Vacuum Digging (69-D-29)

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SINCE the invention of the pick and shovel, there has been almost no advance in the method of digging the small-sized excavations in paved streets required for maintenance work on gas distribution piping. There has been some development of highly specialized equipment for small-hole clamping and the like; however, the majority of holes dug for joint clamping, service cutoffs, anode installations, etc., are still being done with a shovel.

About four years ago the concept of excavating small street openings by means of an industrial-type vacuum cleaner gained acceptance at The Brooklyn Union Gas Company. This is an extremely important concept to us because we make approximately 30,000 such openings each year, and even a small savings in labor or pavement restoration could result in substantial annual savings.

Some early experimentation was done using a small industrial vacuum cleaner in conjunction with a 160 cfm air compressor which proved the feasibility of the concept, but showed the necessity of developing some specialized hardware. This machine used a venturi effect to produce the vacuum and was neither convenient nor powerful enough for use in the field.

The project engineer in collaboration with field people developed the following criteria for an ideal digging machine for gas maintenance work:

It must be able to excavate a small street opening faster than a man with a shovel to justify the capital investment.

It must be capable of being operated in city streets without damaging other utilities.

It must be able to operate within a small pavement opening to avoid expensive pavement restoration, as shown in Figure 1.

It should be highly maneuverable to facilitate its use in streets with congested traffic conditions.

At this point it became necessary to find an equipment manufacturer who would be interested in working with Brooklyn Union engineers on the development of a vacuum digging machine which would meet these criteria. There are many firms which manufacture this type of equipment for cleaning catch basins and manholes; however, it took considerable search to locate a company interested in this new application.

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After discussions with various dealers, the Myers Sherman Corporation of Streator, Ill., agreed to a joint project to design the desired machine. It was eminently qualified to undertake the project as it had many years experience in building not only the conventional manhole cleaners but various types of complex material-moving equipment based on the vacuum principle, one application of which is the loading and unloading of grain on ships for foreign delivery.

Brooklyn Union agreed to purchase one of its standard units and conduct field testing to determine what modifications would be necessary to meet the design criteria. This machine had a 16½ cu yd body with a separately powered fan mounted on a C750 Ford truck chassis. The pick-up hose was 8 in. in diameter and operated in a 120° arc. The overall length was over 20 feet.

Field testing was conducted over a period of several months. It was obvious that depending upon the type of soil and the method used to loosen it, this machine would be able to excavate from 1½ to 2 times as fast as a man with a shovel. The field testing also developed some problem areas which would need correcting if the machine were to be of practical use. These problems were as follows:

Size—The overall vehicle-size must be small enough to use in congested city streets, but must have sufficient capacity to receive the excavated material from several openings.

Control of the Tube—The control of the digging tube must be easy and accurate so that the operator can continue to work without excessive fatigue.

Clogging of the Tube—The tube must be constructed in such a way that it is flexible, will rotate around the truck and must be fabricated of a material to which the spoil will not adhere.

Loosening the Earth—Tools and accessories must be designed to loosen compacted earth and clay so that the vacuum digger tube can remove it.

Unloading the Spoil—There must be a convenient way to unload the spoil so that it does not interrupt the digging operation.

Velocity of Air Required—Sufficient velocity of air through the tube must be developed to carry any excavated material which will pass through the tube.

Necessity of Having Compressor Truck Available—There must be a 125 cfm air compressor as an integral part of the truck so that the truck operators can break pavement without depending on outside help. This makes the truck a self-contained unit.

Excessive Noise—The machine must be designed with the necessary mufflers so that noise level does not create a nuisance.

The new vacuum digging machine which was designed and built by Myers Sherman to overcome these problems is called the Excavactor and has the following characteristics:

Length 223"—Wheelbase 135"—Ford Chassis

Weight—16,000 (unladen)

Engine 391 Cu. In.—with 5652 Spicer Transmission which develops 160 hp at 2600 rpm (fan operating speed), P.T.O. for hydraulic system, air compressor and fan

Suction—Operating pressure of 10" hg vacuum at 3000-4000 cfm

Compressor—125 cfm at 100 psi

Hose and Boom—6" wax impregnated hose which rotates approximately 270°

When these specifications are compared with those of the standard machine, it becomes apparent that most of the design criteria have been met and many of the problems overcome. The new machine which is called the Excavactor was delivered late in 1968 and only limited field testing has been done, the results of which are shown in Table I.

The principle underlying the operation of the Excavactor can be readily understood by reference to Figure 2. A high speed fan is used to produce a partial vacuum in an air-tight chamber so that air will be drawn through an inlet hose at a high velocity. This high-velocity air picks up the particles of earth, carrying them into the chamber, where the particles drop out of the air stream as it loses its velocity. The Excavactor operates at a vacuum of 10 in. hg which is sufficient to carry away any stone which will pass through the 6 in. digging hose.

We lift out the asphalt and concrete when it has been broken small enough and when we are not concerned about the quality of the backfill.

The Excavactor consists of hopper-shaped air-tight chamber with a capacity of 3 cu yds from which air is evacuated by a fan operating at 2600 rpm. The fan is powered from the truck engine by a split-shaft power take-off unit. The suction or digging hose is 6 inches in diameter and is constructed of wax impregnated rubber to eliminate clogging and is swivel-mounted so that it swings in an arc of 270°. The vertical position of the hose is controlled hydraulically from a portable control held in the operator's hand; however, it must be handled from side to side.

This represents one of the unsolved problems as it is a difficult and fatiguing operation which severely limits the number of jobs completed each day. The Excavactor was made self-sufficient by inclusion of a 125 cfm air compressor powered by a power take-off. This permits the crew to break their own pavement openings rather than depending upon a compressor truck.

The hopper was designed at 3 cu yds because this is an optimum size both from the standpoint of truck size and required capacity since it was felt that excavations would be backfilled almost immediately.

The bottom of the hopper tapers down to a hatch which permits dumping the collected spoil at any time.

There is one problem in connection with this operation caused by the tendency of moist heavy soil to remain in the hopper so that it must be removed manually. A partial solution has been obtained by installing vibrators, and we believe additional vibrators will afford a complete solution.

The Excavactor has had limited field testing due in part to a failure of the transfer case of the power take-off which has been redesigned and corrected. The limited amount of data accumulated to date has shown the truck to be very useful in making small openings for service cut-offs and the installations of anodes, making readily up to five or six openings a day under the proper conditions.

The digging rate varies widely from very fast in sand to slow in clay. In an attempt to improve the performance in clay, various auxiliary equipment has been designed to loosen the soil. This consists of an air lance, a rotating ring on the digging tube and spader-type tools, all of which are useful but none of which is the ultimate answer to the problem.

At this point in the development of the Excavactor, we have no doubt that it will meet the design criteria outlined earlier in this report; however, just what the place it will take in day-to-day distribution department operations has not been completely resolved. As of now, its major use appears to be in planned maintenance jobs requiring the excavation of many small street openings which comprises a substantial portion of our work.

The major unsolved problems remaining are difficulty in dumping moist earth from the hopper, the prime necessity of developing a faster and easier method of loosening the dirt to increase the digging rate in clay soils, and an improved mechanical means of positioning the digging tube. ■

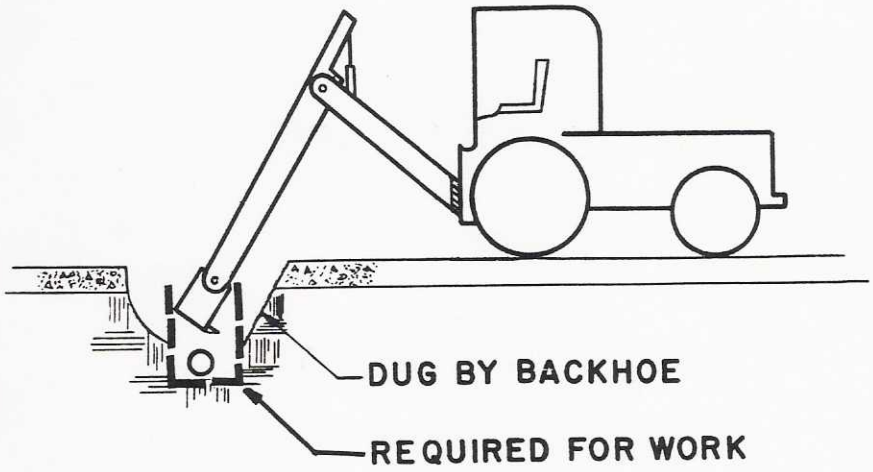

Figure 1.

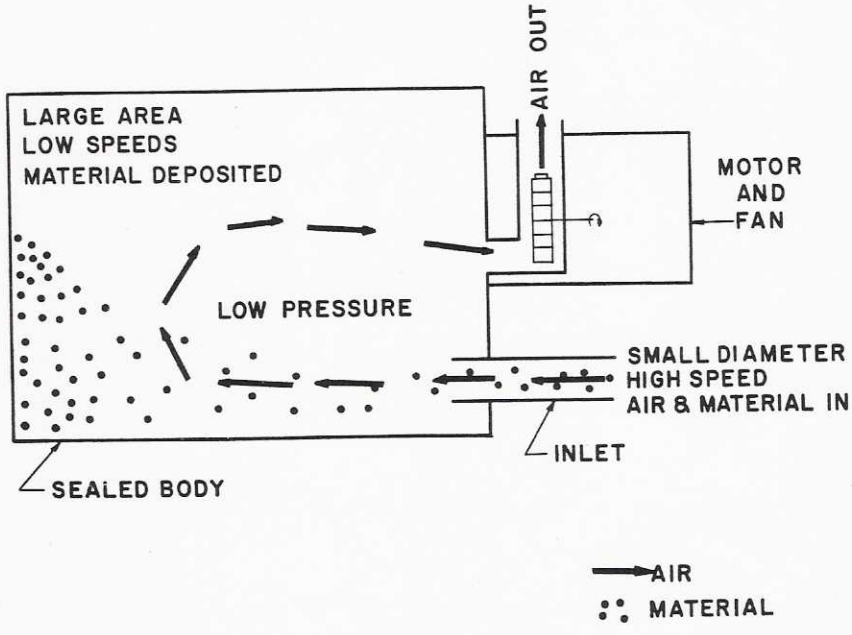

Figure 2.

TABLE I

VACTOR VACUUM DIGGING

Location	*Type of Soil*	*No. of Openings*	*Size*	*Time/Opening*	*Remarks*
Rutledge Street & Marcy Avenue	Sand, Rock, Clay	7	3′ x 2′6″ x 3′	12 Min.	Tube clogged—½ Hr. to clear.
Rutledge & Marcy	Sand, Rock, Clay	6	3′ x 2′6″ x 3′	10 Min.	C/O Service.
Rutledge & Marcy	Sand, Rock, Clay	5	3′ x 2′6″ x 3′	24 Min.	C/O Service.
Cortelyou Road & Stratford Road	Sand, Rock, Clay	1	19′6″ x 4′ x 3′6″	1 Hr. 53 Min.	Spader, Air Lance, Crowbar.
28-75 West 22nd St.	Sand, Rock, Clay	1	3′6″ x 2′ x 4′	12 Min.	
Avenue "V" & East 8th Street	Sand, Rock, Clay	1	3′6″ x 2′6″ x 4′	15 Min.	Sewer and Water Interference.
Ave. V & E. 8 St.	Sand, Rock, Clay	1	4′ x 3′ x 4′	55 Min.	Tube clogged.
Ave. V & E. 8 St.	Sand, Rock, Clay	1	6′ x 2′6″ x 4′	40 Min.	Clamp.
Ave. V & E. 8 St.	Sand, Rock, Clay	1	3′6″ x 2′6″ x 4′	30 Min.	Clamp.
Ave. V & E. 8 St.	Sand, Rock, Clay	1	3′6″ x 2′6″ x 4′	30 Min.	Clamp.
Ave. V & E. 8 St.	Sand, Rock, Clay	1	3′6″ x 3′0″ x 4′	35 Min.	
Ave. V & E. 8 St.	Sand, Rock, Clay	1	3′6″ x 3′0″ x 4′	40 Min.	
Ave. V & E. 8 St.	Sand, Rock, Clay	1	4′ x 2′6″ x 4′	35 Min.	
Ave. V & E. 8 St.	Sand, Rock, Clay	1	3′6″ x 3′ x 4′	25 Min.	
Shell Road & Belt Parkway	Gravel, Clay	21	2′6″ x 2′ x 6′6″	Avg. 44 Min.	Anode holes.