DUST EXPOSURES DURING THE CUTTING AND MACHINING OF ASBESTOS/CEMENT PIPE

ADDITIONAL STUDIES

Prepared for

The A/C Pipe Producers Association
1600 Wilson Boulevard
Suite 1308
Arlington, Virginia 22209

Prepared by

Equitable Environmental Health, Inc.
2020 Milvia Street
Berkeley, California 94704

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EXHIBIT E

INTRODUCTION

On March 16, 1977, Equitable Environmental Health, Inc., submitted a draft report to the A/C Pipe Producers Association which provided quantitative data on dust exposures during field operations in which sewer and pressure pipe were subjected to a number of typical field cutting and machining operations. A final report on the above was completed in July 1977, and the results have been incorporated in recommendations for work practices in the handling of A/C pipe.

On July 12, 1977, the Association requested additional studies of dust exposures involving other field operations. These also included a quantitative estimation of potential exposures to quartz.

STUDY DESIGN & OPERATIONAL PLAN

Determination of airborne asbestos fiber concentrations. Airborne fiber concentrations were determined during the following operations:

(1) Unloading pressure pipe at work site

(2) Laying pressure pipe in trench

(3) Cutting operations

a. Cutting with manual saw (pressure pipe)

b. Cutting with snap cutting equipment (pressure and sewer pipe)

c. Cutting with abrasive disc wet (pressure and sewer pipe)

(4) Machining operations

a. Cutting and machining with Doty tool (pressure and sewer pipe)

b. Use of tapering tool (air duct pipe)

c. Machining differing sizes of pressure pipe (4", 8", and 16") with manual lathe

(5) Hole cutting

a. Use of drill and rasp (pressure and sewer pipe)

(6) Tapping operations

a. Dry tap with Mueller J (pressure and sewer pipe)

b. Wet tap with Mueller B-100 (pressure and sewer pipe)

(7) Coupling removal (i.e. removing pipe from line)

a. Hammer and chisel (pressure and sewer pipe)

It was not possible to set up a cutting operation with a water-cooled masonry (radial arm) saw, or to remove pipe from a line with a sabre saw.

Determination of quartz. Samples of total and respirable dust integrated over a number of operations were collected and analyzed for quartz.

METHODS

Each operation, when performed in the field, is of short duration compared to an 8-hour workday. Consequently, the OSHA ceiling standard, intended to cover short periods of relatively intense exposure, would be more likely to be exceeded than would be the 8-hour time weighted average (TWA) standard. A sampling period of 15 minutes is regarded as suitable for determining "peak" or ceiling exposures while at the same time obtaining an adequate sample for analysis.

Most of the cutting and machining operations took less than 15 minutes; some required less than a minute. In these cases it was decided to perform the same operation several times during the sampling period. The times will be indicated.

For each operation, except as otherwise indicated, three replicate short-term breathing zone samples were collected for the operator and for his helper.

Simultaneously, longer-term personal samples were collected on the operator and his helper, over a period of two to three hours and covering more than one type of field operation. Also, integrated area samples were collected at a site approximately 15 feet away and downwind (if there was air movement). Other area samplers located 1 to 5 feet from the field operations were used to collect total dust and respirable dust by weight. Samples used for total dust were changed every 4 hours; those for respirable dust every 8 hours. Three such samples were used to determine quartz content. Background samples were collected before and after each day's operations.

Air samples were collected on 37-millimeter diameter, 0.8 micron pore size Millipore cellulose ester membrane filters in accordance with OSHA and NIOSH recommendations. They were all "open-face" (with the cover of the filter cassette removed) samples. Personal sampling pumps were operated at flow rates ranging from 1.6 to 2 liters per minute. The pumps were calibrated by the soap bubble technique before use. Both area and personal (breathing-zone) samples were taken. In the latter, the pump was attached to the worker's belt and the filter clipped to his lapel near his face. Figure 1 in the July, 1977 Report illustrates worker and helper with samplers in place. Figure 2 in the same report shows the test site with area samplers located near the operation.

Asbestos fiber counts were done by an experienced and accredited technician, following OSHA and NIOSH methods. The same technician was employed who had worked in the earlier A/C pipe study. Briefly, the analytic procedure consisted of rendering the filter transparent with a high viscosity solution of membrane filter material in a mixture of diethyl oxalate and dimethyl phthalate. The asbestos fibers which lie on the surface of the filter are counted with a phase contrast microscope at 400x magnification. The count area was delineated with a Porton graticule. Only fibers exceeding 5 micrometers in length were counted. The laboratory examined 100 microscopic fields or counted 100 fibers, whichever came first. Fiber identification depended upon a particle having an aspect ratio of at least 3:1 and having approximately parallel sides. No attempt was made to identify individual fibers mineralogically in view of the known chrysotile and crocidolite content of the material under examination. Fibers which appeared not to be asbestos were noted when seen. No estimate was made of the number of fibers less than 5 micrometers in length, nor the number in the electron microscope range. Samples were stored for such studies if they should appear desirable at some later time.

It should be emphasized that estimates of fiber concentrations below 5 fibers/cc are subject to increasing lack of precision, and that those below 0.5 fibers/cc have a wide margin of error, often being based on the observation of very few fibers. For example, in a 15 minute sample, one fiber observed per 100 fields is equivalent to 0.05-0.07 fibers/cc, which is the approximate lower limit of detection for this sampling period. Although counts are reported as calculated, to two decimal places, small differences in counts in these ranges should not be overinterpreted. A zero count merely means that the count was too low for any fibers to be seen in 100 fields and is consistent with a very low concentration of airborne fibers. Samples for gravimetric dust concentrations were weighed in the laboratory of EEH. Quartz analyses were performed by George Clayton Associates.

Performance of study. As in the previous study, all of the operations were carried out on the premises of Pilot Mfg. Co., a manufacturer of A/C pipe equipment in Torrance, California, except for unloading and placing in trench which were done on a job site in Alameda County, California. A workman experienced in the use of the tools performed the individual operations, with a helper provided by EEH. EEH independently purchased the necessary sewer pipe and pressure pipe for cutting and machining from a local supply house. All pipe was 8 inches in diameter unless otherwise specified. As before, no engineering dust control or local ventilation was utilized, except when this was built into the equipment being used (as was true for some of the tests using the Doty tool, and when wetting was added to the use of the abrasive disc).

GENERAL DESCRIPTION OF OPERATIONS

The study, except for unloading and pipe-laying operations, was carried out ring the period October 1-15, 1977. Mrs. Barbara Kawahara was the industrial ygienist, and she was assisted by Mr. Jerry Flanery of the EEH staff. The eather during the period was in general overcast, with clearing skies in mid-orning. Temperatures during the test periods ranged from 16-21° C (60 to 70° F). here was relatively little breeze in the mornings, with gusty breezes up to or 10 mph in the afternoons.

Housekeeping. In order to minimize contamination of the test area with st and scrap, a commercial vacuum cleaner was brought in to maintain a clean rk area. Unfortunately, it was ineffective because of a worn gasket, and blew sible dust from its exhaust. It was necessary to wet down the area periodi-ly and sweep up loose scraps and dust.

DETAILED DESCRIPTION OF OPERATIONS AND SAMPLING TIMES

(1) Unloading. This was done with a palletized load, using a fork-lift (Figures 1 & 2). The pipe was arranged on 4 foot pallets, 8 per bed, plus miscellaneous short lengths and couplings. It took approximately 15 minutes to unload a two-bed truck. Up until three or four years ago, it had been customary for the pipes to be loaded individually by being rolled down skids. To unload a two-bed truck in this manner took about 2 hours.

For this operation a single 24-minute personal sample was collected on the fork-lift operator while pressure pipe was being unloaded.

(2) Laying pipe in trench. The operation which was studied involved trenching, laying pipe, and filling simultaneously (Figures 3-5). One worker remained in the trench at the forward end of the pipe. The second worker worked both topside and in the trench. He attached a clamp to the pipe, lubricated the end, then got into the trench to help guide it into place for coupling. Two 1-1/2 hour samples were collected by personal samplers placed on the two workers.

(3a) Cutting with manual saw. (Figure 6). Due to the inability to procure an appropriate bow saw blade, a standard hack saw was used with a hardened steel blade. The blade was changed before each run. Sampling times ranged from 12 to 15 minutes, during which time it was possible to cut about one-half way through the 8" pressure pipe. This tool was not used with sewer pipe.

(3b) Cutting with snap cutting equipment. For this portion of the study a Wheeler Chain Cutter (Model 2990) was used. It has cutting discs mounted on a chain which is wrapped around the pipe (Figures 7 & 8). The action is controlled hydraulically by an operator who can stand as far as 10 to 15 feet from the pipe being cut. The set-up between cuts took about two minutes. Pumping to build up pressure required about 15 seconds. Five to 8 cuts were made during each sampling period; the average ranged from 14 to 16 minutes for sewer pipe and 13 to 16 minutes for pressure pipe.

(3c) Cutting with abrasive disc, wet. A gasoline-powered abrasive disc saw (Stihl) with a 10-inch carbide blade was used (Figures 9-11). Four 1/4 inch diameter plastic hoses were mounted on the housing of the saw, two on a side as shown in Figure 10, in accordance with TAC Ltd. blueprints provided by AACPP. These were connected to a manifold to which was attached a hose delivering water at a rate of 2 to 3 gallons per minute.

A preliminary run was with a saw that proved to be underpowered, requiring 18 minutes for two cuts. With a more powerful saw (1-1/2 hp motor) a cut could be completed in approximately 1-1/2 minutes. Two to 3 cuts were taken per sample, the sampling periods having been reduced to 3 to 6 minutes after an initial test sampling period of 17 minutes had led to overloading of the filter with dust. ıis test was run on pressure pipe only.

(4a) Cutting and machining with Doty tool. The Doty tool (Figures 12-15) has two operating stations, one for cutting, and one for machining. It has three operating modes: dry, dry with shroud, and wet with shroud. The last two modifications were to reduce dust generation and dispersion. During tests of the tool in the dry mode with shroud and wet mode with shroud, a plastic ıag was placed over the blade to reduce dust (Figure 13).

All cuts were made wet, because a diamond blade is used. A fine spray of ıater is directed across the blade during operations. About one-half minute s required for a single cut.

Machining was done dry with no shroud, dry with shroud, and wet with hroud. Again for the wet mode, a fine spray was used. Machining took about minute. Most of the sampling time involved moving pipe. Use of the Doty ɔol is essentially a one-man operation, a helper being needed only to move ırge pipes.

Two to four cuts and two to four machine operations were completed per sample cycle. Sampling time was reduced from approximately 15 minutes to approximately 10 minutes for the dry mode because it raised visible dust. It was observed that on the dry mode with shroud tests, visible dust was released during bevelling. It is suggested that a gasket or some other seal would be helpful in preventing this.

Sampling times recorded for the use of the Doty tool, wet, for pressure pipe were 10 to 11 minutes and for sewer pipe 9 to 15 minutes. For use of Doty tool, dry with shroud, with pressure pipe the sampling times were 13 to 17 minutes, and for the sewer pipe 12 to 14 minutes. For the use wet with shroud, 13 to 18 minute sampling times were employed for pressure pipe, 12 to 16 minutes for sewer pipe.

(4b) Use of tapering tool with A/C air duct pipe. Test of the tapering tool (Figure 16) was limited to 10-inch A/C air duct pipe, which has a thickness of approximately 1/4 inch. Its operating principle is similar to that of the manual field lathe. Sampling times ranged from 14 to 22 minutes which included one cut and one tapering operation.

(4c) Machining with manual lathe on differing sizes of pipe. In order to determine whether or not the size of pipe had a detectable influence on dust production, a manual lathing operation was carried out on pressure pipe of 4-inch, 8-inch, and 16-inch diameter (Figures 17 & 18). For the 4-inch pipe there was one cut and one machining for each sample, set-up requiring about 3 minutes, cut requiring about 3 minutes, second set-up about 4 minutes, and machining about 8 minutes, the sampling times for the three replications being 13 to 21 minutes.

For 8-inch pipe, again one cut and one machining was carried out for each sample, the set-up requiring about 3-1/2 minutes, the cut about 2 minutes, second set-up requiring about 2 minutes and machining about 10 minutes. The replicate samples ranged from 19 to 21 minutes. For the 16-inch pipe there was one partial cut per sample; each sample included some machining and some cutting. The set-up required 3 minutes, the cutting about 12 minutes, the second set-up about 2 minutes, and machining about 20 minutes.

(5a) Hole cutting with drill and rasp. For this operation (Figures 19-21) 5/8-inch holes were drilled on the pipe in a circular pattern of about 6 inches in diameter, after which the central portion was knocked out with a hammer and the rough edges smoothed with a rasp. The operator used the exhaust air from the drill to blow off excess dust (Figure 22). Although the practice of "blowing" asbestos-cement dust is not recommended, it was used in this instance to duplicate "worst possible" work practices or tool performance characteristics. The drilling took a long time to complete, so that only about 3/4 of the circumference was finished in one sampling period. Therefore, some samples did not include the hammer and file steps. Sampling times for pressure pipe ranged from 16 to 24 minutes, for sewer pipe from 17 to 21 minutes.

(6a) Tapping operations with Mueller J tool. (Figure 23). The Mueller J tool is used for tapping pipes, not pressurized, at the trench top or in the trench. In the latter case, a hole is dug to expose the pipe, but for the test, a pipe which had not been installed was employed. A manually operated tool was used, which cuts a hole and threads it. Two one-inch holes were cut per sampling period. Sampling periods for pressure pipe were 14 to 19 minutes.

(6b) Tapping operations with Mueller B-100 tool. The Mueller B-100 tool (Figure 24) is used for tapping pipes already in line, usually those under pressure. It has a pressure chamber to keep the water from flowing out during the tests. At the recommendation of the local Mueller representative, this chamber was filled with water to simulate "wet" conditions during the tests. There were two holes cut per sampling period; the sampling times were 14 to 19 minutes.

(7a) Removal of coupling with hammer and chisel. For pressure pipe, a hammer and chisel were used to make a longitudinal trough in the coupling (Figure 25). When this had been completed, a crowbar was used to separate the coupling. For pressure pipe this took about 22 minutes, one coupling being removed per sample. With sewer pipe, the same procedure took about 10 minutes per sample. It was soon found that by placing the chisel midline on the coupling, one or two sharp hits would split the coupling, a procedure which took only 10-30 seconds per coupling. For sewer pipe, 3 to 4 couplings were cut per sample, the major portion of the sampling time being during moving pipe and securing it to supports.

Order of tests. Availability of equipment and efficient use of pipe and manpower led to the actual tests being carried out in an order different from that summarized in the foregoing outline. The order of testing was as follows:

Monday, October 10, 1977

Cutting with snap cutting equipment, pressure pipe (3b)
Cutting with hack saw, pressure pipe (3a)
Machining with manual lathe, 8-inch pressure pipe (5c)
Machining with manual lathe, 4-inch pressure pipe (5c)
Machining with manual lathe, 16-inch pressure pipe (5c)
Hole cutting with drill and rasp, pressure pipe (5a)

Tuesday, October 11, 1977

Coupling removal, hammer and chisel, pressure pipe (7a)
Tap with Mueller J, pressure pipe (6a)
Tap with Mueller B-100, pressure pipe (6b)
Tap with Mueller B-100, sewer pipe (6b)
Tap with Mueller J, sewer pipe (6a)
Use of tapering tool on A/C air duct (4b)
Cutting with snap cutting equipment, sewer pipe (3b)

Wednesday, October 12, 1977

Cutting with hack saw, sewer pipe (3a)

Hole cutting with drill and rasp, sewer pipe (5a)

Cutting with abrasive disc, wet, pressure pipe (3c)

Removal of coupling with hammer and chisel, sewer pipe (7a)

Thursday, October 14, 1977

Cutting and machining with Doty tool, dry, pressure pipe (4a)

Cutting and machining with Doty tool, dry, shroud, pressure pipe (4a)

Cutting and machining with Doty tool, wet, shroud, pressure pipe (4a)

Cutting and machining with Doty tool, dry, sewer pipe (4a)

Cutting and machining with Doty tool, dry, shroud, sewer pipe (4a)

Cutting and machining with Doty tool, wet, shroud, sewer pipe (4a)

Friday, October 15, 1977

Cutting with abrasive disc, wet, pressure pipe (3c)

Cutting with abrasive disc, wet, sewer pipe (3c)

Testing at Bay Area site

Unloading pipe at site (1)

Laying pipe in trench (2)

Integrated long-term samples were taken as shown in the tables of results.

RESULTS

The short-term or peak exposures during the operations studied are shown in Tables 1-6. Integrated personal samples analyzed for asbestos fiber concentrations are shown in Table 7. Table 8 summarizes integrated area samples, which were studied for asbestos fiber concentrations, total dust, respirable dust, and quartz content, as shown. None of the respirable samples, i.e. samples collected with a pre-filter cyclone to remove large non-respirable particles, showed a measurable amount of dust sufficient for quartz analysis. Table 9 summarizes background levels.

DISCUSSION

Background levels, as in the previous study, were at the limit of sensitivity for the volumes of air and the methods employed. Ranging from below the level of detection to 0.07 fibers/ml, they indicate low concentrations, similar to those found in many earlier studies.

Short-term or peak exposures. All operations that were studied produced airborne concentrations far below the current short-term standard of 10 fibers/ml or the proposed short-term standard of 5 fibers/ml, except for some operations using the Doty tool and operations using the abrasive disc saw. Some operations using the Doty tool, particularly when used dry, although below the permissible concentrations for short-term exposures, would if continued over an 8-hour day, exceed the permissible time weighted average of 2.0 fibers/ml. It is, of course, unlikely that use would be continuous.

The abrasive disc saw, even when used wet, produced unacceptably high concentrations of airborne fibers, averages ranging from 10 to 65 fibers/ml. It is believed that use of water to cut down dust with this machine could be improved upon. Because the hose was attached to the housing and the latter could be rotated with respect to the handle of the saw, the water was not invariably directed to the cutting area. It was observed also that dust was generated within the pipe during the cutting and would exhaust from the ends of the pipe, and this could not be reduced by water applied to the outside of the pipe. Also, although the outside of the pipe was thoroughly wet, as the cut proceeded, the disc would generate heat and dry an area on either side of the blade. It is recommended that water be applied through a fine spray, spread over a wide field, so that nozzle placement would not be critical. We do not feel that the wet-cutting modification employed in our tests was designed to cover all conditions of tool positioning and usage, therefore the possibility of effective dust reduction with a proper method of wetting should not be ruled out.

The quartz analyses, which employed x-ray diffraction methods which would be used by OSHA and most industrial hygienists, showed more than 5% quartz in each of the total dust samples that were analyzed, specifically 5.7%, 9.0%, and 5.4%. The threshold limit value, i.e., the permissible time-weighted average for total quartz-containing dust, is $\frac{30\ mg/m^3}{\%\ quartz + 3}$. Therefore, in the three samples measured, the range of TWA's would have been from 1.6 to 2.6 mg/m^3. No concentrations this high were reported in the integrated samples collected during the current studies. The high levels reported in the previous survey were peak, not integrated samples.

Summary and Conclusions

Determinations were made of airborne asbestos fiber concentrations, total dust and respirable dust concentrations, and crystalline silica concentrations during a number of field operations used in the cutting, machining and installation of asbestos-cement pipe. These were designed to supplement studies reported in 1977, which showed that potential asbestos exposures during most operations were well below current occupational health standards, but that one tool, the abrasive disc saw, resulted in unacceptably high concentrations of fibers. In addition, short term concentrations of total dust suggested that if crystalline silica content was high, permissible levels might be exceeded.

The additional studies included a test of the abrasive disc saw with an attachment for wetting the area being cut, tests in which concentrations of crystalline silica were determined, as well as tests of several operations not previously studied. Specifically, the following operations were included: (1) unloading of pressure pipe at the work site; (2) laying pressure pipe in a trench; (3) cutting pressure pipe with a manual saw; cutting pressure and sewer pipe with snap cutting equipment; cutting pressure and sewer pipe with an abrasive disc, wet; (4) cutting and machining pressure and sewer pipe with a Doty tool, with various modifications, wet and dry; use of tapering tool on air duct pipe; machining differing sizes of pressure pipe (4-, 8-, and 16-inch), with a manual lathe; (5) hole cutting pressure and sewer pipe with drill and rasp; (6) dry tapping pressure and sewer pipe with a Mueller J tool, wet tapping pressure and sewer pipe with a Mueller B-100 tool; and (7) removing coupling from pressure and sewer pipe with hammer and chisel.

All operations that were studied produced airborne concentrations of asbestos far below the current short term OSHA standard of 10 fibers/ml (> 5um in length) and none would have exceeded a time-weighted average of 2 f/ml or even 0.5 f/ml if continued for a full working day except for (1) the abrasive disc saw and (2) some operations with the Doty tool when used dry. The abrasive disc, even when used wet, resulted in fiber concentrations ranging from 10 to 65 f/ml. It was concluded that better design of the wetting method was essential. The concentrations observed with the Doty tool, dry, were below short-term standards, and would have exceeded the time weighted average of 2 f/ml only in the unlikely event of being used continuously over a full work day.

Integrated total dust samples contained 5.7%, 9.0% and 15.4% quartz. This meant that permissible time-weighted averages would have ranged from 1.6 to 2.6 mg/cubic meter. The only integrated sample that exceeded the current OSHA standard was that collected during use of the abrasive disc saw.

These additional studies confirm that asbestos-cement pipe can be cut, machined, and installed without exceeding current and proposed OSHA standards, but that use of proper tools and adherance to recommended work practices are essential.

Table 1

Airborne Fiber Concentrations During
Unloading of Pressure Pipe and Laying Pipe in Trench

Operation	Duration (min)	Fibers/ ml
Unloading pipe	24	0.03
Laying pipe	92	0 *
Laying pipe	90	0.02
Background	32	0 *

*Below detectable limit.

Airborne Fiber Concentrations During Cutting Operations with Hack Saw, Snap Cutting, and Use of Abrasive Disc (Wet)

	A/C Pressure Pipe				A/C Sewer Pipe			
	Operator		Helper		Operator		Helper	
	Duration (min)	Fibers/ml	Duration (min)	Fibers/ml	Duration (min)	Fibers/ml	Duration (min)	Fibers/ml
Hack saw	15	0.06	15	0.05	18	0.11	16	0
	15	0	15	0.21	17	0.23	16	0.17
	12	0	12	0.07	15	0.19	15	0.06
Mean		0.01		0.11		0.18		0.08
Snap cutting	16	0	16	0	15	0	15	0.05
	14	0	13	0	15	0.07	14	0.06
	15	0.07	16	0	16	0.06	16	0.05
Mean		0.02		0		0.04		0.05
Abrasive disc (Wet)	17	30.4*	17	30.9*				
	6	60.1	5	54	5	95.3	5	14.4
	3	25.8	4	46	5	19.8	5	8.4
	4	109.1	5	47.5	6	11.3	6	7.8
Mean		65.0		49.2		42.1		10.2

*Filter overloaded, not used in calculating mean.

Table 3

Airborne Fiber Concentrations During Machining Operations

	A/C Pressure Pipe				A/C Sewer Pipe			
	Operator		Helper		Operator		Helper	
Operation	Duration (min)	Fibers/ml	Duration (min)	Fibers/ml	Duration (min)	Fibers/ml	Duration (min)	Fibers/ml
Cutting & Machining with Doty Tool								
Dry	11	3.75	11	1.37	15	1.13	15	0.32
	10	1.62	10	2.15	10	8.91	10	0.48
	10	0.32	10	3.18	9	1.44	9	0.08
Mean		1.9		2.23		3.83		0.29
Dry, Shroud	16	0.3	17	0.19	14	0.23	14	0
	13	1.56	13	0.24	13	0.25	13	0.06
	14	2.02	14	0.11	12	0.20	12	0.20
Mean		1.29		0.18		0.23		0.09
Wet, Shroud	18	0.18	17	0.47	14	0.17	14	0
	14	0.29	13	0.18	12	0.14	12	0
	16	0.15	16	0.15	16	0.30	15	0.11
Mean		0.21		0.27		0.20		0.04

'ne Fiber Concentrations
anual Lathe

Helper	
Duration (min)	Fibers/ ml
18	0
19	0
21	0.05
	0.02
22	0.07
20	0.24
21	0.07
	0.13
18	0.05
15	0.07
20	0.05
	0.06

Table 5

Airborne Fiber Concentrations During Use of Tapering Tool with A/C Air Duct Pipe

	Operator		Helper	
	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml
tool	14	0.28	14	0.06
r duct	23	0.13	22	0
	14	0.14	15	0
Mean		0.18		0.02

Table 6

Airborne Fiber Concentrations During Hole Cutting, Tapping Operations, and Coupling Removal

	Pressure Pipe				Sewer Pipe			
	Operator		Helper		Operator		Helper	
Operation	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml	Duration (min)	Fibers/ ml
ole Cutting with Drill and Rasp	24	0.18	24	0.08	21	0.28	21	0.25
	19	0.14	18	0.11	17	0.17	17	0.15
	16	0.33	17	0	17	0.23	18	0 *
Mean		0.22		0.06		0.23		0.13
ry Tap with Mueller J	14	0.06	15	0.06	18	0.07	15	0.05
	17	0.09	17	0.10	16	0.12	16	0
	19	0	19	0.05	15	0	15	0.05
Mean		0.05		0.07		0.06		0.03
et Tap with Mueller B-100	19	0.17	19	0.14	14	0.17	14	0
	13	0	18	0.20	18	0	16	0
	14	0.17	14	0.06	15	0	19	0
Mean		0.11		0.13		0.06		0
oupling Removal Hammer and Chisel	22	0.29	24	0.11	12	0.12	13	0.12
	16	0.30	15	0.12	12	0.07	13	0
	15	0.32	16	0.06	9	0	9	0.18
Mean		0.30		0.10		0.06		0.10

*Plus One (1) Glass Fiber

Table 7

Integrated Personal Samples Covering Successive Operations

Operation	Average Peak Counts: Operator Fibers/ml	Average Peak Counts: Helper Fibers/ml	Integrated Sample Counts: Operator Duration (min)	Operator Fibers/ml	Helper Duration (min)	Helper Fibers/ml
ıap cutting pressure	0.02	0	250	0.02	250	0.11
ıck saw, pressure	0.01	0.11				
:nual field lathe 8"	0.03	0.13				
nual field lathe 4"	0	0.02	228	0.08	229	0.02
nual field lathe 16"	0.02	0.06				
le drilling	0.22	0.06				
upling, hammer and chisel	0.3	0.1	275	0.05	279	0.04
eller J, pressure	0.05	0.07				
eller, B-100, pressure	0.11	0.13				
eller, B-100, sewer	0.06	0.0				
eller-J, sewer	0.06	0.03	226	0.06	226	0.02
ering tool, air-duct	0.18	0.02				
ing, snap-cutting	0.04	0.05				
:ting, hack saw, sewer	0.18	0.08	264	0.34	263	0.14
e drilling, sewer	0.23	0.13				
asive disc, wet, pressure*	4.30	0.79				
pling removal, sewer	0.06	0.10	132	0.05	178	0.03
y tool, dry, pressure	1.90	2.23	237	0.35	237	0.26
y tool, dry, shroud, pressure	1.29	0.18				
/ tool, wet, shroud, pressure	0.21	0.27				
/ tool, dry, sewer	3.83	0.29				
/ tool, dry, shroud, sewer	0.23	0.09				
' tool, wet, shroud, sewer	0.20	0.05				
sive disc, wet, pressure	65.02	49.15	69	5.84	74	5.80
sive disc, wet, sewer	42.1	10.22				

ɔr underpowered, only one test tried.

Table 8

Integrated Area Samples Covering Successive Operations

	Area Samples				
	Asbestos Fibers		Total Dust		
Operations	Duration (min)	Fibers ml	Duration (min)	mg/m^3	Quartz Content
tting pressure w cutting, pressure field lathe 8" pressure	251	0.57	252	0.33	11.1%
field lathe 4" pressure field lathe 16" pressure illing	234	0.04	235	0.31	
removal, hammer isel , Mueller J, pressure . Mueller B-100, ire Mueller B-100, sewer	286	0.02	290	0.34	
Mueller J, sewerpipe tool with A/C air ipe ting sewer pipe	225	0.02	233	0.00	
cutting, sewer pipe ling, sewer pipe ive disc, pressure	272	0.08	272	0.12	5.7%
removal, sewer pipe	17	0.02	191	0.79	

Table 8 Cont'd

Integrated Area Samples Covering Successive Operations

Operations	Area Samples: Asbestos Fibers Duration (min)	Asbestos Fibers Fibers ·ml	Total Dust Duration (min)	Total Dust mg/m^3	Quartz Content
Cutting and machining, Doty dry pressure; Cutting and machining, dry, shroud, pressure; Cutting and machining, wet, shroud, pressure; Cutting and machining wet, shroud, pressure; Cutting and machining dry, sewer; Cutting and machining dry, shroud, sewer; Cutting and machining wet, shroud, pressure	238	0.03	240	0.20	Not Determined
Abrasive disc wet, pressure pipe; Abrasive disc wet, sewer pipe	80	3.83	82	1.66	15.4%

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Table 9

Airborne Fiber Concentrations Before and After Operations
(Background Levels)

Date and Time	Duration (min)	Fibers/ ml
October 10, 1977 am	55	0*
October 10, 1977 pm	67	0.02
October 11, 1977 am	72	0.07
October 11, 1977 pm	85	0.0
October 12, 1977 am	72	0.01
October 12, 1977 pm	75	0
October 14, 1977 am	129	0.002
October 14, 1977 pm	51	0
October 15, 1977 am	72	0.01
October 15, 1977 pm	32	0

*Below detectable limit.

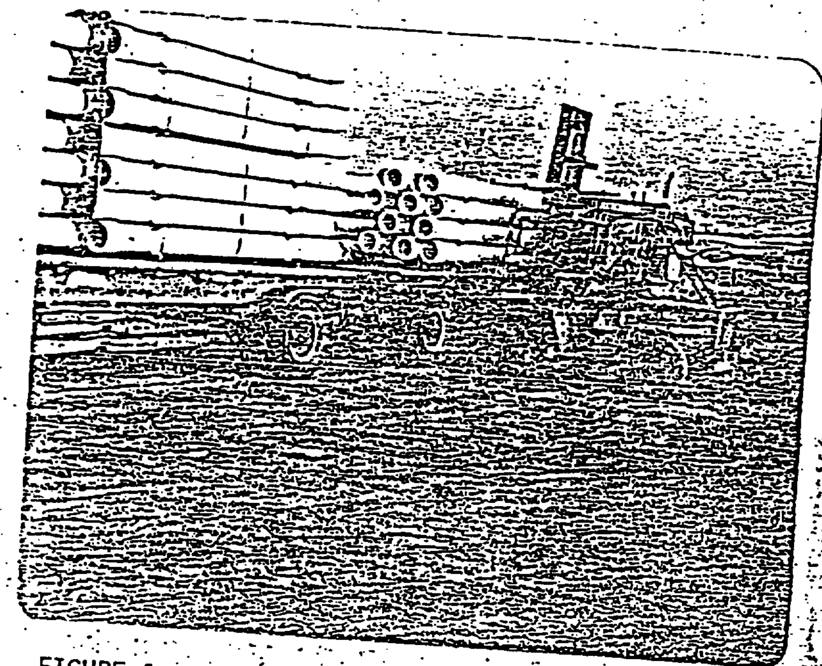

FIGURE 1. Unloading 8-inch pressure pipe at work site.

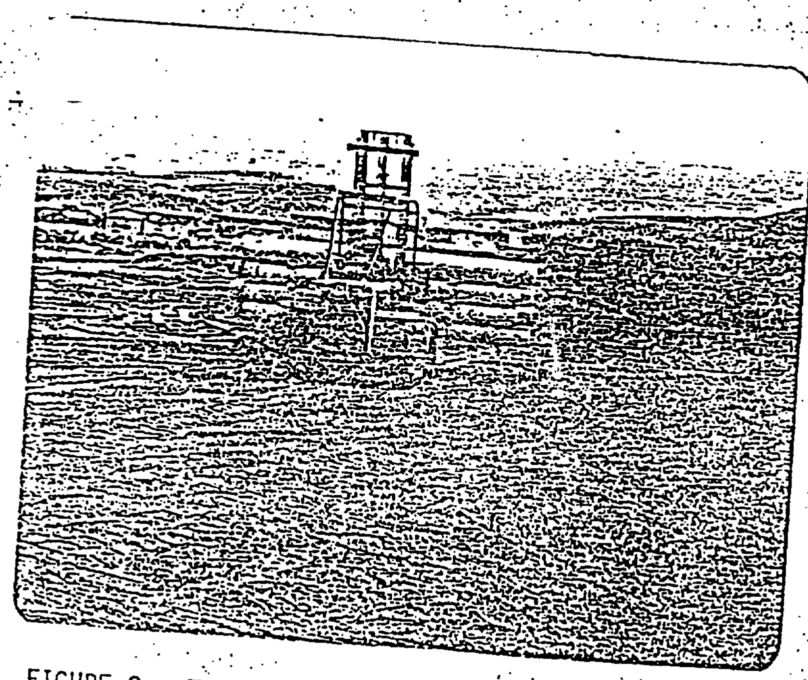

FIGURE 2. Transporting 8-inch pressure pipe from truck to trench.

1.

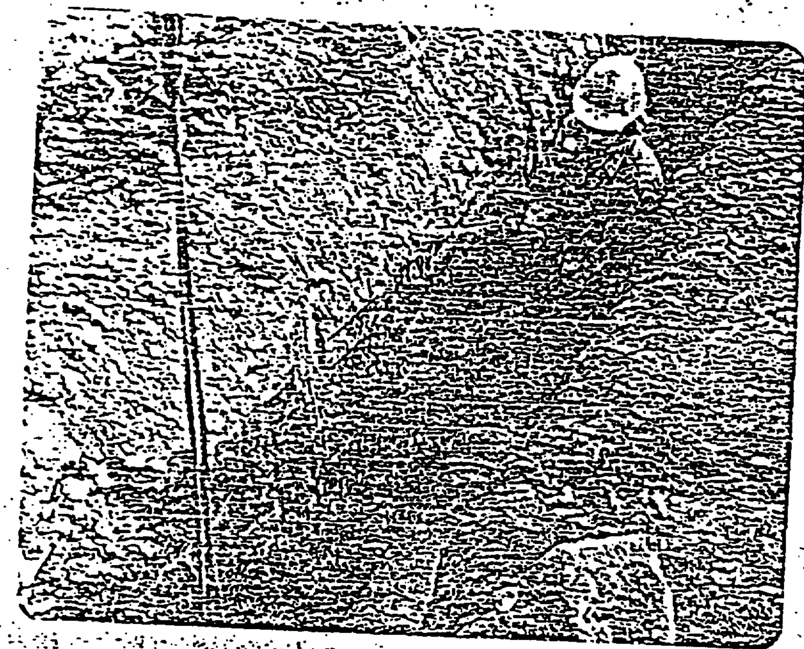

FIGURE 5. Positioning in trench.

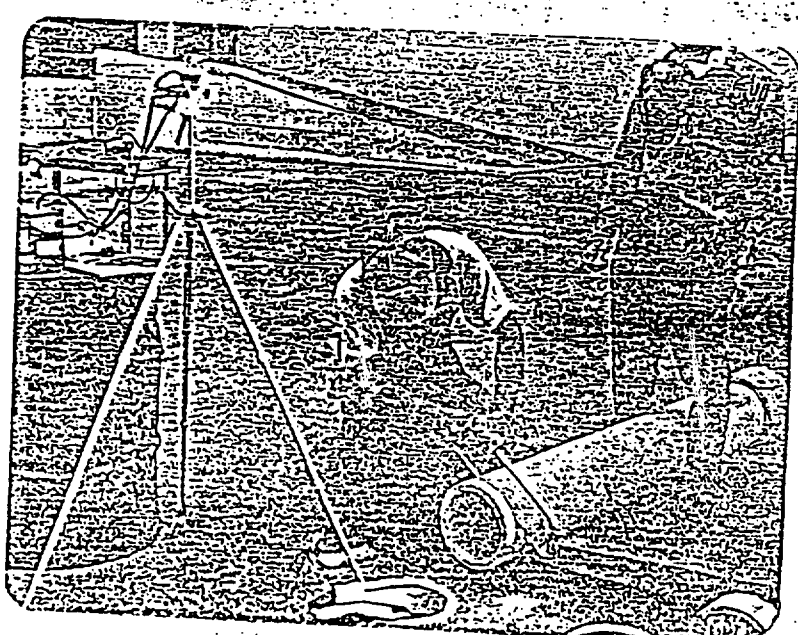

FIGURE 6. Cutting with hack saw.

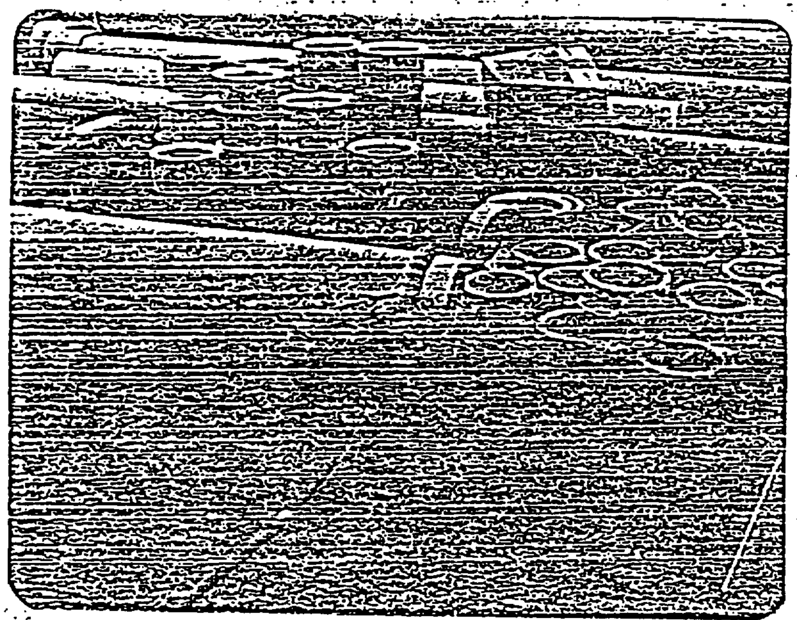

FIGURE 7. Snap cutting tool.

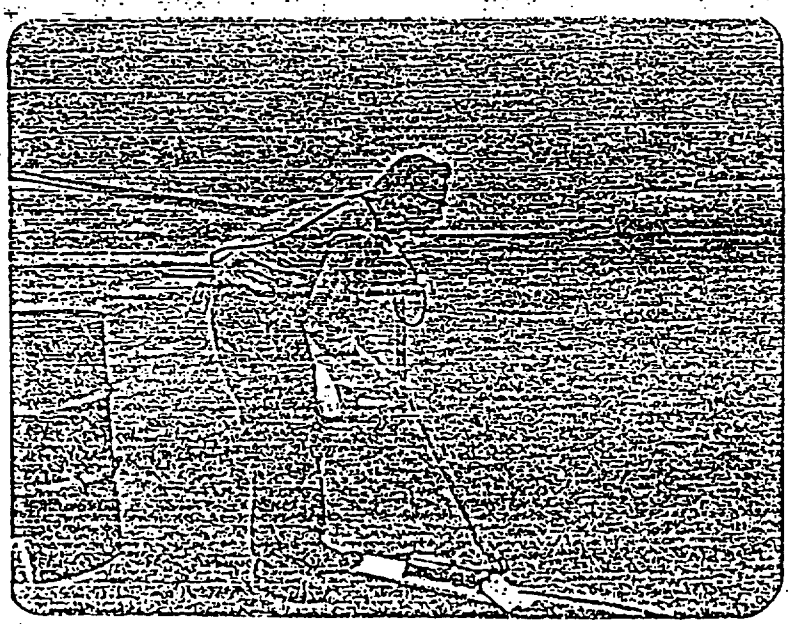

FIGURE 8. Hydraulic control of snap cutting equipment.

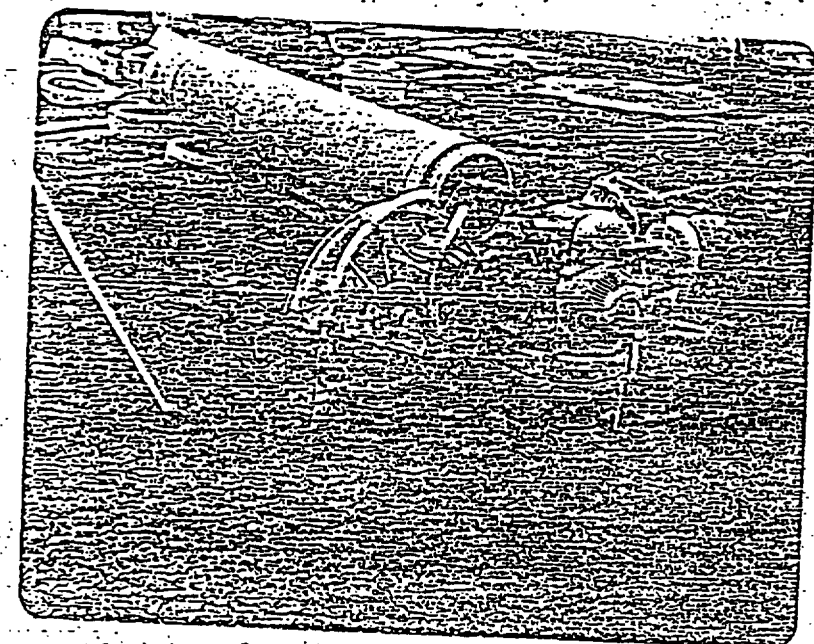

FIGURE 9. Abrasive disc saw with hoses for wet cutting.

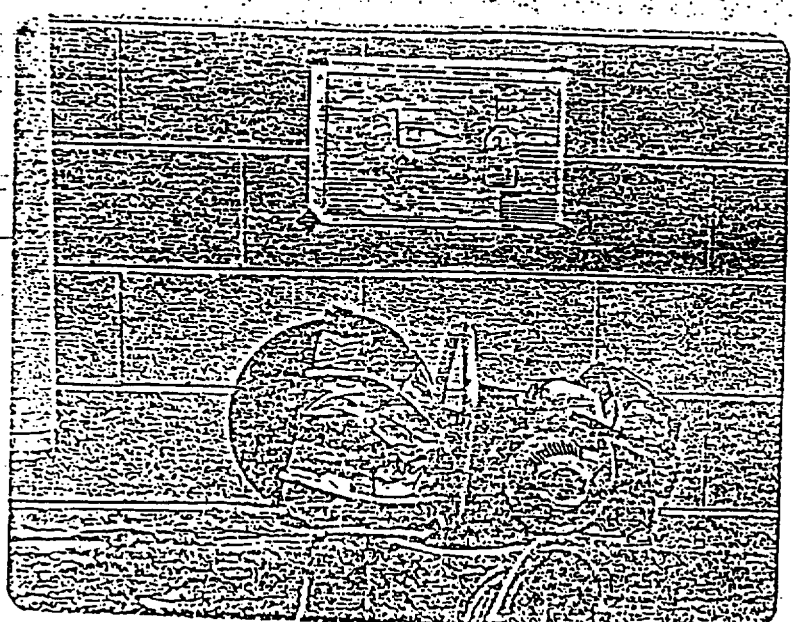

FIGURE 10. Abrasive disc saw with hoses for wet cutting.

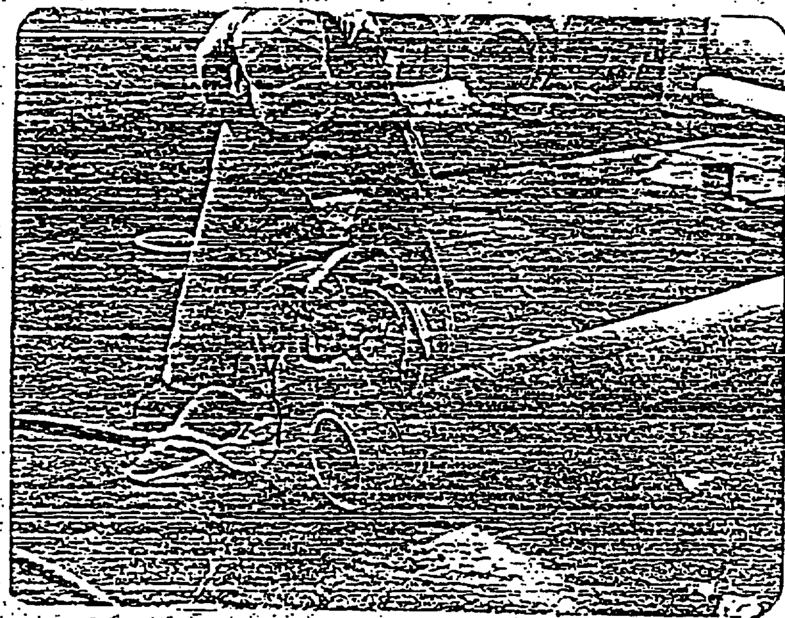

FIGURE 11. Use of abrasive disc saw, wet.

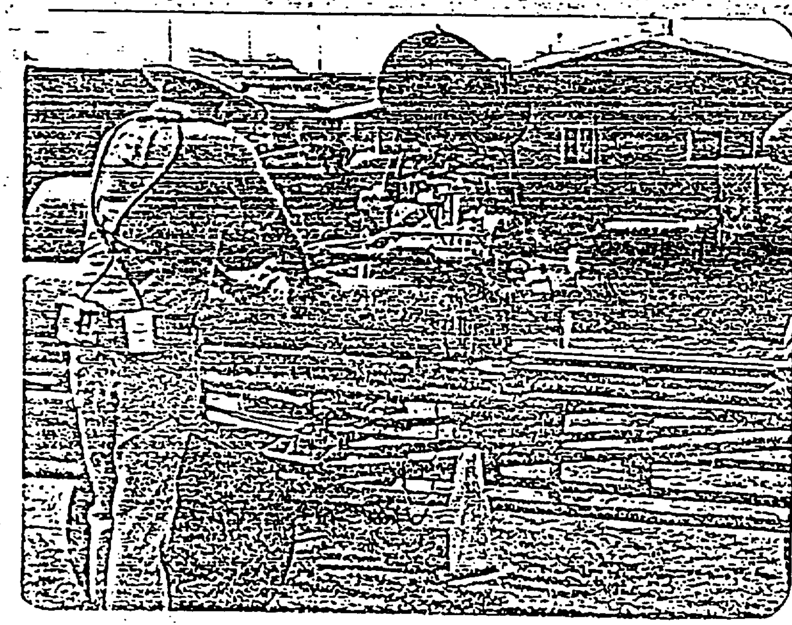

FIGURE 12. Doty tool, cutting.

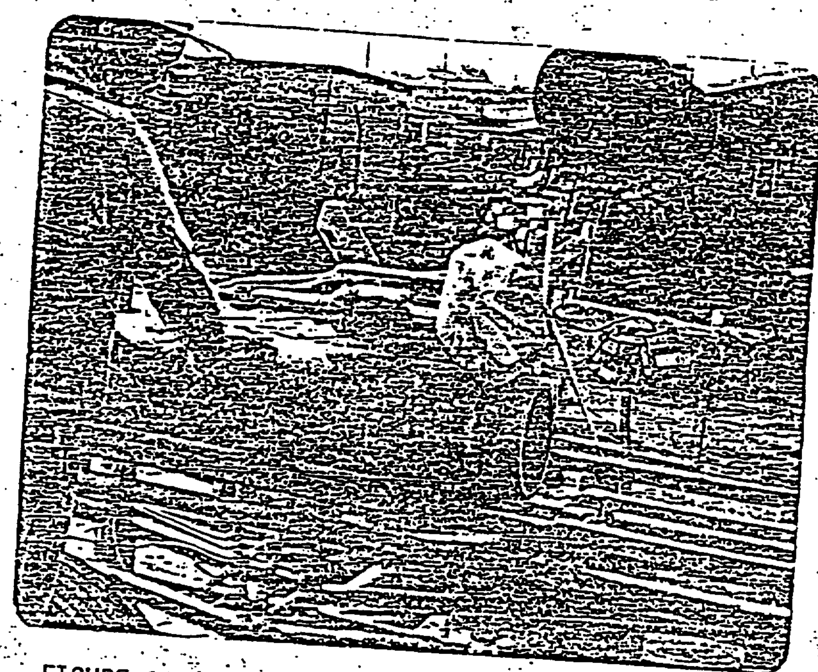

FIGURE 13. Doty tool, cutting, with bag around blade.

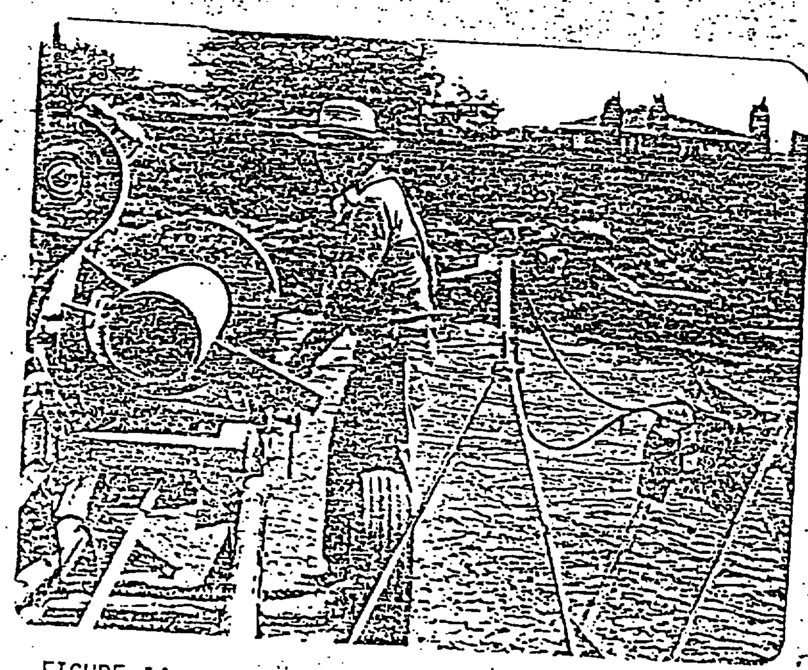

FIGURE 14. Doty tool, machining with shroud.

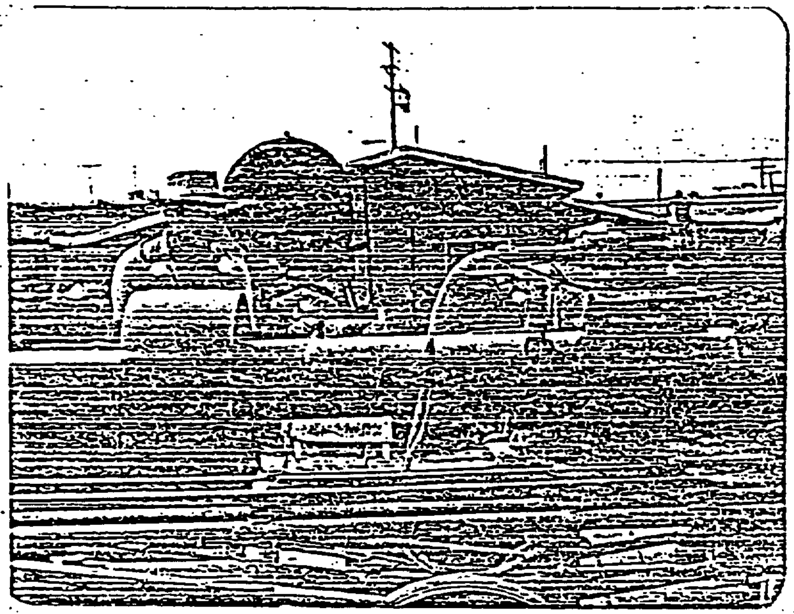

FIGURE 15. Doty tool, machining dry without shroud.

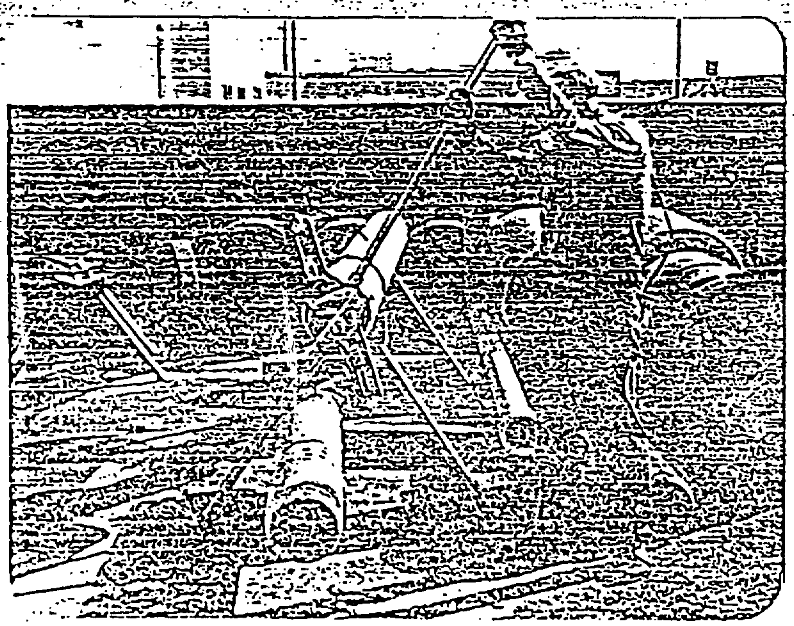

FIGURE 16. Tapering A/C air duct.

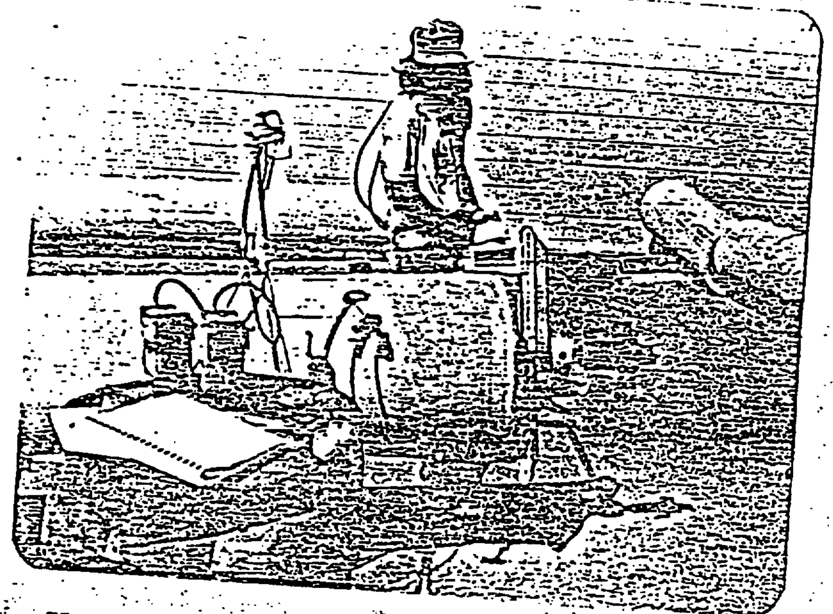

FIGURE 17. Use of manual lathe on 16-inch pressure pipe.

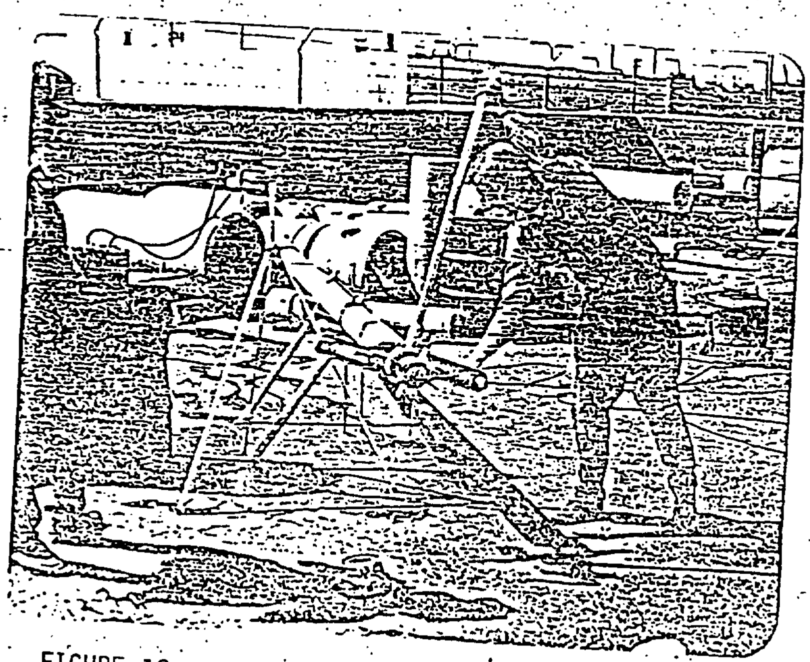

FIGURE 18. Use of manual lathe on 4-inch pressure pipe.

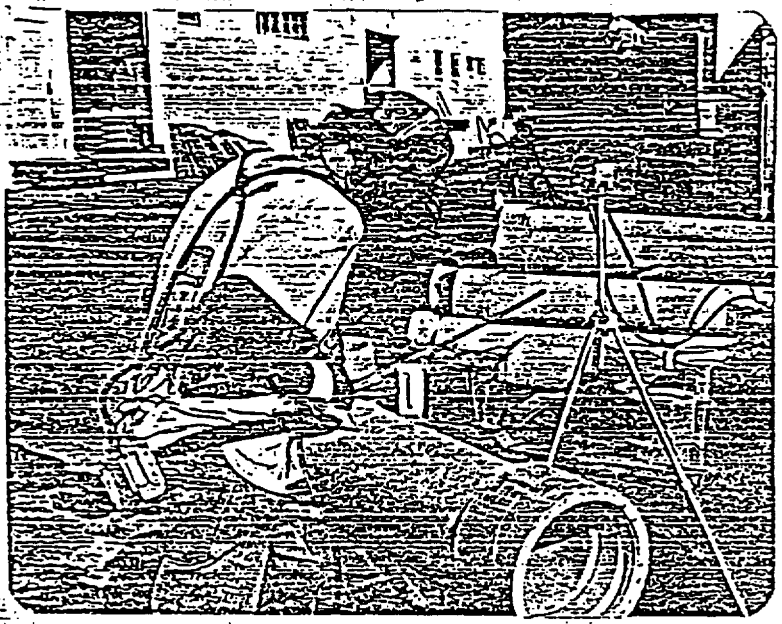

FIGURE 19. Cutting hole with drill.

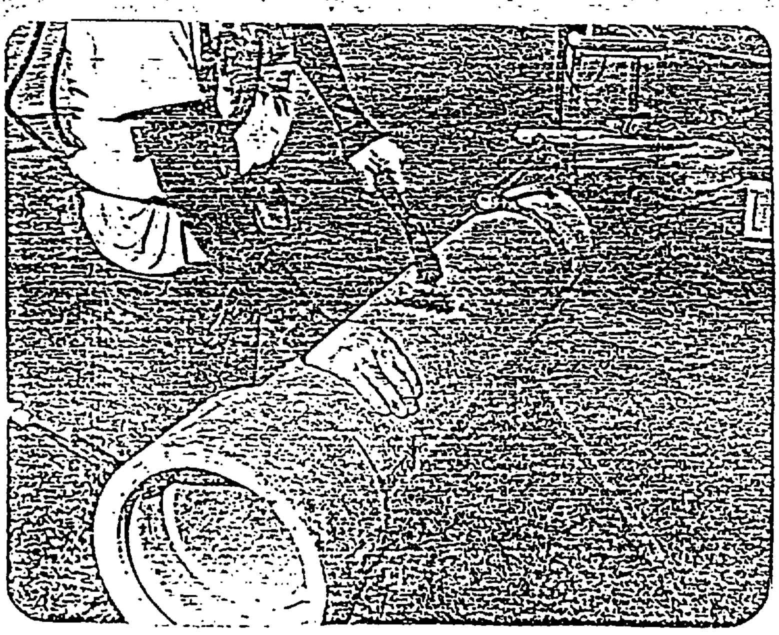

FIGURE 20. Knocking central portion with hammer.

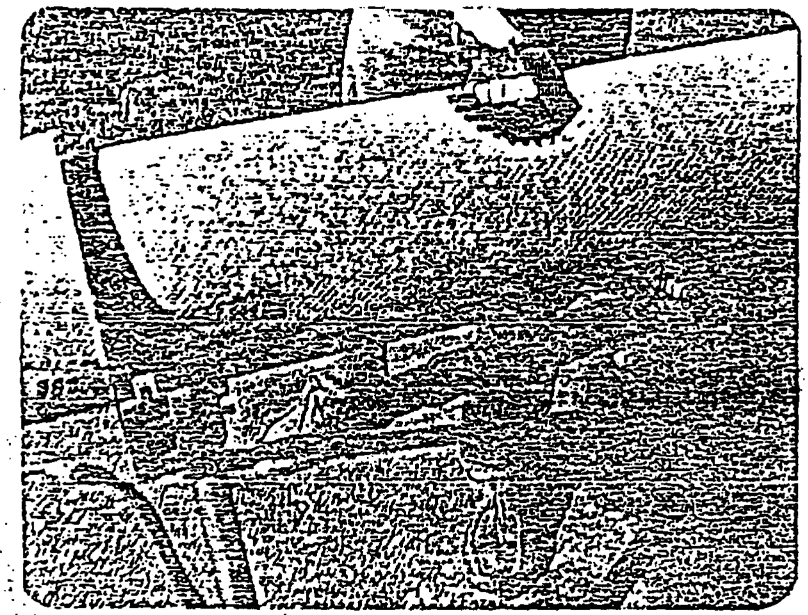

FIGURE 21. Smoothing rough edges with rasp.

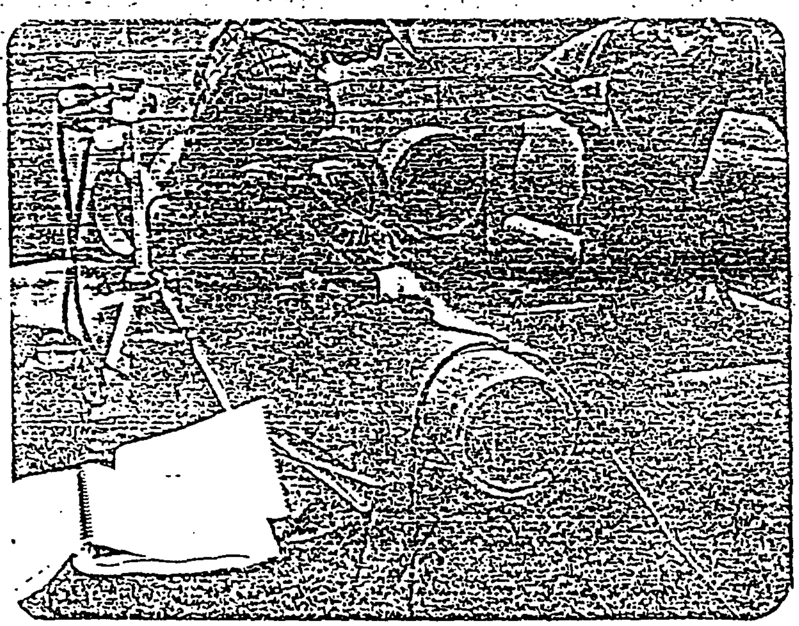

FIGURE 22. Blowing dust with exhaust.

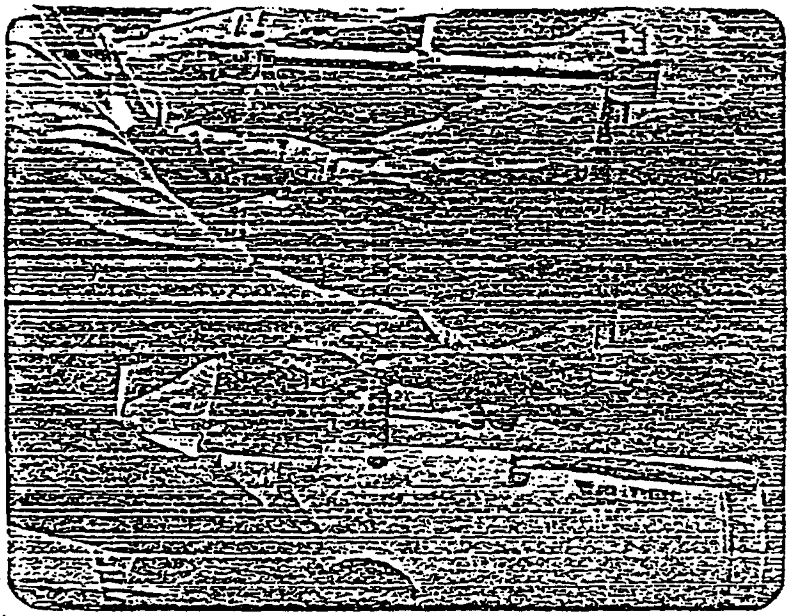

FIGURE 23. Use of Mueller J tool.

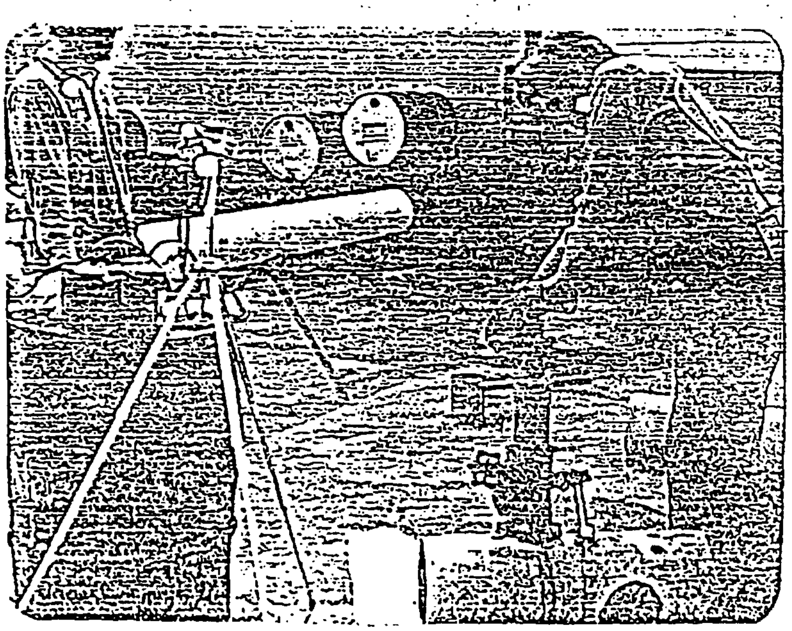

FIGURE 24. Mueller B-100 tool.

FIGURE 25. Removal of coupling with chisel.