Chapter 3

Excavating and Lifting

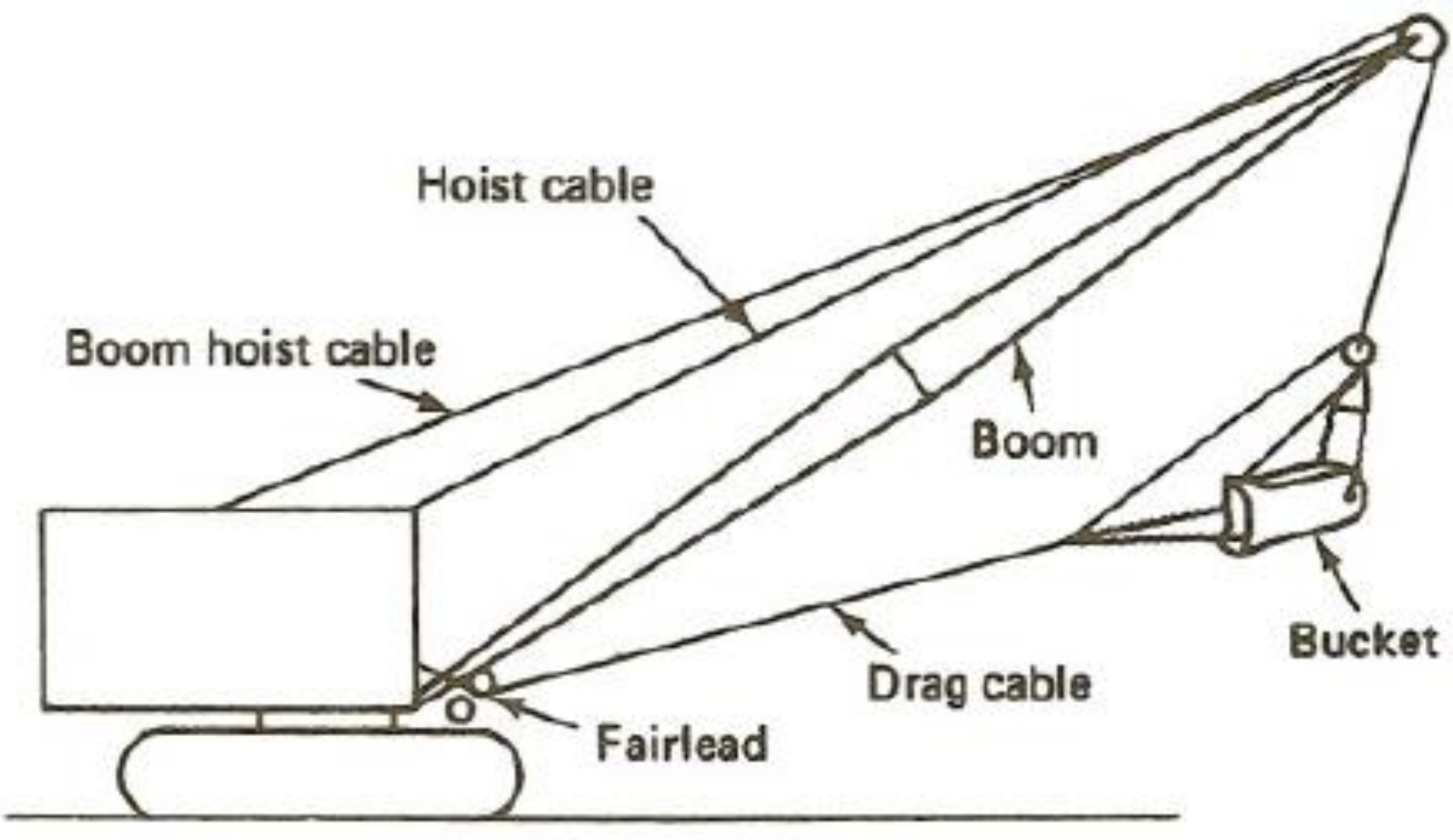
Part 2

3-4 DRAGLINES

- **Operation and Employment**
- **Production Estimating**
- **Job Management**

FIGURE 3-10: Components of a dragline.

https://www.youtube.com/watch?v=TFIS4YxeJS0

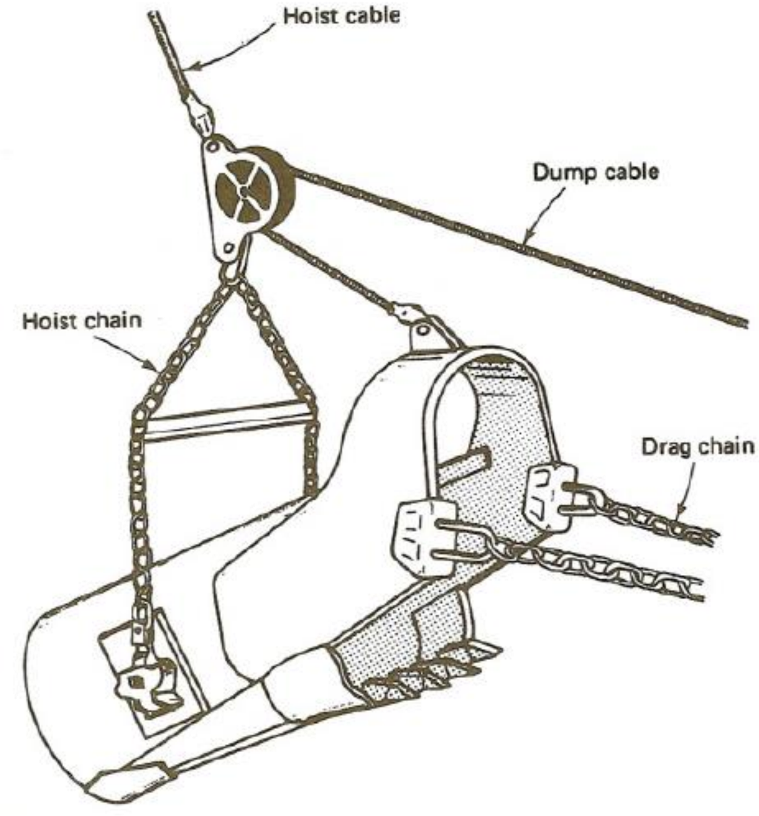


Operation and Employment

- The *dragline* is a very versatile machine that has the longest reach for digging and dumping of any member of the crane-shovel family.
- It can dig from above machine level to significant depths in soft to medium-hard material.
- Bucket teeth and weight produce digging action as the drag cable pulls the bucket across the ground surface.

- Digging is also controlled by the position at which the drag chain is attached to the bucket .

FIGURE 3-11: Dragline bucket.



- It does not have the positive digging action or lateral control of the shovel. Because of that:
  - the bucket may bounce or move sideways during hard digging.
  - More spillage must be expected in loading than would occur with a shovel
- The maximum bucket size to be used on a dragline depends on <u>machine power</u>, <u>boom length</u>, and <u>material weight</u>.
  - Therefore, use the dragline capacity chart provided by the manufacturer instead of the machine's lifting capacity chart to determine maximum allowable bucket size.

Table 3–7 Ideal dragline output—short boom [BCY/h (BCM/h)]*. (This is a modification of data published in *Technical Bulletin No. 4,* Power Crane and Shovel Association, Bureau of CIMA, 1968.)

Type of Material	Bucket Size [cu yd (m^3)]										
	$\frac{3}{4}$ (0.57)	1 (0.75)	$1\frac{1}{4}$ (0.94)	$1\frac{1}{2}$ (1.13)	$1\frac{3}{4}$ (1.32)	2 (1.53)	$2\frac{1}{2}$ (1.87)	3 (2.29)	$3\frac{1}{2}$ (2.62)	4 (3.06)	5 (3.82)
Light moist clay or loam	130 (99)	160 (122)	195 (149)	220 (168)	245 (187)	265 (203)	305 (233)	350 (268)	390 (298)	465 (356)	540 (413)
Sand and gravel	125 (96)	155 (119)	185 (141)	210 (161)	235 (180)	255 (195)	295 (226)	340 (260)	380 (291)	455 (348)	530 (405)
Common earth	105 (80)	135 (103)	165 (126)	190 (145)	210 (161)	230 (176)	265 (203)	305 (233)	340 (260)	375 (287)	445 (340)
Tough clay	90 (69)	110 (84)	135 (103)	160 (122)	180 (138)	195 (149)	230 (176)	270 (206)	305 (233)	340 (260)	410 (313)
Wet, sticky clay	55 (42)	75 (57)	95 (73)	110 (84)	130 (99)	145 (111)	175 (134)	210 (161)	240 (183)	270 (206)	330 (252)

*Based on 100% efficiency, 90° swing, optimum depth of cut, material loaded into haul units at grade level.

Table 3–8 Optimum depth of cut for short boom. (This is a modification of data published in *Technical Bulletin No. 4,* Power Crane and Shovel Association, Bureau of CIMA, 1968.)

Type of Material	Bucket Size [cu yd (m^3)]										
	$\frac{3}{4}$ (0.57)	1 (0.75)	$1\frac{1}{4}$ (0.94)	$1\frac{1}{2}$ (1.13)	$1\frac{3}{4}$ (1.32)	2 (1.53)	$2\frac{1}{2}$ (1.87)	3 (2.29)	$3\frac{1}{2}$ (2.62)	4 (3.06)	5 (3.82)
Light moist clay, loam, sand, and gravel	6.0 (1.8)	6.6 (2.0)	7.0 (2.1)	7.4 (2.2)	7.7 (2.3)	8.0 (2.4)	8.5 (2.6)	9.0 (2.7)	9.5 (2.9)	10.0 (3.0)	11.0 (3.3)
Common earth	7.4 (2.3)	8.0 (2.4)	8.5 (2.6)	9.0 (2.7)	9.5 (2.9)	9.9 (3.0)	10.5 (3.2)	11.0 (3.3)	11.5 (3.5)	12.0 (3.7)	13.0 (4.0)
Wet, sticky clay	8.7 (2.7)	9.3 (2.8)	10.0 (3.0)	10.7 (3.2)	11.3 (3.4)	11.8 (3.6)	12.3 (3.7)	12.8 (3.9)	13.3 (4.1)	13.8 (4.2)	14.3 (4.4)

Table 3–9 Swing-depth factor for draglines. (This is a modification of data published in *Technical Bulletin No. 4*, Power Crane and Shovel Association, Bureau of CIMA, 1968.)

Depth of Cut (% of Optimum)	Angle of Swing (deg)							
	30	*45*	*60*	*75*	*90*	*120*	*150*	*180*
20	1.06	0.99	0.94	0.90	0.87	0.81	0.75	0.70
40	1.17	1.08	1.02	0.97	0.93	0.85	0.78	0.72
60	1.25	1.13	1.06	1.01	0.97	0.88	0.80	0.74
80	1.29	1.17	1.09	1.04	0.99	0.90	0.82	0.76
100	1.32	1.19	1.11	1.05	1.00	0.91	0.83	0.77
120	1.29	1.17	1.09	1.03	0.98	0.90	0.82	0.76
140	1.25	1.14	1.06	1.00	0.96	0.88	0.81	0.75
160	1.20	1.10	1.02	0.97	0.93	0.85	0.79	0.73
180	1.15	1.05	0.98	0.94	0.90	0.82	0.76	0.71
200	1.10	1.00	0.94	0.90	0.87	0.79	0.73	0.69

- To estimate dragline production using the tables,
  - determine the ideal output of the dragline for the machine size and material (Table 3-7),
  - then adjust this figure by multiplying it by a swing-depth factor (Table 3-9) and a job efficiency factor, as shown in Equation 3-3.
  - Expected production =

    = Ideal output × Swing-depth factor × Efficiency (3-3)

  - Notice the conditions applicable to Table 3-7 given in the footnote..

- To use Table 3-9, it is first necessary to determine the optimum depth of cut for the machine and material involved from Table 3-8.
- Next, divide the average depth of cut by the optimum depth and express the result as a percentage.
- The appropriate swing-depth factor is then obtained from Table 3-9,
  - interpolating as necessary.

EXAMPLE 3-4

- Determine the expected dragline production in loose cubic meter LCM per hour based on the following information.
  - Dragline size = 1.53 m^3
  - Swing angle = 120^o
  - Average depth of cut = 2.4 m
  - Material = common earth
  - Job efficiency = 50 min/h
  - Soil swell = 25%

Solution

Ideal output =176 BCM/h (Table 3-7)

Optimum depth of cut = 3.0 m   (Table 3-8)

Average depth/optimum depth = 2.4/3.0 × 100 = 80%

Swing-depth factor=0.90 (Table 3-9)

Efficiency factor =50/60 = 0.833

Volume change factor = 1 + 0.25 = 1.25

Estimated production =

= 176 × 0.90 × 0.833 x1.25 = 165 LCM/h

Job Management

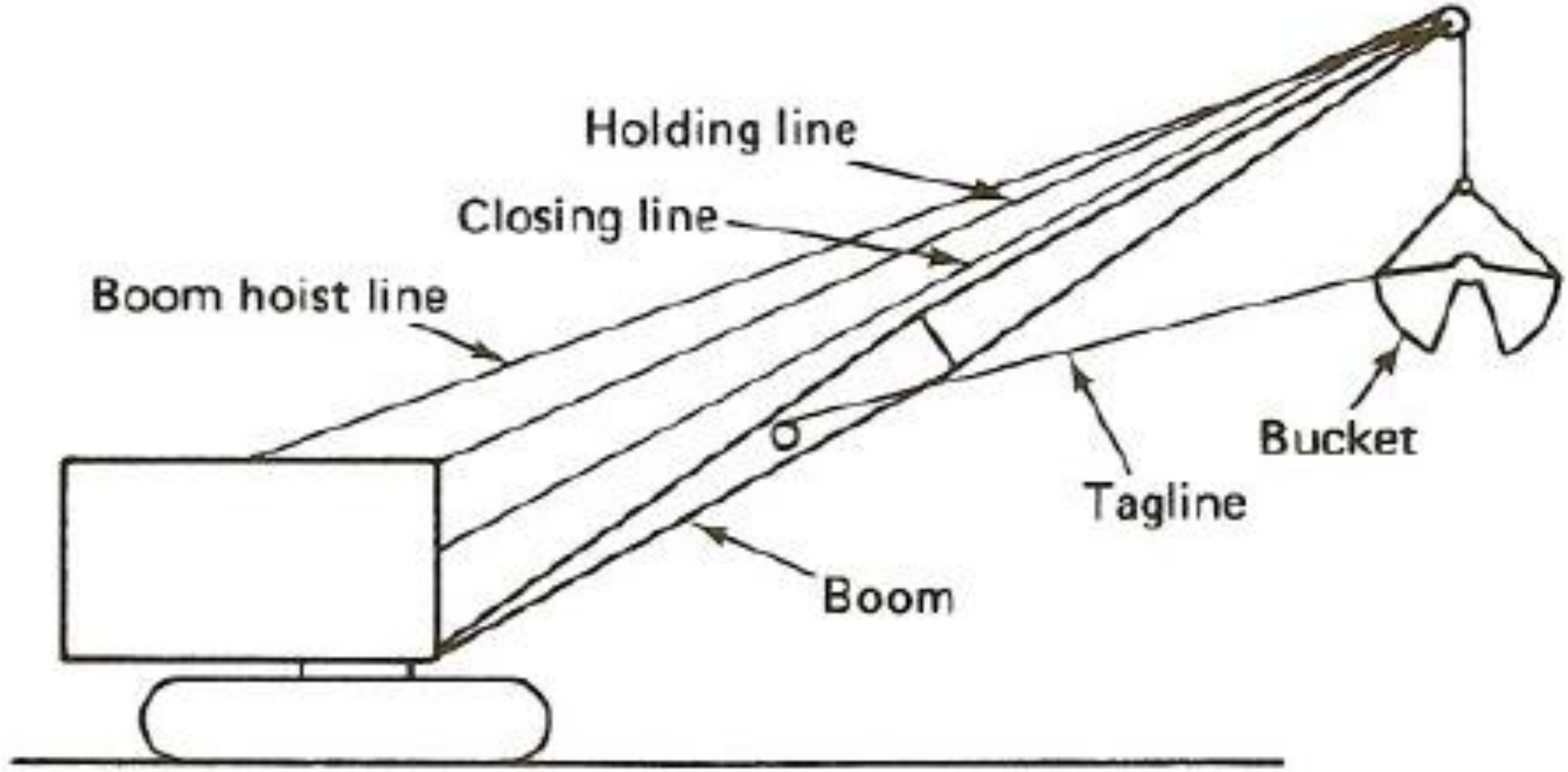
- Trial operations may be necessary to select:
  - the boom length,
  - boom angle,
  - bucket size and weight, and
  - the attachment position of the drag chain that yield maximum production.
- As in shovel operation, maximum production is obtained with a minimum swing angle.
- Special bucket hitches are available which shorten the drag distance necessary to obtain a full bucket load.
- Deep cuts should be excavated in layers whose thickness is as close to the optimum depth of cut as possible.

3-5 CLAMSHELLS

- Operation and Employment
- Production Estimating
- Job Management

FIGURE 3-13: Components of a Clamshell

https://www.youtube.com/watch?v=KtQSPBy831s

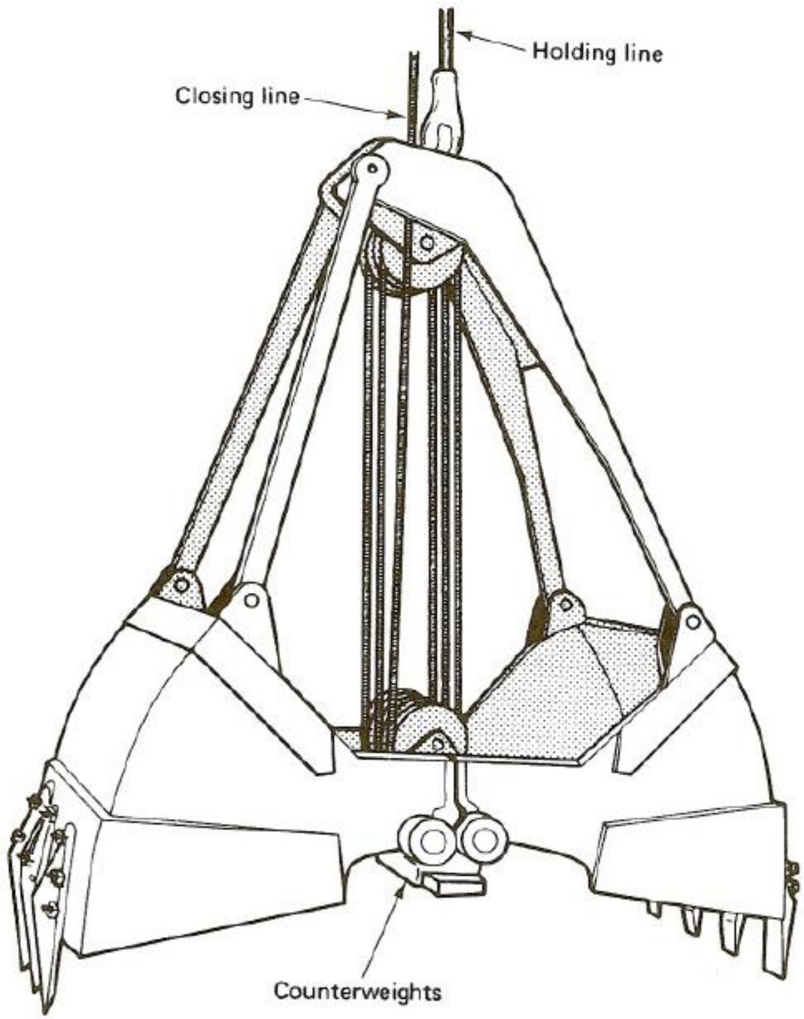


Operation and Employment

- When the crane-shovel is equipped with a crane boom and clamshell bucket, it becomes an excavator known as a *clamshell.*
- The clamshell is capable of excavating to great depths.
- The shovel and backhoe is better than clamshell because of :
  - lacks the positive digging action and
  - precise lateral control.

- Clamshells are commonly used for:
  - excavating vertical shafts and footings,
  - unloading bulk materials from rail cars and ships, and
  - moving bulk material from stockpiles to bins, hoppers, or haul units.

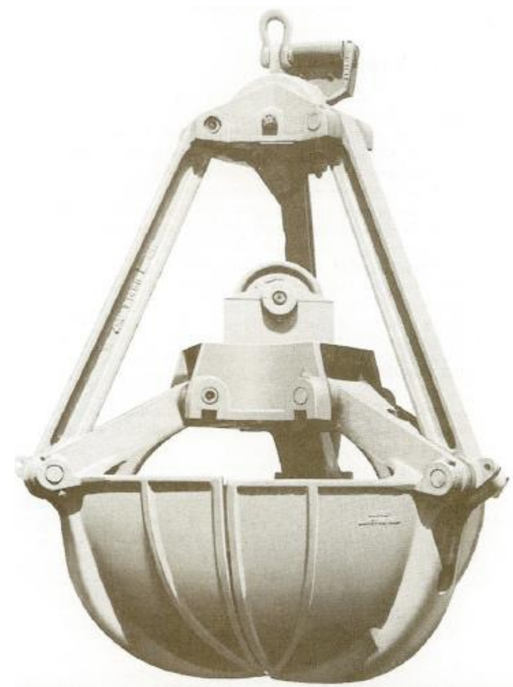
FIGURE 3-14: Clamshell bucket



- Bucket penetration depends on bucket weight assisted by the bucket teeth.
- Therefore, buckets are available in light, medium, and heavy weights, with and without teeth.
  1. Heavy buckets: are suitable for digging medium soils.
  2. Medium buckets: are used for general-purpose work, including the excavation of loose soils.
  3. Light buckets: are used for handling bulk materials such as sand and gravel.

- The orange peel bucket is principally utilized for underwater excavation and for rock placement.
- Because of its circular shape, it is also well suited to excavating piers and shafts.
- It operates on the same principle as does the clamshell.

FIGURE 3-15: Orange peel bucket (Courtesy of ESCO Corporation)



Production Estimating

- No standard production tables are available for the clamshell.
  - Thus production estimation should be based on the use of Equation 2-1.
  - The procedure is illustrated in Example 3-5.

EXAMPLE 3-5

- Estimate the production in loose cubic meter per hour for a medium-weight clamshell excavating loose earth.
  - Heaped bucket capacity is 0.75 m^3.
  - The soil is common earth with a bucket fill factor of 0.95.
  - Estimated cycle time is 40 s.
  - Job efficiency is estimated at 50 min/h.

<u>Solution</u>

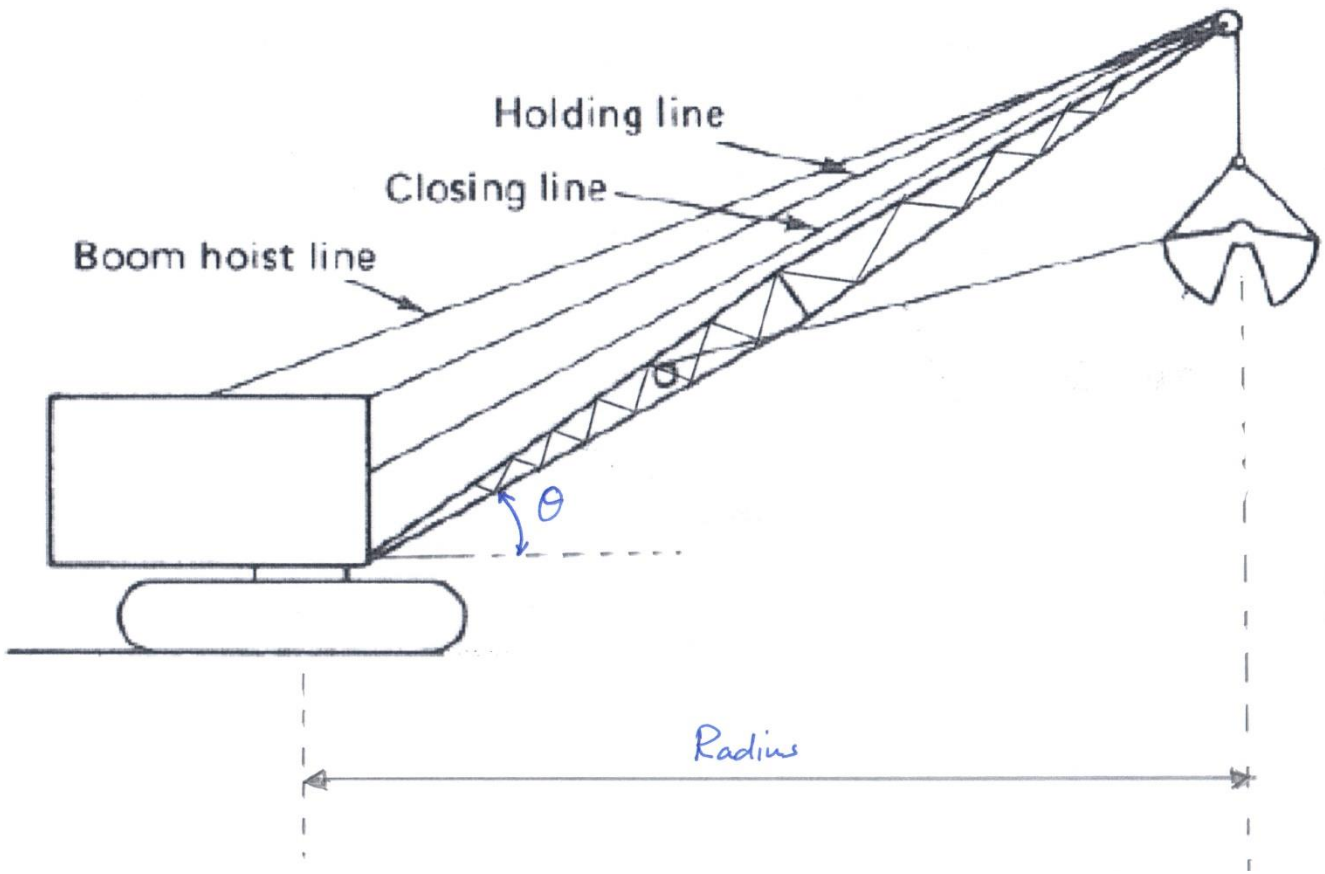
Production = 3600/40 × 0.75 × 0.95 × 50/60 = 53 LCM/h

Job Management

- The maximum allowable load (bucket weight plus soil weight) on a clamshell should be obtained from the manufacturer's clamshell loading chart for continuous operation.
- limit the load to 80% of the safe lifting capacity given by the crane capacity chart for rubber- tired equipment or 90% for crawler-mounted equipment.
- use of the lightest bucket capable of digging the material will enable a larger bucket to be used and will usually increase production.

Job Management

- Cycle time is reduced by organizing the job so that the dumping radius is the same as the digging radius (fixed boom angle).
- Keep the machine level to avoid swinging uphill or downhill.
- Non level swinging is hard on the machine and usually increases cycle time.


Holding line
Closing line
Boom hoist line
θ
Radius

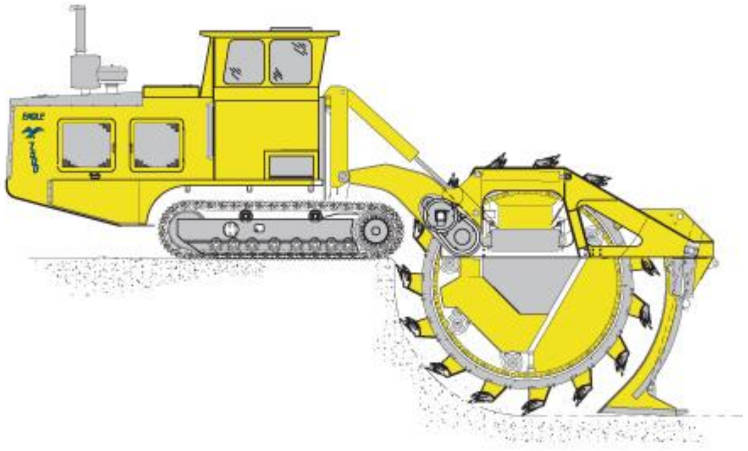
3-6 TRENCHING AND TRENCHLESS TECHNOLOGY

- There is a growing demand for methods of installing utility systems below the ground with minimum open excavation.
- Some methods available for achieving this goal include:
  - – 1. Specialized trenching machines
  - – 2. Plows
  - – 3. Trenchless technology (trenchless excavation).

1. Trenching Machines

- A. Chain trenchers, Figure 3-16 shows a large chain trencher capable of digging 356-911-mm wide vertical-sided trenches to a depth of 3.1 m.
- B. Ladder trencher, are similar to chain trencher, but are larger. They are capable of digging trenches up to 10-ft (3.1 m) wide and 25-ft (7.6-m) deep.
- C. Bucket wheel trenchers use a revolving bucket wheel to cut a trench up to 5-ft (1.5 m) wide and 9-ft (2.7-m) deep.

Chain trencher
https://www.youtube.com/watch?v=sdtib4YU1Rk
Bucket wheel trencher
https://www.youtube.com/watch?v=cY9O0NBKZ3E


7500 BUCKET WHEEL TRENCHER

Ladder Trencher

https://www.youtube.com/watch?v=-JD3vrSs5Tw

2. Plows

- Plows can be used to cut a narrow trench and simultaneously insert a small diameter cable or pipeline in most soil.
- Vibratory plows, deliver a more powerful cutting action than static plows and can be used to insert utility lines in hard soil or soft rock

- https://www.youtube.com/watch?v=4Vb7-ZEW5vE

Figure 3–17 Hydrostatic vibratory plow. (Courtesy of Vermeer Manufacturing Co.)

3. Trenchless Technology

- The principal categories of trenchless technology include:
  - 1. pipe jacking,
  - 2. horizontal earth boring, and
  - 3. microtunneling.

1. Pipe Jacking

- The process of *pipe jacking* involves forcing pipe horizontally through the soil.
- Working from a vertical shaft, a section or pipe is carefully aligned and advanced through the soil by hydraulic jacks braced against the shaft sides.
- As the pipe advances, spoil is removed through the inside of the pipe.
- After the pipe section has advanced far enough, the hydraulic rams are retracted and another section of pipe is placed into position for installation.
- The process often requires workers to enter the pipe during the pipe jacking operation.

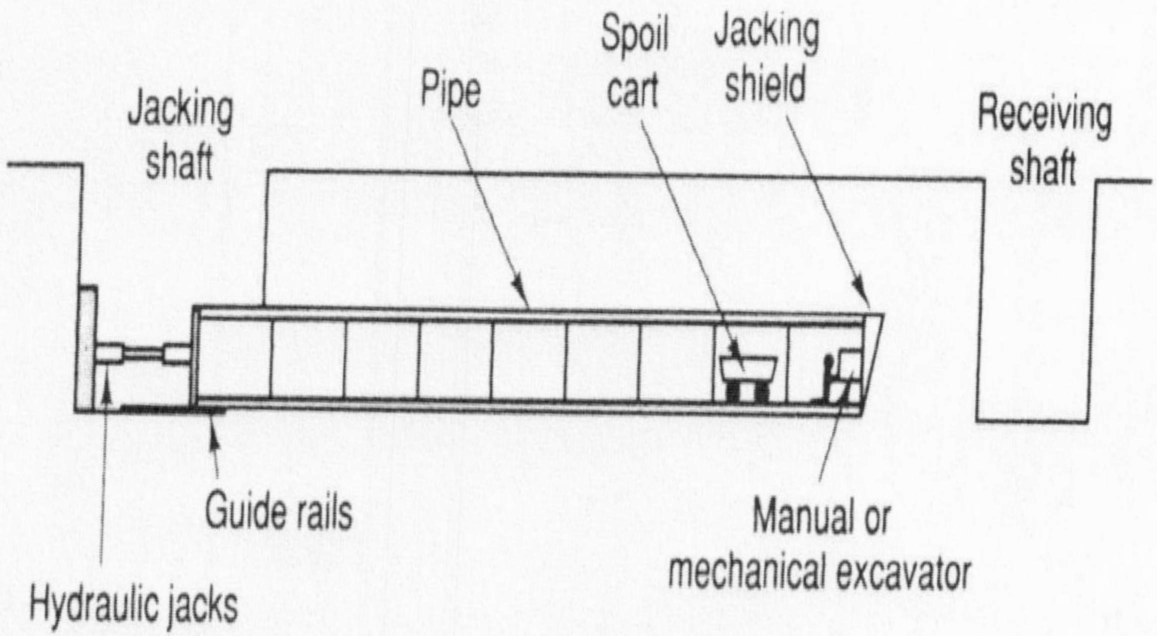


Figure 3-18 Installing a utility line by pipe jacking.

2. Horizontal earth boring

- In *horizontal earth boring* a horizontal hole is created mechanically or hydraulically with the pipe to be installed serving as the casing for the hole.
- Some of the many installation methods used include auger boring, rod pushing (thrust boring), rotational compaction boring, impact piercing, horizontal directional drilling, and fluid boring.
- Many of these technologies utilize lasers and television cameras for hole alignment and boring control.

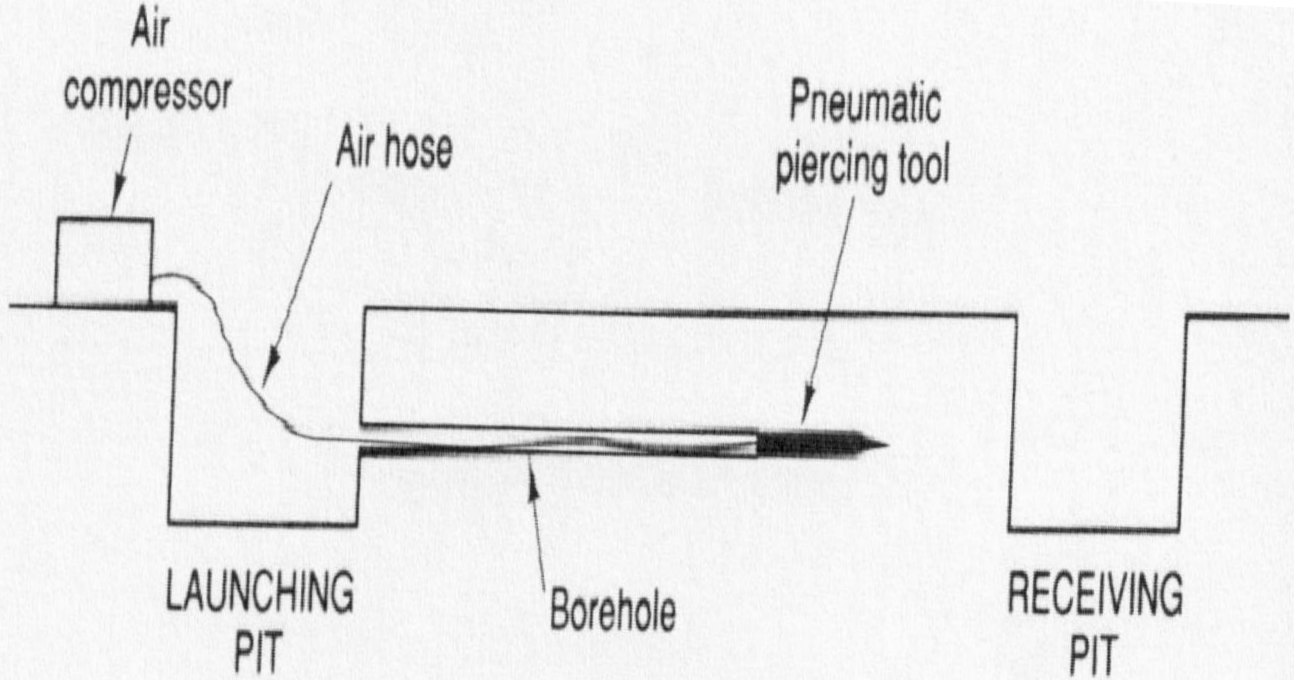


Figure 3-20 Installing a utility line by horizontal earth boring.

Placing pipe into the borehole.

- In one method, pipe is pulled through the bore using the tool's air hose or a steel cable pulled by the air hose.
- Another method uses the piercing tool to push the pipe through the borehole.
- A third method uses a pipe pulling adapter attached to the piercing tool to advance the pipe at the same time as the piercing tool advances the bore.

Microtunneling or Utility Tunneling

- *Microtunneling* or *utility tunneling* is similar to the conventional tunneling except for the tunnel size and use.
  - Since the tunnels are used for utility systems rather than for vehicle passage, they are normally smaller than road or rail tunnels.
  - They differ from other trenchless methods in their use of a conventional tunnel liner instead of using the pipe itself as a liner. Small moles are frequently used in creating such tunnels.

Repair and Rehabilitation of Pipelines

- The repair and rehabilitation of existing pipelines without excavation is another form of trenchless technology.
- most repair and rehabilitation methods involve the
  - relining of the existing pipeline or
  - the bursting of the existing pipe while inserting a new pipe.

- Relining of a pipeline is accomplished by
  - pulling a new plastic pipe into the existing pipe, the resulting pipe must be slightly smaller than the original pipe.
  - by inserting a liner into the existing pipe which involves pulling a folded liner into the existing pipe, expanding the liner, treating the liner with an epoxy, and curing it in place.

Pipe bursting

- *Pipe bursting* uses a high-powered hydraulic or pneumatic piercing tool equipped with a special bursting head to shatter the existing pipe and enlarge the opening. A new, often larger, pipe is then pulled into the opening by the piercing head.
- https://www.youtube.com/watch?v=HX5beh0ubGY
- https://www.youtube.com/watch?v=qTMZLfjzHDk

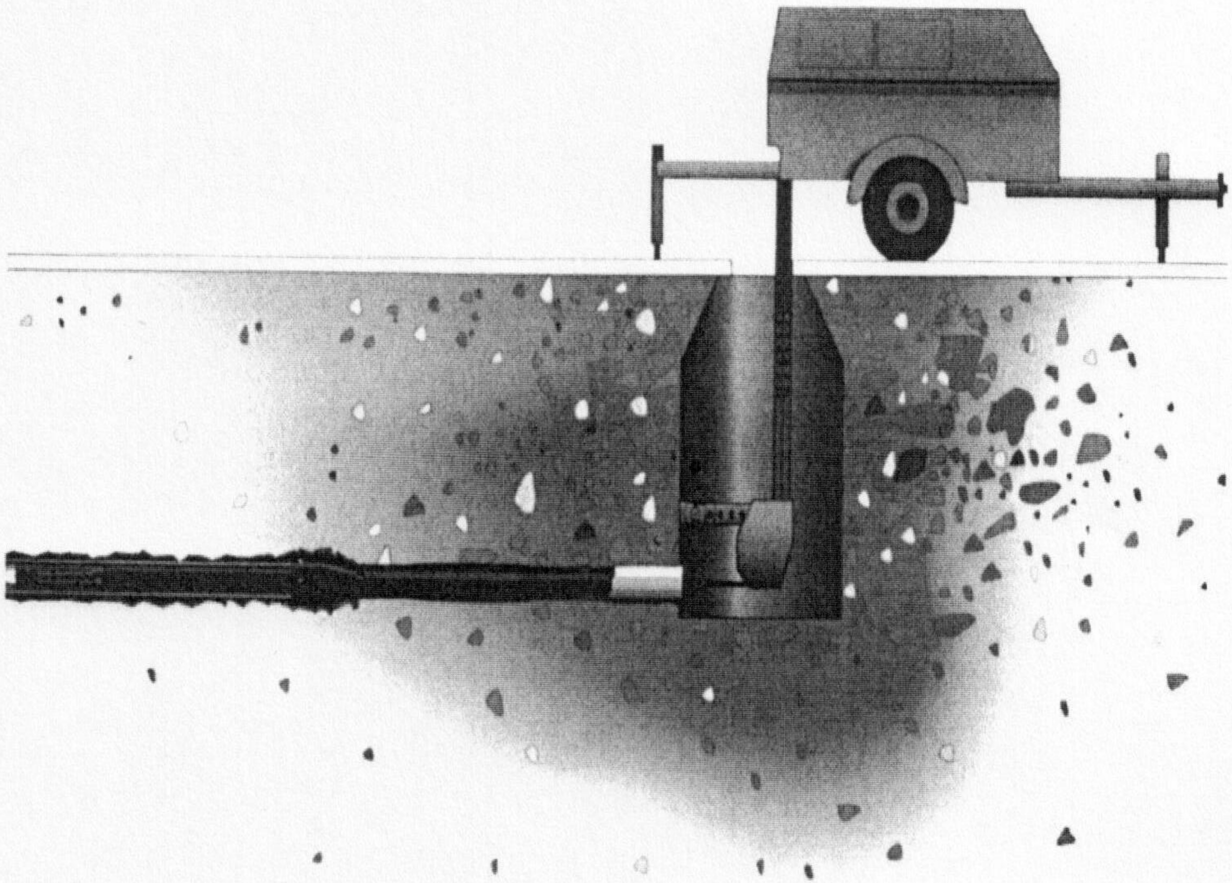


Figure 3–21 Schematic of pipe bursting. (Courtesy of Vermeer Manufacturing Co.)