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PRACTICES AND RESULTS OBTAINED WITH SAMPLE COLLECTORS FOR WAGON-DRILL CUTTINGS

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PRACTICES AND RESULTS OBTAINED WITH SAMPLE COLLECTORS FOR WAGON-DRILL CUTTINGS

By E. D. Gordon, C. F. Withington, and V. T. Dow

ABSTRACT

The U. S. Geological Survey has experimented with wagon drilling as a low-cost method of subsurface exploration on the Colorado Plateau. The wagon drill is a percussion-type drill mounted on a truck or half-track. Compressed air is used to operate the drill and to blow the cuttings from the hole. For the collection of the cuttings, three sample collectors have been tested.

One machine, designated as Machine A, is activated by a motor-driven, vacuum-type fan. Two units were tested extensively for about 6 months. Under the field operating conditions, sample recovery averaged about 67 percent. Initial cost for each unit was $722.61 and repair costs during operations were $141.00 for each unit.

The collector designated as Machine B was tested during a two-month period. Sample recovery averaged 91 percent; initial cost was $481.20; and repair cost during operation was negligible.

Machine C was tested for 4 months. Sample recovery averaged 96 percent; initial cost was $373.87 and repair cost during operation was negligible.

Continuous samples were collected by each sample collector, and geologic logs were made from examination of these samples. All samples which contained mineralized material as indicated by visual estimate or gamma-ray log were assayed. A comparison of the assay returns of samples collected from wagon drilling with those collected from diamond drilling showed a close correlation.

INTRODUCTION

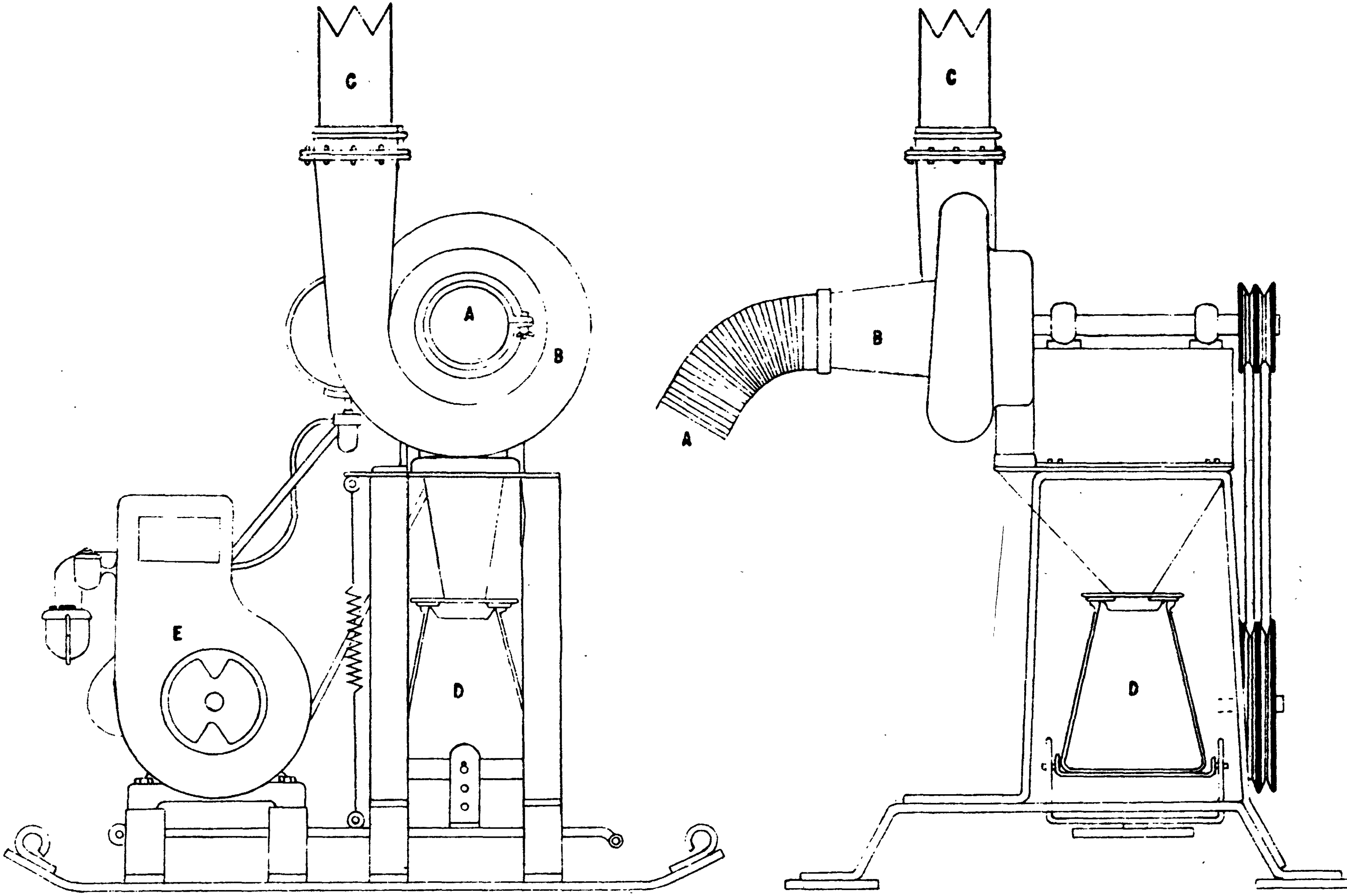
Since November 1947, the U. S. Geological Survey, on behalf of the Atomic Energy Commission, has been engaged in a program of exploration by diamond drilling for carnotite deposits in the Colorado Plateau. In order to adapt a cheaper and faster method of exploration in areas where the hole depth is less than about 150 feet, use is being made of the wagon drill. This report summarizes the practices and results obtained with three dust-collecting machines that were adapted as sample collectors for wagon-drill cuttings. The tests were not exhaustive, and it is possible that the effectiveness of each machine could be increased with minor modifications in equipment or technique. Certainly different results may be expected under different drilling conditions and perhaps in different drilling areas. It is also possible that there are other types of machines, or machines manufactured by other firms, that may yield better results. For these reasons, the machines used by the Geological Survey are only described by types and are not identified by trade names. This report merely gives data on the results obtained under the conditions and time of the tests.

The drilling was done in the Yellow Cat area, Grand County, Utah, from October 1951 to May 1952. The rocks cut by drilling consist of sandstones and interbedded mudstones of the upper part of the Salt Wash and the lower part of the Brushy Basin members of the Morrison formation. The wagon drills used on the drilling project consisted of pneumatic drills mounted on trucks or half-track vehicles for mobility. The pneumatic drills were supported on endless chain feeds attached to vertical guides. The feed mechanisms were actuated by air-driven motors. Compressed air, provided by 210 cubic-feet-per-minute compressors mounted on the vehicles, was used to operate the drills and air motors, blow the cuttings from the hole, and provide an air stream for operation of two of the three types of dust collectors tested. The round drill steel used was 1-1/8 inches in outside diameter and ranged in length from 9 to 20 feet. Drilling was done with 2-inch "cross" bits set with tungsten-carbide inserts, which drilled a hole slightly more than 2 inches in diameter. The average bit drilled about 1,800 feet of hole before it was worn out.

Percussion-type drilling with air is not new on the Colorado Plateau. Coffin (1921) mentioned the use of the jackhammer as the best method of prospecting for carnotite where the ore bodies lay within 25 feet of the surface. Wagon drills were first used on the Plateau about 1940; they have been widely used for exploration since 1948.

A covered tub or large pan, slotted to admit the drill rods, has been used by many private operators to collect wagon-drill samples. With this method, much of the dust from the cuttings escapes through the slots in the tub and cover, and constitutes a source of annoyance and a health hazard to the operators. The average recovery of drill cuttings is usually about 50 percent.

The relatively percentage of recovery thus obtained is generally satisfactory to the private operators, who are interested mainly in determining the presence or absence of mineralized material. The Geological Survey, on the other hand, needed a larger percentage recovery of cuttings in order to obtain representative assays of mineralized materials and reliable geologic logs of the holes.



Side View   Approximate scale 1 inch=7.2 inches   Front View

Figure 1. Sketch of Machine A showing component parts: (A) intake, (B) fan housing, (C) exhaust tube, (D) jar, and (E) motor. (Modified from Huleatt, 1952)

In order to obtain a higher percent recovery of rock cuttings from the wagon drill, and to protect the health of the operators, three dust-collecting machines were modified as sample collectors and tested by the Geological Survey. One machine, designated as Machine A, is activated by a motor-driven, vacuum-type fan. The other two machines, designated as Machine B and C, are both activated by compressed air.

DESCRIPTION OF THE SAMPLE COLLECTORS

Machine A

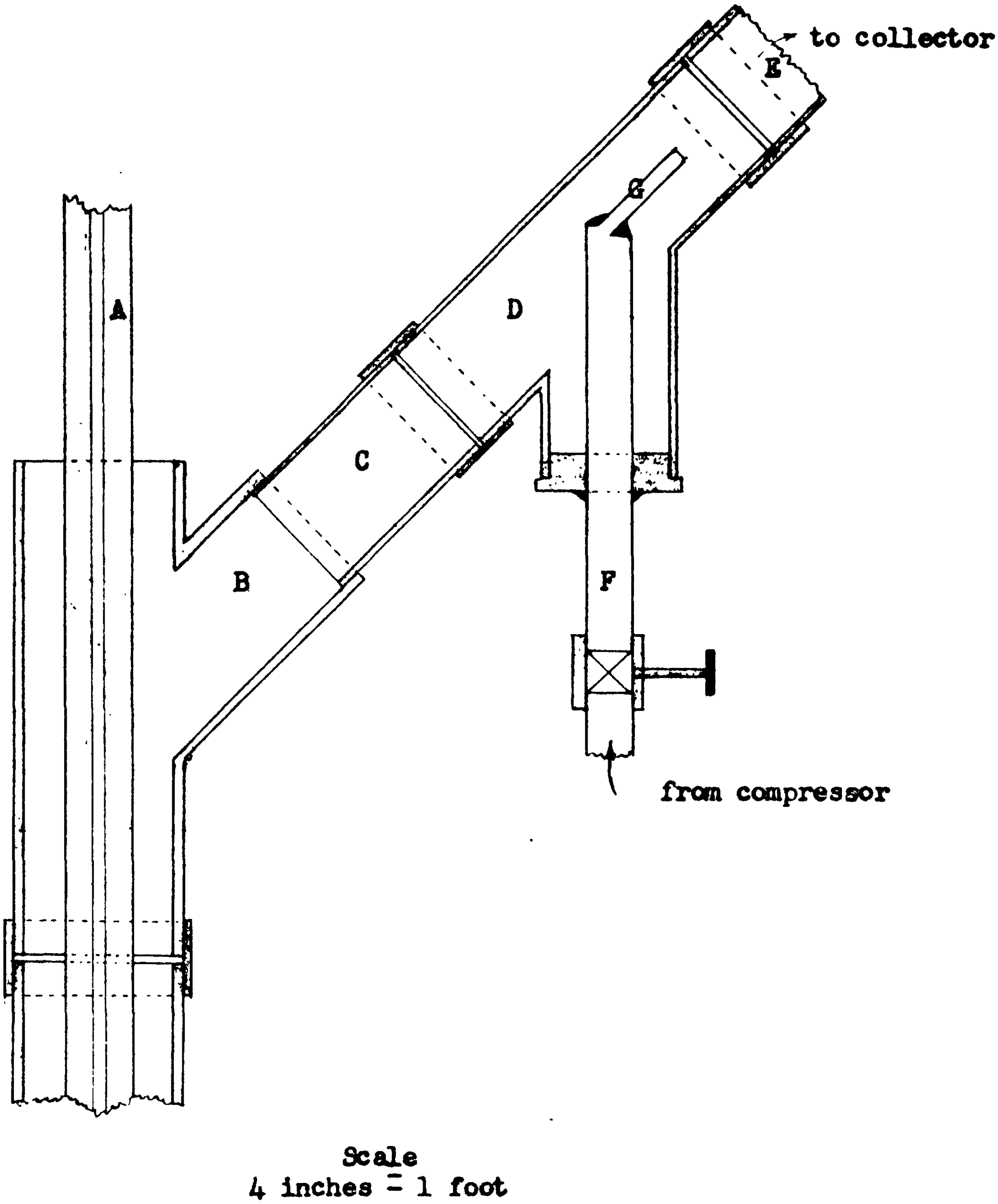
Machine A is essentially a motor-driven, vacuum-type suction fan which draws the cuttings from the collar of the hole and deposits them in a sample container (fig. 1). From the collar of the drill hole the cuttings are first drawn into a hood in which a slot has been cut to admit the drill rods. A flexible suction tube connects the hood to an opening in the center of the suction fan housing. The cuttings pass from the suction tube to the fan housing, and from there the bulk of the cuttings are dropped through a hopper into a glass or plastic sample jar. The exhaust air, which includes some fine material, is discharged through a 3-inch opening in the fan housing.

Machine A was originally designed (Huleatt, 1952) to discharge the exhaust downward, with the opening near the jar. A porous cotton bag was placed over the exhaust tube in an effort to catch most of the fine material discharged with the exhaust air. The bag was necessarily porous to eliminate back pressure in the system. Field experience showed that the fine material escaping from the bag in a fine dust cloud obscured the jar and possibly endangered the health of the operating personnel. Tests made to determine the weight and grade of the mineralized material collected in the bag showed that the bag samples were small in amount compared with the total sample collected, and that they did not differ appreciably in uranium and vanadium content from the jar samples. The procedure of collecting bag samples, therefore, was discontinued, and the exhaust was then changed to discharge upward through a 3-inch tube which extended above the heads of the operators.

Two units of Machine A were used much of the time during a 6-month period, from October 1951 to March 1952, during which time they collected cuttings from about 18,000 feet of wagon drilling.

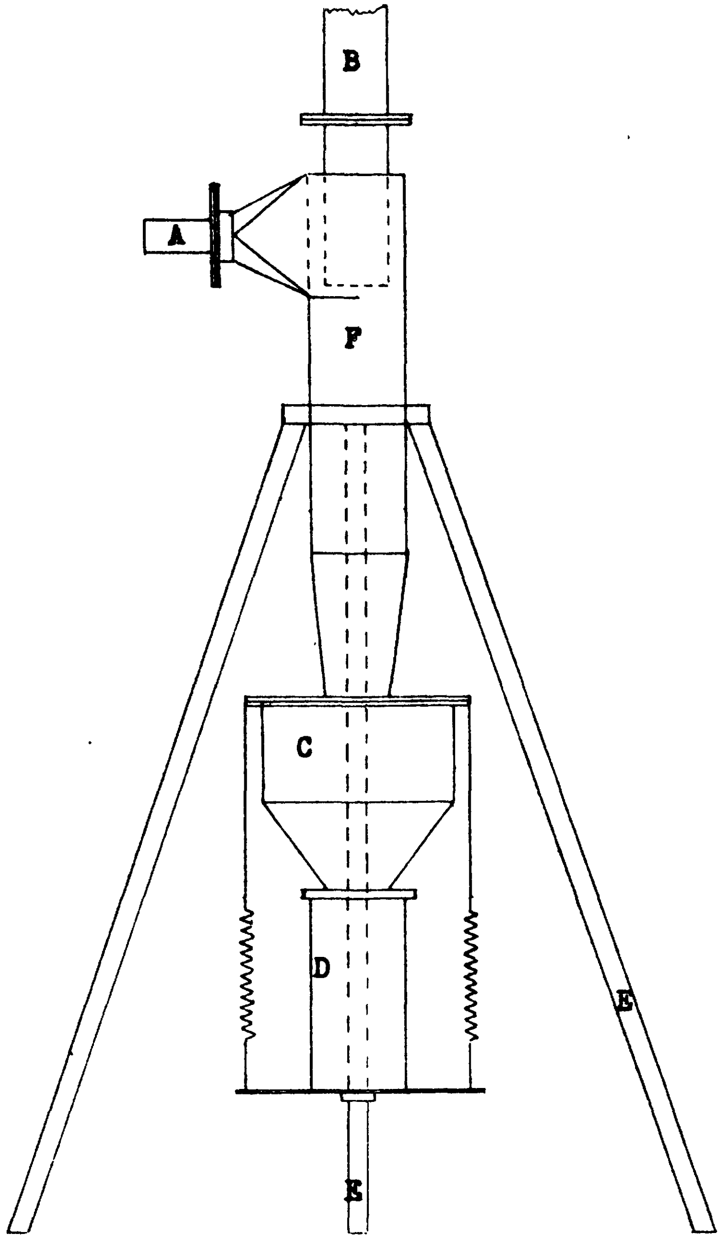
Machine B

Machine B (fig. 2), is an air-operated, centrifugal-cyclone type dust collector having no moving parts. The air is injected through a jet assembly (fig. 3), which uses a small amount of compressed, high-pressure air (30 cubic feet per minute at 100 pounds pressure per square inch) to produce a large volume of low-pressure air. The high-pressure air for the jet assembly is furnished by the compressor which provides air to operate the drill. The suction end of the jet assembly, which consists of a 2 1/2-inch "Y", is placed in the collar of the drill hole, so that the drill rods can operate through it. The cuttings are drawn from the collar of the hole through the jet assembly into a 2-inch steel-reinforced rubber hose which is connected to the intake opening of the collector. The jet assembly design is based on the one developed by John H. Soulé (1947). The intake is designed so that the dust-laden air is forced into a spiral stream on the inside of the tube, and the centrifugal action forces the cuttings to remain close to the wall of the tube as they descend. The



Scale
4 inches = 1 foot

Figure 3.--Sketch of jet assembly used with Machines B and C, showing component parts: (A) drill steel, (B) 2 1/2-inch "Y", (C) nipple, (D) 2-inch "Y", (E) outlet, (F) air intake pipe, and (G) one-fourth inch jet tube



Scale
1 inch = 1 foot

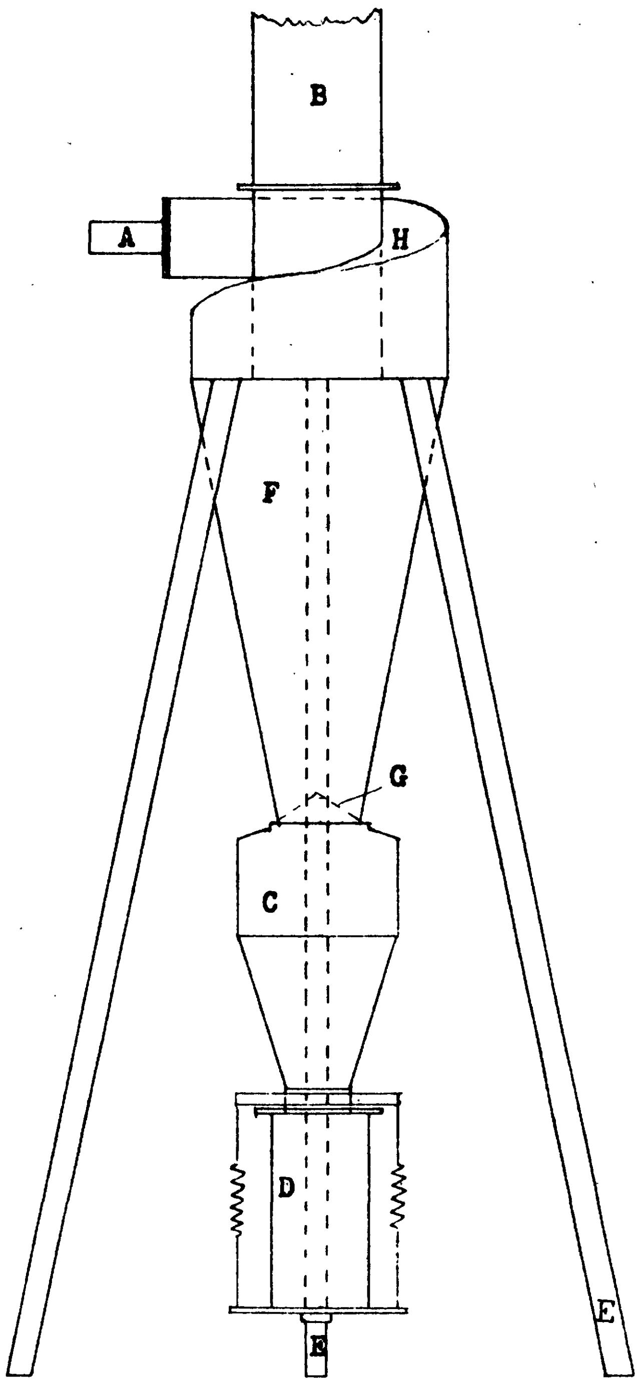
Figure 2.--Sketch of Machine B showing component parts: (A) intake, (B) exhaust tube, (C) hopper, (D) jar, (E) tripod, and (F) tube

cuttings, because of their high velocity, follow the wall of the tube into the dust trap from which they pass into a plastic or glass sample jar. The exhaust air, which is practically dust-free, passes upward through the central part of the tube and leaves the machine through a 3 1/2-inch exhaust tube.

Machine B was tested during April and May 1952 and collected cuttings from about 9,500 feet of drilling.

Machine C

Machine C (fig. 4) is also an air-operated, centrifugal-cyclone type dust collector with no moving parts. The cuttings are drawn from the collar of the drill hole through the jet assembly (fig. 3) into a 2-inch steel-reinforced rubber hose which is attached to the intake opening. The air intake is designed so that the dust-laden air is forced into a spiral stream by the helical roof on the inside of the cone housing, and the centrifugal force thus created causes the cuttings to remain close to the wall of the cone as they descend. A vortex shield at the bottom of the cone arrests the downward flow of the air stream and causes the air to spiral upward in the center of the cone. The cuttings, because of their high velocity, follow the wall of the cone downward past the vortex shield into the hopper which is located directly beneath the small end of the cone. The cuttings then pass from the bottom of the hopper into a plastic or glass sample jar. The exhaust air, which is practically dust-free, moves upward through the central part of the cone and leaves the machine through an 8-inch exhaust tube. For a period during the tests, a porous cotton bag was placed over the exhaust tube in an effort to catch the fine material included in the exhaust air. The resulting slight back pressure



Scale
1 inch = 1 foot

Figure 4.—Sketch of Machine C showing component parts: (A) intake, (B) exhaust tube, (C) hopper, (D) jar, (E) tripod, (F) cone, (G) vortex shield, and (H) helical roof

caused considerable loss of efficiency in the device which could be overcome only by the use of an excessive amount of high-pressure compressed air in the jet assembly.

Machine C was tested for 4 months, February to May 1952, and collected cuttings from about 17,500 feet of drilling.

COST OF THE SAMPLE COLLECTORS

Total costs of the three sample collectors are summarized in table 1.

Table 1.--Comparative cost of sample collectors

	Machine A	Machine B	Machine C
Initial cost	$ 360.00	$ 320.18	$ 212.85
Trailer mounting	362.61 1/	101.27	101.27 2/
Hoses	-----	46.00	46.00
Jet assembly	-----	13.75	13.75
Totals	$ 722.61	$ 481.20	$ 373.87

1/ Includes cost of trailer, hoses, gasoline engine, and belt guard.

2/ Machine C was mounted in a jeep and required no trailer. Machines A and B were both mounted in trailers. Cost of a trailer is shown to place all collectors on a comparable basis.

The initial and subsequent repair costs presented in table 2 provide a basis for comparison of total costs of the three sample collectors. Machine A has many moving parts that are subject to wear. Major expenditures were for the replacement of fan blades, which were badly worn after each machine had sampled cuttings from 6,000 to 7,000 feet of drill hole. In addition, the fan housings of both machines were worn through and needed replacing after each had sampled cuttings from about 9,000 feet of hole, and the gasoline engines were in need of extensive repairs on the completion of the field tests. Furthermore, breakdowns in the field resulted in considerable time lost while repairs were being made. Installation of a pre-cleaner unit in the air circuit might reduce the wear on the impeller blades and fan housing, and thereby, lower the repair costs appreciably.

Table 2.--Initial and subsequent repair costs of the three sample collectors

	Machine A	Machine B	Machine C
Initial cost, per unit, ready for operation	$ 722.61	$ 481.20	$ 373.87
Repairs during operation	141.00	Negligible _/	Negligible _/
Totals	$ 863.61	$ 481.20	$ 373.87

_/ Minor changes and repairs were made in jet assembly and and hose connections.

DRILLING PROCEDURE

Holes were first drilled through the overburden, which averaged 2 feet thick in the area drilled. The suction hood of Machine A was then placed over the collar of the hole, or, if Machine B or C was used, the 2 1/2-inch "Y" of the jet assembly was placed in the hole, and drilling was resumed. In barren material runs were usually 3 feet in length; in mineralized material runs ranged from 6 to 12 inches in length.

On completion of a run, the rods were raised about 2 feet, and air was blown through the hole for 5 to 10 seconds in order to clear the hole of cuttings. The jar was then changed and drilling was resumed. The time required to blow the hole and to change jars on each of the three sample collectors averaged about 10 seconds.

SAMPLING PROCEDURE

At the end of each run the jar was removed from the sample collector and the cuttings were poured through a Jones sample splitter. Part of the sample was saved in a paper sack, and the remainder discarded. When mineralized material was noted in the jar during drilling, the drill was stopped, the hole blown, and the jar changed. The entire sample of mineralized material was saved for assay.

All samples in the paper sacks were saved until a gamma-ray log of the hole was obtained. The samples which contained mineralized material, as indicated by visual estimate or gamma-ray log, were then assayed. All other samples were discarded.

SAMPLING RESULTS

In the sandstones and mudstones of the area in which drilling was done, the material from a 1-foot length of a 2-inch diameter hole weighed from 3.2 to 3.4 pounds. Test samples were collected and weighed to determine relative percentages of recovery of the cuttings.

The moisture content of the rocks cut in drilling was a major factor in the percentage of recovery obtained, regardless of the sampling device used. The average moisture content of the wagon-drill cuttings was approximately 2.5 percent by weight. Not much difficulty was experienced while collecting material with a moisture content of less than 6 percent. Material with a moisture content of 6 percent or more, however, tended to cling to the sides of the drill holes, reducing the recovery of the cuttings and causing the drill rods to stick or bind in the holes. Presence of moisture in excessive amounts prevented completion of some drill holes.

Machine A

Weights of the samples collected both in the jar and in the cotton bag placed over the exhaust tube of Machine A showed that the recovery of cuttings ranged between 1.5 and 2.7 pounds per foot of hole drilled (about 45 to 85 percent). The average recovery of cuttings by Machine A, based on the collection of 515 pounds of material for 231 feet of drilling, was 67 percent, in contrast to 96 percent obtained by Huleatt (1952) under different conditions and in different material. Samples collected in the jar alone ranged from about 1.3 pounds per foot to 2.6 pounds per foot. The material caught in the cloth bag ranged from 0.1 to 0.4 pound per foot, or from 2 to 20 percent of the total sample collected. The recovery was governed principally by the amount of moisture present in material cut by the drills; recovery decreased with increasing moisture content. Material containing 5 percent or more moisture by weight collected in the fan blades of Machine A and clogged the hopper between the fan housing and the jar. Accumulation of material on the fan blades decreased the efficiency of the collector and substantially increased the amount of material discharged through the exhaust tube.

Machine B

Weights of samples collected in the jar from Machine B ranged from 2.9 to 3.2 pounds per foot and averaged 3.0 pounds per foot for the six holes tested. The average recovery of cuttings was 91 percent. No sample was taken from the exhaust air because the cloth bag caused a slight back pressure, thereby adversely affecting the recovery of cuttings in the jar. Machine B obtained good recovery of cuttings with moisture contents up to 6 percent.

Machine C

Weights of samples collected in the jar from Machine C ranged from 3.0 to 3.3 pounds per foot, and averaged 3.2 pounds per foot for the six holes tested. Average recovery of cuttings was 96 percent, highest of all the results obtained with the three sampling devices tested. No samples from the exhaust air from Machine C were taken for the same reason described under Machine B sampling results. Machine C obtained good recovery of cuttings with moisture contents up to 6 percent.

GEOLOGIC LOGGING

In order to determine the favorableness for ore deposits of the ground drilled, lithologic descriptions were prepared from an examination of all cuttings. Criteria used to determine favorable ground were based on those developed by the Geological Survey (Weir, 1952). These criteria include the type, color, and thickness of the rock, and the grain size and carbon content of the sandstone. When a lithologic change was observed in the jar of the sampling device, the depth at which the change occurred was noted. With a recovery of at least 80 percent of cuttings, the thickness of lithologic units thus obtained generally was accurate to within 0.2 foot.

Sampling personnel were required to be present at the drills at all times, in order to prepare satisfactory logs of the holes. An experienced sub-professional diamond-drill sampler, after a week of training by a geologist, generally could prepare an adequate geologic log of a wagon-drill hole. A geologist checked each log and determined the favorableness of the ground drilled. Gamma-ray logs also were obtained from each drill hole.

SELECTING SAMPLES FOR ASSAY AND INTERPRETING RESULTS

The ore minerals in the carnotite deposits contain uranium and vanadium; both metals are of economic value. The minerals are erratically distributed in the deposits, however, so that the ratio and grade of the two metals is not uniform through ore deposits. This characteristic, plus the fact that drill cuttings are contributed continuously to the sample-collecting jar during drilling, present special problems in avoiding the dilution of mineralized samples with barren material and in interpreting assay results.

Generally, drill cuttings containing 0.5 percent or more V_2O_5 can be recognized visually, for the principal vanadium minerals color the rock gray, and the color darkens as the vanadium content increases. Samples adequate for chemical assay, for both vanadium and uranium, can be selected by visual inspection where vanadium-bearing material is recognized in the cuttings if the drill is stopped promptly, the hole blown, and the jar changed when the drill enters or leaves a layer of vanadium-bearing sandstone.

Because small though valuable amounts of uranium-bearing minerals in sandstone cannot be readily seen in cuttings, it is helpful to make gamma-ray logs of all drill holes. With these logs, the depth and thickness of the radioactive layer can be determined and samples that should be assayed chemically can be selected. If the radioactive layer represents only part of an interval penetrated by a drill run, the sample of that run, of course, will contain both barren and mineralized material. A relatively accurate expression of the grade of the mineralized layer can be obtained, however, by prorating the chemical assays of a drill-run sample to the thickness of the radioactive layer as shown by the gamma-ray log.

As shown in table 3, comparison of wagon-drill and diamond-drill samples shows a close correlation considering the rapid range in thickness and grade of mineralized material within short distances.

Table 3.--Comparison of diamond-drill and wagon-drill samples a/

Hole No.	Base of sample (feet)	Thickness of sample (feet)	Percent U_3O_8	Percent V_2O_5	Sample recovery (percent)
YC-106 b/	29.2	1.3	0.31	0.80	94
WYC-86	30.0	2.0	0.25 c/	0.88 c/	Undetermined
WYC-136	30.0	1.8	0.51 c/	0.80 c/	78
WYC-137	30.0	2.0	0.27 c/	0.65 c/	86

a/ Wagon-drill assay figures are calculated rock values.

b/ Diamond-drill hole; all others are wagon-drill holes.

c/ Assay weighted from several samples.

Wagon-drill hole WYC-86 and diamond-drill hole YC-106 were drilled 1 foot apart. Wagon-drill holes WYC-136 and WYC-137 were drilled as 6-foot offsets on opposite sides of WYC-86.

SUMMARY AND CONCLUSIONS

Three dust-collecting machines were adapted and tested by the Geological Survey for collection of wagon-drill cuttings. These machines showed several advantages over earlier methods of sample collecting: (1) More accurate samples of mineralized material were obtained. (2) The stratigraphic sequence of material sampled could be determined, so that a geologic log of the hole could be prepared. (3) The dust hazard to the operating personnel was greatly reduced.

During the field tests, Machine A was used for about 6 months, and cuttings from approximately 18,000 feet of wagon-drill holes were sampled. Tests made with this machine yielded recoveries ranging from 45 to 85 percent and averaging 67 percent. This recovery at times was not high enough to give an accurate determination of individual thickness of rock layers. Machine A has many moving parts that are subject to wear and need replacement.

Machine B was used in field tests for 2 months, during which time, cuttings from 9,500 feet of hole were collected. At the end of the test period the machine was in excellent condition and had required no major repairs during the period of operation. The advantages as determined by field tests were: (1) A large percentage of the cuttings were recovered; recoveries ranged from 88.0 to 96.0 percent and averaged 91.0 percent. (2) The absence of moving parts resulted in low upkeep cost. (3) Only a small amount of dust was lost with the exhaust air, thus reducing the health hazard to the operators. No serious disadvantages were found in the tests made with Machine B, though it does draw a small amount of air from the compression unit that operates the wagon drill, as does Machine C.

Machine C was tested in the field for 4 months; samples were collected from 17,500 feet of wagon-drill holes during this period. The machine was in excellent condition on completion of the tests, and had required no major repairs during that period. Advantages of the machine were: (1) The initial cost is low. (2) A very high recovery (averaging 96.0 percent) of cuttings from drill holes was attained. (3) Very little dust escaped with the exhaust air, thus reducing the health hazard to a minimum.

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