as 1 plus and two were 4 plus in the Wassermann test, and four were graded as 2 plus or more in the Kahn test. Three other specimens were graded as 1 plus or more in the interpretation of the Kahn test, but were negative in the Wassermann test, and one additional sample was graded 1 plus Wassermann but was considered to be doubtful in the Kahn test. Of the seven persons (1.6 percent) whose blood specimens tested 1 plus or more in both tests, four were males and three were females. Of the 11 persons (2.5 percent) graded as 1 plus or more on either test, seven were males and four were females. Ten of these 11 people had been employed in the fur-cutting industry for 5 years or more, and the concentrations of mercury vapor in the air of the workrooms in which they were employed ranged from 0.7 to 5.4 mg per 10 m³ of air. There is little to be gained, it seems, from a study of the lengths of time these persons had been exposed to mercury because there is no way of knowing how recently these individuals contracted the cases of syphilis they had at the time of examination, and hence the length of employment may be a very misleading estimate of the amount of mercury exposure these individuals received after their cases of syphilis began.

Nevertheless, these findings may be of interest because of the centuries-old practice of treating syphilis with mercury. It may well be that the inhalation of mercury vapor had a therapeutic effect on most of the individuals employed in these factories who may have contracted syphilis before or during their employment, but the data here presented cannot be used to support such a statement because it was not possible to study the incidence of syphilis in a population similar in social and economic status and in racial origin who were not exposed to mercury vapor.

Comparable data on the incidence of syphilis are available for four industrial groups. Sawyer and Slater (34) reported that between 3.5 and 4 percent of 3,447 employees of a camera factory had positive Wassermann reactions. Low (33) found positive Wassermann reactions in 3.7 percent of 4,117 employees of a shoe factory. Gehrman (31) obtained positive Kahn reactions in 4.0 percent of 36,794 employees of a chemical company with factories in a large number of widely scattered cities. Heller (32) quoted data indicating that 4.1 percent of native-born, white, male employees of an industrial plant in Tennessee had syphilis. It appears from our data that the incidence of syphilis in the fur-cutting industry is lower than in other industries for which data are readily available.

SUMMARY AND RECOMMENDATIONS

ENGINEERING FINDINGS

The present report discusses the technique employed in conducting complete engineering surveys of the working environment for the purpose of investigating the relationship between industrial environment and health. In the present instance this type of survey is applied to the hatters' fur cutting industry. A discussion is given of the results of a preliminary survey of the entire industry and of a detailed study of five representative plants. The various instruments and methods used in determining the exposure of workers to mercury are described, the processes and occupations involved in the production of hatters' fur are discussed in detail, as well as the occupational exposure to mercury vapor and dust, and the methods for minimizing hazard in this industry are also presented.

RECOMMENDATIONS

The recommendations which follow are based on what has been found to be good engineering practice in the industry itself.

1. By segregating those operations handling untreated skins, approximately 23 percent of the workers employed in this industry may be removed entirely from the hazard of mercury exposure.

2. Local exhaust ventilation properly designed and maintained for such operations as cutting, brushing, and blowing, will serve to decrease the exposure for the workers in these occupations.

3. Good natural or mechanical ventilation was found to decrease the amount of mercury associated with the occupations of piling and shipping.

4. Since this study showed that in large plants considerable exposure may be attributed to the handling of mercury compounds in bulk, and to the storing of large quantities of treated fur, it is recommended that all treated material be removed from workrooms as quickly as possible and stored in well-ventilated rooms.

5. Good housekeeping and general sanitation should diminish the mercury concentration in the various workrooms. This study showed that mercury vapor is being generated constantly from treated fur. Hence, if treated fur skins and dust be allowed to accumulate in the rooms they will be a source of mercury vapor. It is recommended, therefore, that all floors, benches, and other objects on which dust may accumulate be swept and cleaned daily. Sweeping should be done either by wet methods or by vacuum. In addition, a complete general cleaning should be made once a week. In the larger plants it may be well to delegate the maintenance of protective equipment and the practice of good housekeeping to some responsible official

who should make periodic inspections of all devices and methods used to eliminate the mercury hazard.

6. As a result of this study, it was shown that many of the plants have their operations arranged very poorly. Such practice is not only inefficient from the standpoint of production, but often increases the exposure to mercury.

The engineering studies indicate that exposure to mercury can be reduced to less than 2.0 mg per 10 cubic meters of air in all departments of fur-cutting factories.

MEDICAL FINDINGS

The most important physical impairments found on examination of these fur cutters are the disorders that are generally considered to be symptomatic of chronic mercurialism. The term, chronic mercurialism, as used in this report, designates a chronic disease resulting from long-continued occupational exposure to mercury vapor and mercury-impregnated dust.

The characteristic symptomatology, physical and laboratory findings of this disease as observed in this study are as follows:

Symptomatology.—A past history of disease of the nervous system was found much more frequently than is usual in industrial groups. The most common present complaints volunteered (listed in order of their frequency) were psychic disturbances, digestive disturbances, insomnia, loss of appetite, tremor, and loss of weight.

Physical findings.—1. Fine intention tremor varying in degree from a slight tremor of the hand, eyelids, or tongue, to marked generalized tremor.

2. Psychic irritability of an exaggerated degree, as indicated by irascible temper, discouragement without cause, feeling of depression or despondency, excessive embarrassment in presence of strangers, timidity, a desire for solitude, anxiety, excitability, inability to take orders, or a strong feeling of self-consciousness.

3. Vasomotor disturbances, as dermatographia, excessive perspiration, and abnormal readiness to blush.

4. Exaggerated patellar reflexes.

5. Oral conditions, such as dry discoloration of the oral mucous membranes, gingivitis, loss of teeth, dark line on the gums, and excessive salivary flow.

Laboratory findings.—A complete hematological study was carried out. There were only two respects in which the fur cutters appeared to differ from other industrial populations; there was a slight increase in the lymphocyte and the reticulocyte ratios. Neither difference appeared to be closely related to mercury exposure. It is possible that the incidence of renal pathology (as indicated by albumin and fine granular casts in the urine) was also somewhat higher than is usual in industrial populations.

Mercury was present in the urine of 65 percent of the fur cutters. The presence of mercury in the urine does not seem to be a symptom of chronic mercurialism but it is indisputable evidence of mercury absorption.

There appeared to be a low incidence of syphilis among fur cutters, according to the results of serological tests.

General medical findings.—Forty-three of the 529 employees examined were diagnosed as having the symptoms of chronic mercurialism. Thirty-three of these cases were classified as mild, six as moderate, and four as severe.

All of the 529 employees examined were exposed to mercury-contaminated atmosphere in concentrations varying from a weighted average of 0.6 to 7.2 mg per 10 cubic meters of air.

From the data obtained it is impossible to define a reasonably safe maximum concentration of mercury in the workroom atmosphere. Symptoms of chronic mercurialism developed among individuals working in atmospheric concentrations ranging from 0.6 to 7.2 mg per 10 cubic meters.

The severity of chronic mercurialism and the percentage of persons affected increased with the degree of exposure to mercury. The incidence of chronic mercurialism increases rapidly with increasing mercury concentration after the concentration exceeds 2.0 mg per 10 cubic meters. For instance, of the 377 persons exposed to 2.0 mg or less per 10 cubic meters at the time of the study, 4.5 percent were diagnosed as having chronic mercurialism, and of the 152 persons exposed to greater mercury concentrations, 17.1 percent were so diagnosed.

The symptoms of mercurialism were found among blowers, shippers, brushers, blown fur packers, yellow carrot dryers, cutters, clippers, spreaders, and sorters, being most numerous in occupations with high mercury exposure.

There was no roentgenological evidence to show that pulmonary changes had resulted from occupational dust exposure in this industry.

RECOMMENDATIONS

It is suggested that periodic medical examinations of fur cutters be made, paying particular attention to the symptom complex of mercurialism. A person whose condition is diagnosed as chronic mercurialism should be removed from further exposure until he is no longer suffering from mercurialism and he should not be permitted to return to his old occupation until the mercury hazard has been controlled.

ACKNOWLEDGMENTS

Grateful acknowledgments are made to the employers and employees of the hatters' fur-cutting industry for the spirit of cooperation

they have shown throughout the course of this study, and thanks are due the Connecticut State Health Department and private physicians practicing in the several communities for the assistance they have willingly given.

Quantitative spectrographic analyses of the mercury content of urine were made by Assistant Physicist David Armstrong with the aid of Howard Brubach, senior technical assistant. Chemical analyses of fur dust in samples of air collected in the workrooms were made by Associate Chemist F. H. Goldman, who also collaborated with Mr. Armstrong in developing a method for the quantitative spectrographic estimation of mercury. Junior Statistical Clerk Marjorie W. Hertford assisted in the tabulation and analysis of these data and in the preparation of this report. Assistance in conducting part of the physical examinations was rendered by Nurse Blanche Bohland. Laboratory analyses of blood and urine samples were made in the field by Senior Medical Technician H. O. Proske.

Wassermann and Kahn tests were made on blood samples by the National Institute of Health and the laboratory division of the Connecticut State Board of Health.

ANNOTATED BIBLIOGRAPHY

To facilitate reference to the literature on chronic mercurialism resulting from the inhalation of mercury vapor and other subjects discussed in this bulletin a brief description of the contents has been appended to each bibliographic citation. This bibliography includes a number of papers which have been consulted and found useful during the preparation of this report but which have not been referred to in the text either because they did not contribute information dealing with the question under discussion or because they contained essentially the same information as other articles based on larger numbers of cases. The annotations are intended to indicate what sort of information may be sought for profitably in each article. So far as possible, no information that can be gained from the title has been repeated in the annotation, and consequently the length of the note is no measure of the merit of the article.

Three of the papers listed here represent three phases of a medical study of 138 employees of a mercury smelting plant in Nikitovka in the Donetz Valley of the Union of Soviet Socialist Republics. Dunajewsky and Peissachowitsch (12) reported the blood findings, Reiselman (18) reported on the condition of the digestive tract and cardiovascular system, and Weger (23) reported the neurological findings. Exposure to mercury vapor was heavy and a large proportion of the employees were found to be suffering from acute, sub-acute, or chronic mercurialism. They describe more advanced cases than do most other writers.

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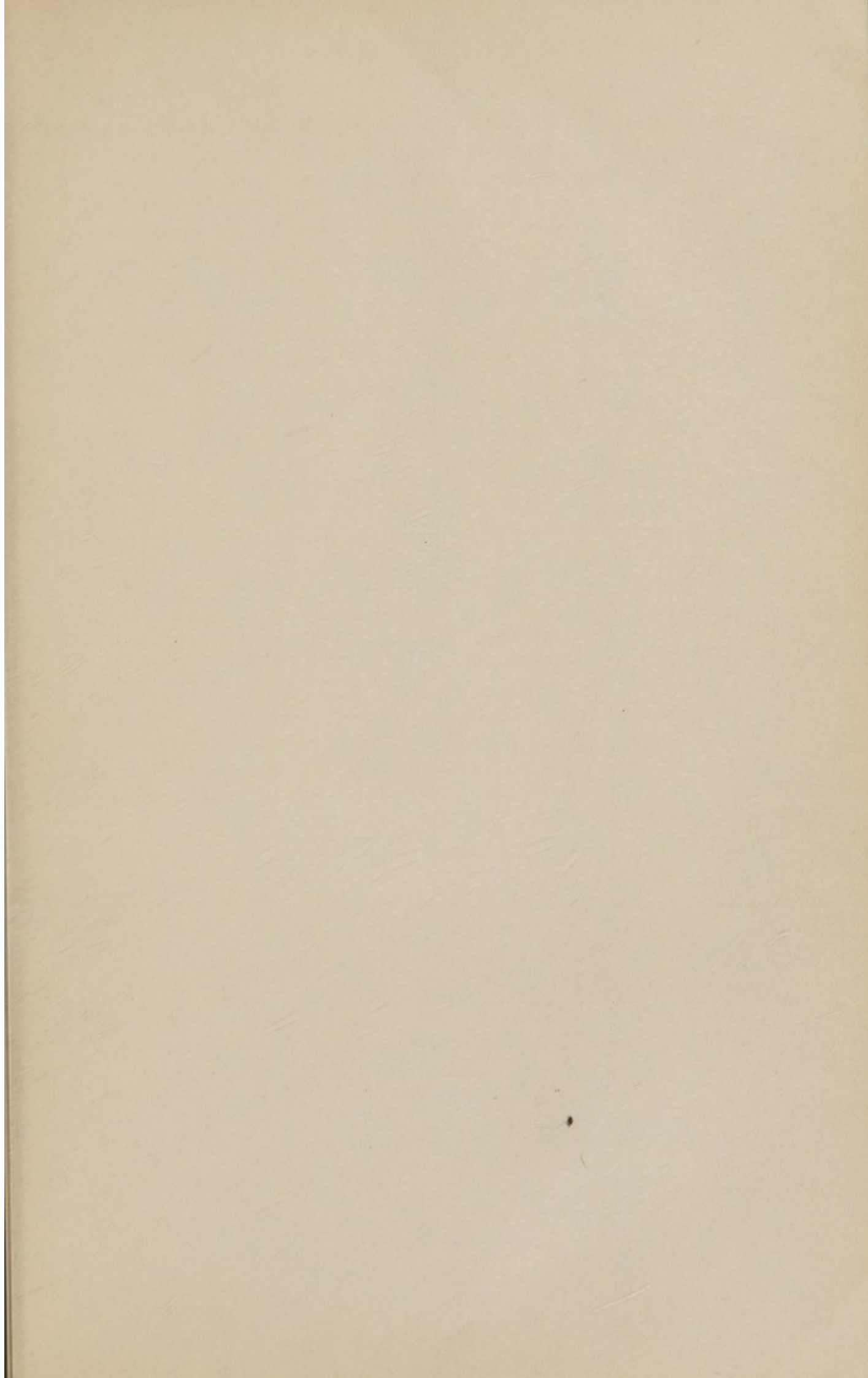
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