

UNITED STATES DEPARTMENT OF AGRICULTURE
Rural Utilities Service

BULLETIN 1751F-641

SUBJECT: Construction of Buried Plant

TO: All Telecommunications Borrowers
RUS Telecommunications Staff

EFFECTIVE DATE: Date of Approval

EXPIRATION DATE: Seven years from effective date

OFFICE OF PRIMARY INTEREST: Outside Plant Branch,
Telecommunications Standards Division

PREVIOUS INSTRUCTIONS: This bulletin replaces REA Telephone Engineering & Construction Manual (TE&CM) Section 641, Construction of Buried Plant, Issue 4, dated April 1973.

FILING INSTRUCTIONS: Discard REA Telephone Engineering & Construction Manual (TE&CM) Section 641, Construction of Buried Plant, Issue 4, dated April 1973, and replace it with this bulletin. File with 7 CFR 1751 and is available to RUS staff on RUSNET.

PURPOSE: This bulletin provides RUS borrowers, consulting engineers, contractors and other interested parties with information concerning the construction of buried plant facilities.

Adam Golodner

06/30/95

Administrator

Date

TABLE OF CONTENTS

1.	General	6
2.	Supervision of Construction	7
3.	Characteristics of Tractors	13
4.	Characteristics of Plowing Equipment	15
5.	Capabilities of Tractors and Plows	17
6.	Handling and Care of Materials During Construction	18
7.	Repair of Cables or Wires Damaged During Construction .	19
8.	Preparation for Splicing or Termination	20
9.	Installation Procedures for Filled Cables in Cold Weather	21
10.	Assembly Units	22
11.	Directional Boring	22
12.	Figure Eighting Cable	22
13.	Aerial Inserts	23
14.	Numbering and Identification	23
15.	Acceptance Testing	23

TABLES & FIGURES

Figure 1	Typical Cable or Wire Plowshare with Fixed Feed Tube.....	25
Figure 2	Plowshare with Vertical Shin	26
Figure 3	Plowshare with Shin Angled Back From Plow-Point ..	27
Figure 4	Plowshare with Shin Angled Toward Plow-Point	28
Figure 5	Plowshare with Hinged Feed Tube	29
Figure 6	Plowshare with Floating Feed Tube	30

INDEX:

Outside Plant
Construction
Telecommunications

ABBREVIATIONS

AWG	American Wire Gauge
BFC	Buried Filled Cable Assembly Unit
BFO	Buried Filled Fiber Optic Cable Assembly Unit
°C	Degrees Celsius
CATV	Community Antenna Television
CFR	Code of Federal Regulations
°F	Degrees Fahrenheit
LD	Loan Design
NESC	National Electrical Safety Code
R/W	Right-of-way

REA Rural Electrification Administration
RUS Rural Utilities Service
TE&CM Telecommunications Engineering and Construction Manual

DEFINITIONS

BFC: A buried filled cable assembly unit which includes all the material and labor costs to place, plow, and/or trench and backfill 1,000 feet (304.8 meters) of filled buried copper cable.

BFO: A buried filled fiber optic cable assembly unit which includes all the material and labor costs to place, plow and/or trench and backfill 1,000 feet (304.8 meters) of filled buried fiber optic cable.

Construction Drawings: The drawings developed through the staking process and used to guide the construction of outside plant facilities.

Drawbar Pull: The effective pulling force delivered.

Feed Tube: A tube attached to the blade of a plow which guides and protects the cables or wires as they enter the earth. There are several types of feed tubes.

Figure Eighting: A method of removing cable or wire from a reel and forming the removed cable or wire in the shape of the numeral eight.

Fixed Feed Tube: A feed tube permanently attached to the plow; it may have a removable back plate.

Floating Feed Tube: A feed tube attached to a plow so relative motion may occur between the feed tube and the plow around axes that are essentially vertical and horizontal (perpendicular to direction of travel).

Fuse Link: A fine gauge section of cable or wire that serves as a fuse (that is, open-circuits to interrupt the current should it become excessive) that coordinates with telecommunications cable and wire plant, and telecommunications protective devices.

Hinged Feed Tube: A feed tube attached to a plow so relative motion may occur between the feed tube and the plow around an essentially vertical axis.

Loan Design: A comprehensive engineering plan for a project used to support a loan application to the Rural Utilities Service (RUS).

Static Plow: A plow that depends upon drawbar pull only for its movement through the soil.

Type H Outside Plant Housing: A housing consisting of an upper cover and a base cover. The upper cover consists of a top, front and back plate with the front cover removable to permit entry. The base cover consists of a front and back plate. The base cover back plate can be an extension of the upper back plate cover.

Type M Outside Plant Housing: A housing consisting of a one piece upper sleeve designed to fit over the base cover trapping air to prohibit water from entering the splice area.

Resident Engineer: The representative of the Engineer who is delegated full-time "on-site" engineering responsibilities for construction administration.

Right-of-Way: The strip of land over which facilities such as highways, railroads, power lines, other utilities, or telecommunication lines are constructed.

RUS accepted (material and equipment): Material and equipment which RUS has reviewed and determined that:

a. Final assembly is conducted within the United States, Mexico, or Canada or any of their respective territories and the cost of United States, Mexican, or Canadian, manufactured components, in any combination, is more than 50 percent of the total cost of all components utilized in the material or equipment, and

b. The material or equipment complies with pertinent RUS or industry standards and field experience has demonstrated that the material or equipment is suitable for use on systems of RUS telecommunications borrowers.

RUS technically accepted (material and equipment): Material and equipment which RUS has reviewed and determined that:

a. Final assembly is not conducted within the United States, Mexico, or Canada, or any of their territories, or the cost of components within the material or equipment which are manufactured within the United States, Mexico, or Canada, or any of their territories, cost 50 percent or less than the total cost of all components utilized in the material or equipment, and

b. The material or equipment complies with pertinent RUS or industry standards and field experience has demonstrated that the material or equipment is suitable for use on systems of RUS telecommunications borrowers.

Supervision: The responsibility of the resident engineer or the resident engineer's assigned inspector to observe the contractor's employees installing cable, outside plant housings, splices, clean-up, and other related work items associated with the construction project.

Vibratory Plow: A plow utilizing induced periodic motion of the blade in conjunction with drawbar pull for its movement through the soil.

1. GENERAL

1.1 This bulletin discusses construction of buried plant facilities using filled copper cables or wires, and filled fiber optic cables. The information and recommendations in this bulletin are advisory.

1.2 Some of the work items associated with buried plant construction are as follows:

- a. Pre-installation inspection of copper cables and wires and fiber optic cables;
- b. Plowing or trenching of copper cables and wires and fiber optic cables;
- c. Lateral trenching of copper cables and wires and fiber optic cables to outside plant housings or poles;
- d. Installation of outside plant housings;
- e. Installation of serving area interface cabinets;
- f. Tamping of trenches;
- g. Installation of direct buried filled splice cases for copper cables and wires and fiber optic cables;
- h. Splicing of copper cables and wires and connection of shield bonds and related grounding;
- i. Splicing of fiber optic cables and connection of armor bonds and related grounding;
- j. Installation of filled buried service wires;
- k. Terminating of filled buried service wire directly to cable conductors;
- l. Construction of aerial inserts;
- m. Placement of filled terminal blocks in outside plant housings in high service order activity locations;
- n. Placement of load coils (See Note);
- o. Placement of digital carrier repeater housings, and lightwave repeater housings;

Note: When loaded lines are determined by RUS to be economically feasible and the overall system design complies with the Modernization Plan (7 CFR 1751, Subpart B).

- p. Placement of directional route and warning markers, and route and terminal numbers on outside plant housings; and
- q. Conducting acceptance tests.

1.3 Information for the design, staking, splicing, acceptance testing, and construction of direct buried plant can be found in the following Rural Utilities Service (RUS) documents:

- a. RUS Form 515, RUS Telephone System Construction Contract (Labor and Materials);
- b. RUS Bulletin 345-150, Specifications and Drawings for Construction of Direct Buried Plant (RUS Form 515a);
- c. RUS Bulletin 345-153, Specifications and Drawings for Construction of Pole Lines, Aerial Cables and Wires (RUS Form 515f);
- d. RUS Bulletin 345-63, RUS Standard for Acceptance Tests and Measurements of Telephone Plant (PC-4);
- e. RUS Bulletin 1751F-640, Design of Buried Plant - Physical Considerations;
- f. RUS Bulletin 1751F-642, Construction Route Planning of Buried Plant; and
- g. RUS Bulletin 1753F-401(PC-2), RUS Standard for Splicing Copper and Fiber Optic Cables (codified under 7 CFR 1755.200).

2. SUPERVISION OF CONSTRUCTION

2.1 The construction of buried plant facilities should be closely supervised because of the rapid rate at which plowing or trenching proceeds and because the cable or wire cannot be visually inspected after installation. This close supervision should be accomplished by having the resident engineer or resident engineer's assigned inspector present at all times during the buried plant construction operation. The resident engineer or the resident engineer's assigned inspector also has the responsibility to ensure that the correct pair sizes, gauges, and types of copper cables or wires, and the correct number of optical fibers, type of optical fibers and types of fiber optic cables are placed at the correct depths and locations within the right-of-way (R/W), and are free of damage during the buried plant construction operation.

2.2 When more than one plowing or trenching operation is being performed at the same time, each plowing or trenching operation

should be supervised. During the installation of the cables or wires, construction may be stopped pending the resident engineer's decision concerning proposed changes in the construction route from that shown on the construction drawings. Undue delays in making such decisions are costly to the borrower and should be avoided.

2.3 Cables or wires should be inspected for damage after installation. In order to perform this inspection, the plow should be advanced 10 feet (3.05 meters) past an outside plant housing location and stopped. A length of cable or wire should then be pulled through the plow's feed tube, back through the slot and over to the outside plant housing. This procedure provides an opportunity to inspect short lengths of cables or wires for damage. Particular care should be exercised in bending the cables or wires during this inspection procedure.

2.4 The minimum bending radius for copper cables and wires should not be less than 10 times the outside diameter of the copper cable or wire. The minimum bending radius for fiber optic cables should not be less than 20 times the outside diameter of the fiber optic cable. If cables or wires are bent too sharply, damage could occur to the copper conductors, optical fibers, shields, armors, and/or jackets of the cables or wires.

2.5 All reels of filled copper cable and wire and all reels of filled fiber optic cable should be inspected before installation for visual signs of damage. In addition, filled copper cable and wire ends and filled fiber optic cable ends should be sealed to prevent moisture entry into the cores of copper cables and wires and fiber optic cables during transportation, in storage, and during placement.

2.6 The buried plant construction route should be inspected before beginning the plowing or trenching operation. When selecting the buried plant construction route, the convenience and ease of installation should be considered providing the quality of construction, which would affect future operation and maintenance of the telecommunications system, is not decreased and construction costs to the borrower are not substantially increased.

2.7 Cables and wires, as well as, the equipment and procedures should be continuously inspected during the installation to prevent damage to the cables and wires and to ensure that proper depths are maintained at all times. Caution should be exercised to prevent damage to the cables and wires because of cable or wire slippage in the ground as the plow or trencher leaves the starting pit. Cables and wires should be checked for damage at sudden or severe changes in grade or where the plow or trencher is violently impaired in movement (such as striking a large rock). Generally, buried plant facilities are more susceptible to damage during trenching operations and backfilling than they

are when being plowed into the ground. The resident engineer should make certain that the cables or wires are properly installed in open trenches, that the trenches are properly backfilled, and that the surfaces of the ground are restored to the previous conditions. Lateral trenches should be backfilled and tamped where necessary to provide solid bases for the cables or wires to rest upon between the plow slots and the outside plant housings. At outside plant housing locations, the soil should be properly tamped so that it will conform to the cables or wires bending radii. If this procedure is not followed, the cables or wires may sag downward from the attachments within the outside plant housings as the soil settles resulting in possible damage to the copper conductors, optical fibers, and/or loss of cable or wire shield or armor continuity. All trenches should be promptly backfilled with soil and mechanically tamped so that the soil is restored to its original grade to ensure that future settlement does not result in a hazard to vehicular, animal, or pedestrian traffic. In areas where experience indicates that water added to the backfill (flooding) does help achieve compaction, (usually in sandy soil), the flooding method may be used as an alternative method to mechanical tamping. Unprotected and unmarked trenches should not be left open overnight.

2.8 Construction work should be organized so that plowing and/or trenching operations, together with the placement of cables or wires, service wires, outside plant housings, and other associated functions are done concurrently. In this manner, the interval from start to completion of any section of the project is held to a minimum. The resident engineer assigned to each buried plant construction operation may not have time to inspect all the details of related work being performed along the construction route. Therefore, the resident engineer should have additional personnel to supervise and inspect all such construction. The number of supervisory personnel required to inspect all aspects of construction depends on the amount of proposed construction and on the number of different operations being performed simultaneously.

2.9 Installation of reel-end splices which may change proposed digital carrier or lightwave repeater locations should be considered for re-routing. Because of the limited deviations allowed in digital carrier or lightwave repeater spacings, all repeatered lines should be constructed first, starting at the central office and advancing in the direction of the repeatered line with a continuous operation to the last repeater point on each repeatered section unless otherwise specified in the contract. Deviations from this procedure should be approved in lieu of holding up the construction project in the event of late cable or wire deliveries, or R/W difficulties, etc.

2.10 Installation of reel-end splices on loaded lines (See Note on Page 6) which may change proposed load coil locations should be considered for re-routing. Because of the limited deviations

allowed in load coil spacings, all loaded lines should be constructed first, starting at the central office and advancing in the direction of the loaded line with a continuous operation to the last load point on each loaded section unless otherwise specified in the contract. Deviations from this procedure should be approved in lieu of holding up the construction project in the event of late cable or wire deliveries, or R/W difficulties, etc.

2.11 Sequential markings on the outer jackets of cables and wires are provided to facilitate proper spacing of digital carrier or lightwave repeater housings, load coils (when loaded lines are determined by RUS to economically feasible and the overall system design complies with the Modernization Plan [7 CFR 1751, Subpart B]), and inventory of cable and wire units. The resident engineer and the contractor should agree on the inventory of buried plant units as they are installed. Construction drawings should be appropriately marked so they can be used as permanent records of all plant items.

2.12 Road and ground surfaces should be inspected to determine if the surfaces have been damaged by the plowing or trenching equipment. If the surfaces have been damaged, the surfaces should be repaired and reinspected to determine that the surfaces have been properly repaired. If repairs are necessary, the repairs should be performed in accordance with Federal, State, or local codes, and as set forth in RUS Form 515, RUS Telephone System Construction Contract.

2.13 Outside plant housings should be inspected during construction to determine that:

- a. The correct size and sealer have been properly installed;
- b. Copper cable or wire conductors have been correctly terminated;
- c. Shields and/or armors of copper cable or wire have been bonded and grounded;
- d. Cables or wires tags have been marked with the proper information per RUS Bulletin 1753F-401(PC-2);
- e. Correct routes and outside plant housing numbers, and warning decals have been installed;
- f. Stakes or stub poles have been installed at the proper depths; and
- g. Rodent protection has been properly installed, as required.

2.14 Direct buried filled splices and cases should be inspected during construction to ensure that:

- a. Cable or wire jackets have been properly prepared;
- b. Copper cable or wire conductors have been properly spliced;
- c. Optical fibers have been properly spliced;
- d. Buffer tubes containing the optical fibers have a sufficient amount of slack;
- e. Shields and/or armors of cables or wires have been bonded and grounded;
- f. Encapsulating compounds have been properly mixed and applied; and
- g. The direct buried filled splice cases have been properly installed.

2.15 When direct buried filled splice cases are required to be protected from mechanical damage, protection of the splice cases should be accomplished either by placing treated planks approximately 6.0 inches (152 millimeters) above the splice cases or by placing the splice cases in handholes.

2.16 Construction drawings should be accurately marked to indicate the following:

- a. Routing of cables or wires;
- b. Lengths, pair sizes, gauges, and types of copper cables;
- c. Lengths, number and types of optical fibers, and types of fiber optic cables;
- d. Locations of direct buried filled splice cases and splice warning signs;
- e. Locations of handholes;
- f. Locations of outside plant housings;
- g. Locations of warning and route signs;
- h. Locations of load coils (See Note on Page 6);
- i. Locations of digital carrier repeater and serving area interface cabinets;

- j. Locations of lightwave repeater housings; and
- k. Locations of other buried utilities and obstacles.

This should facilitate future reinforcements which may be required on the project. If depths greater than normal depths in the Loan Design (LD) have been specified to facilitate future reinforcing or to provide a greater degree of mechanical protection to the buried plant facilities, the resident engineer should make certain that such depths are achieved.

2.17 For copper cable buried construction projects, direct buried filled splice cases, trenching, labor, and other materials associated with the installation of reel-end splices are included in the BFC assembly unit. Therefore, such splice cases are not covered in the final inventory for compensation purposes. Although the splice cases are not inventoried, all splice cases and cable or wire lengths should be shown on the construction drawings for future reference. For ease of future location, all direct buried filled splices should be located at a measured distance with respect to the center of the road or from some other permanent marker such as a locating ball, etc. Construction drawings should also indicate the location of all outside plant housings or direct buried filled splice cases that were installed for the purpose of repairing cable or wire damage that occurred during construction.

2.18 For fiber optic cable buried construction projects, the BFO assembly unit does not include direct buried filled splice cases, trenching, labor, and other materials associated with the installation of reel-end splices. Therefore, such splice cases should be covered in the final inventory for compensation purposes. All splice cases and cable lengths should be shown on the construction drawings for future reference. For ease of future location, all direct buried filled splices should be located at a measured distance with respect to the center of the road or from some other permanent marker such as a locating ball, etc. Construction drawings should also indicate the location of all outside plant housings or direct buried filled splice cases that were installed for the purpose of repairing cable damage that occurred during construction.

2.19 Where rock conditions exist that make the plowing of cables or wires impractical or inadvisable, trenching, aerial inserts, or re-routing should be considered as construction options along that particular section of the route. The decision as to what option should be used is normally made during the construction period by the resident engineer.

2.20 The buried construction route should be cleared only to a width that will allow for the passage of the cable or wire placing equipment. The responsibilities in regards to obtaining, operating on, clearing obstructions (trees, brush, etc.),

disposal of debris and restoration of public and private R/W, including any compensations are defined in RUS Bulletin 345-150, Specifications and Drawings for Construction of Direct Buried Plant (RUS Form 515a).

2.21 Special care should be exercised to avoid damage to fences, trees, lawns, and shrubs. Disturbance of ground surfaces by heavy construction equipment should be kept to a minimum. All fences removed or cut for access of the equipment should be repaired promptly in accordance with RUS Bulletin 345-150, Specifications and Drawings for Construction of Direct Buried Plant (RUS Form 515a). When installing cables or wires in pasture and/or range lands, gates should be closed and fence openings should be repaired as soon as possible.

2.22 Plowing or trenching operations within the area of subsurface structures should be carried out in a manner that will avoid accidental contact of the digging tools with such structures. The equipment which may be used for such operations should be operated only by qualified personnel. When foreign structures are encountered such as buried power cables, Community Antenna Television (CATV) cables, gas lines, etc., the installation of the buried telecommunications cables or wires should be performed in accordance with the requirements of the latest edition of the National Electric Safety Code (NESC) or Federal, State, or local codes. Where Federal, State, or local codes are more stringent than the NESC, the installation of the buried telecommunications cables or wires should be performed in accordance with the more stringent codes.

2.23 The minimum depth requirements for buried cables or wires are given in RUS Form 515 and RUS Bulletin 345-150 (RUS Form 515a). In certain situations it may be desirable to bury cables or wires at depths greater than the minimum depths given in RUS Form 515 and RUS Bulletin 345-150 (RUS Form 515a). These greater depths need to be approved by RUS prior to bidding.

2.24 Portions of the filled buried service wires that are exposed to possible subscriber damage should be protected by placing the exposed portions of the wires in nonmetallic conduits or split "U" guards.

3. CHARACTERISTICS OF TRACTORS

3.1 The resident engineer should be familiar with the characteristics and capabilities of the tractors and plowing equipment used in the construction of buried cable or wire plant facilities. The equipment used on the construction project should be subjected to the requirements listed in RUS Form 515 and RUS Bulletin 345-150 (RUS Form 515a) and approval of the public authorities having jurisdiction over highway and road R/W. The size and maneuverability of the equipment should also be

considered in the selection of the cable or wire construction route.

3.2 The power capabilities of static type tractors may be stated in either terms of drawbar horsepower or drawbar pounds pull. Direct gear drive tractors are normally rated in terms of drawbar horsepower and tractors with torque converters are normally rated in terms of drawbar pounds pull at a given forward speed. The terms drawbar horsepower and drawbar pounds pull refer to the reserve tractive horsepower and the reserve tractive force, respectively, available beyond that required to move the tractor itself. Crawler and rubber-tired tractors are two types of static tractors.

3.3 In crawler tractors, the factors which influence traction are the width and length of the track and the design of the grousers. Grousers are metallic ribs which are attached to the tracks to penetrate and grip the soil. The grousers are attached to the tracks at right angles to the tracks and to the direction of motion. Grousers are used to ensure that traction is obtained by shearing the soil and not by friction of the metal on the soil alone. In general, crawler tractors with long, wide tracks and high grousers obtain greater traction than crawler tractors with short, narrow tracks and low grousers.

3.4 Factors influencing the traction of rubber-tired tractors include the weight and weight distribution of the tractor, tire size, inflation pressure and tread pattern, and wheel base.

3.5 For traction in various soils, a choice of various widths, lengths, and depths of track may be obtained on crawler tractors. For rubber-tired tractors, the traction in various soils will depend on sizes and inflation pressures of the tires. Both crawler and rubber-tired tractors may be operated in surface conditions varying from solid rock to swamp-like soils and weather conditions varying from droughts to floods and from frosts to summer sun.

3.6 Manufacturers of both crawler and rubber-tired tractors should be contacted to determine the tractive forces of their respective equipment in various soil conditions.

3.7 Rubber-tired tractors are more difficult to keep on straight courses, particularly on slopes, than crawler tractors. Factors which can influence the steering of rubber-tired tractors are the tractor's transmission type and steering mechanism. Rubber-tired tractors can be manufactured with clutch-brake, differential and limited slip differential transmissions. Steering of clutch-brake rubber-tired tractors is accomplished by the skidding of the wheels. Steering rubber-tired tractors with differential drive transmissions is accomplished with steerable wheels at the front, at the back, or all around.

3.8 If rubber-tired tractors are used for the construction project, all-wheel drive tractors with all wheel steering and limited slip differential transmissions should be the preferred rubber-tired tractor types because the oblique steering properties tend to offset any tendency of the tractors to slip sideways on the slopes. It should be noted that rubber-tired tractors having rear wheel steering are difficult to keep on straight courses when the plow is in the ground.

3.9 Cables or wires are usually installed along the most feasible route, whether it is along public R/W, private R/W, or across farming or grazing lands. Farming or grazing landowners are usually reluctant to consent to the use of crawler or rubber-tired tractors on farming or grazing lands because of the surface damage that can be done to the farming or grazing lands as a result of these type tractors. Since crawler tractors do far less surface damage than rubber-tired tractors, crawler tractors should be the preferred tractors for buried plant construction projects involving private R/W across farming or grazing lands.

3.10 Department of transportation officials frown upon surface damage done to hard highway or road surfaces as a result of track slippage. Since track slippage can result from the crawler's insufficient power and traction (weight), either rubber-tired tractors or crawler tractors with rubber pads should be the preferred tractors for buried plant construction projects involving hard surfaces because the rubber-tired tractors and the rubber padded crawler tractors do not damage the hard surfaces of the public or private R/W.

3.11 The drawbar pull characteristics of static type tractors are not entirely applicable to vibratory tractors. The vibratory tractor's principle of cutting and vibrating can reduce the drawbar pull, as related to static type tractors, as much as 80 percent in some soil conditions. In addition, since the vibratory tractor's weight is dictated by drawbar requirements and not engine size, a significant reduction in the vibratory tractor's weight and size can be achieved through plow vibrations. However, drawbar requirements for vibratory type tractors increase as the plowing speeds increase and, therefore to obtain full advantage of plow vibrations, plowing speeds are relatively low. Thus for a vibratory tractor's drawbar capability, a vibrating plow should settle to a speed that depends on the soil conditions.

4. CHARACTERISTICS OF PLOWING EQUIPMENT

4.1 The soil properties such as hardness, friction, adhesion, cohesion, and abrasion should be evaluated before selecting the type of plow for the construction project. Soil hardness is the resistance to penetration. Soil hardness is at a minimum for sandy soil and at a maximum for dry clay. Friction is the force

at the plow/soil interface that resists the motion or tendency to motion of the plow to the soil. Friction is affected by the amount of moisture and natural lubricants in the soil. Adhesion is the sticking of the soil to the plow being used. Cohesion is the resistance of the soil to tearing apart and it is at its maximum in clay soil. Abrasion is the property of wearing away of the plowing equipment by the soil particles.

4.2 Static and vibratory type tractors can be equipped with either direct mounted or towed plows. One advantage in using towed plows over direct mounted plows is that the tractors can be of the general purpose type. Towed plows can also be unhitched for crossing soft patches of soil, swamps, and streams and winched across these areas with the tractors standing on firm ground. When undulating terrain is encountered, towed plows in some instances can do better jobs of installing the cables or wires at the proper depths than some of the direct mounted plows. However, direct mounted plows are considered superior to towed plows for most terrain and soil conditions. One of the reasons that direct mounted plows are considered superior to towed plows is that the direct mounted plows can be easily maneuvered. Another reason is that direct mounted plows rely on the weight of the tractor and its hydraulics for positive holddown rather than the dead weights used for towed plows. The dead weights placed on towed plows to maintain a 15,000 pound (67,723 newton) downward force may result in a reduction of the tractor's power necessary for plowing. With properly designed direct mounted plows, the proper depths of the cables or wires can be maintained.

4.3 Direct mounted plows are considered more stable than towed plows because the towbars of the tractors pulling the separately mounted plows tend to lift the fronts of the tractors off the ground. For tractors equipped with towed plows, the stability of the tractor increases as the tractor's weight is increased but decreases as the drawbar pull increases. For tractors with direct mounted plows, the stability of the tractor increases as the drawbar pull increases and the resistance offered by the earth to the plow increases.

4.4 The ideal plow should be designed so that the cables or wires exit the plowshare at approximately the same heights above the bottoms of the plowed slots regardless of the depths. The disadvantage of these type plows are that the cables or wires may be damaged because of abrupt changes in elevation when passing over rocks, etc. One method of overcoming this type of cable or wire damage is the use of four point or parallelogram type linkage.

4.5 If hydraulic rams are used to transmit part of the tractor's weight to the plow for positive holddown, the hydraulic rams should be double acting and capable of raising the rear of the tractor with the plow-point resting on the ground.

4.6 The equipment should be capable of extending the plow blade to a depth of at least 36 inches (914 millimeters) when the tractor is angling across and along drainage ditches or rough terrain. The plow-point, leading-edge (shin), share-shape, and share-width should be designed to cut a narrow slot through the earth without excessively disturbing the soil. The broad "V" shaped leading-edge (shin) equal to the plowshare's thickness has been found to be satisfactory. Figure 1 depicts a sketch of a typical cable or wire plowshare. The proportions and the angles of attack of the plow-points have been shown to have the greatest effect on drawbar pull and pull-down. This means that plows designed with vertical shins as shown in Figure 2 or shins that angle back from the plow-points as shown in Figure 3 tend to stay in the ground better than plows designed with shins angled towards the plow-points as shown in Figure 4. For most soils and rock, the plow-point penetration angles should range from a minimum of 30° to a maximum of 50° from the horizontal. In addition to plowshares with fixed feed tubes as shown in Figure 1, plowshares are also available with either hinged or floating feed tubes. Figure 5 shows a plowshare with a hinged feed tube, while Figure 6 shows a plowshare with a floating feed tube.

5. CAPABILITIES OF TRACTORS AND PLOWS

5.1 One tractor should be able to pull a plow through most soil types. A second tractor to assist the prime tractor should be used when additional traction is needed in hard to plow soil types, muddy and swampy type soils, or other difficult areas. Crawler tractors generally provide better flotation and more positive traction than rubber-tired tractors. The prime tractor used to pull the plow should be the larger of the two tractors. The prime tractor should have a minimum rating equivalent to 55,000 pounds (2.45×10^5 newtons) drawbar pull at 1.2 miles per hour (1.93 kilometers/hour) or 130 drawbar horsepower at the rated engine speed at a depth of 24 in. (61 cm). For burial depths greater than 24 in. (61 cm), tractor manufacturers should be contacted to determine minimum drawbar pull or drawbar horsepower requirements necessary to achieve the specified burial depth.

5.2 Plowing should be considered difficult when the equivalent of at least 250 drawbar horsepower is applied to the plow. When difficulty in plowing as defined above is encountered, alternative methods of placing the cable or wire should be considered for those areas. The alternative methods for placing the cable or wire in those areas could be the use of aerial inserts, pre-ripping, rock trenching, or major re-routing of the construction route. Since the 250 drawbar horsepower is considered to be a very large amount of power, good judgement should be exercised to prevent damage to the equipment and

unnecessary or undue damage to the terrain caused by the upheaval of large boulders.

5.3 When a second tractor is needed to assist in the plowing operation, the second tractor should be equipped with a winch and a blade. The second tractor containing the winch and blade may then be used for necessary R/W clearing and cleanup when it is not required to assist the prime tractor.

5.4 Compaction of plow slots should be performed after the cables or wires have been plowed-in. The method of compacting most plow slots should be as follows:

- a. Run the tractor track or tire along and immediately adjacent to both sides of the plow slot;
- b. Fill in any ground depressions which may have developed with soil to form a mound over the center of the plow slot; and
- c. Then run the track or tire over the center slot.

5.5 A signaling method between the person riding the reel tender or plow, and the tractor operator should be developed to:

- a. Inform the tractor operator when the plow or reel tender is to be stopped at access points along the construction route;
- b. Prevent damage to the buried cables or wires; and
- c. Minimize the possibility of injury to construction personnel.

The signaling method chosen should be able to attract the attention of the tractor operator over the operating noise of the tractor. One such method could be use of a loud alarm bell with a flashing light.

6. HANDLING AND CARE OF MATERIALS DURING CONSTRUCTION

6.1 Extreme care should be exercised in handling materials during the construction process. The plowing operation should be supervised at all times to ensure that the cables or wires feed through the plow and into the ground under zero tension. Under no circumstances should tension be allowed to develop in the cables or wires. Whenever the plow is stopped, sufficient lengths of cable or wire should be removed from the reel to guard against sudden movements when the plow is restarted.

6.2 Extreme caution should be exercised to ensure that the plow is never backed up while the blade is in the ground. The backing

up of the plow could cause severe damage to the cables or wires. If the plow strikes a buried object or rock during the plowing operation, the plow should be stopped without backing up and the plow removed from the soil and the cable or wire inspected for possible damage. Should it be necessary to back up the plow, the cables or wires should be uncovered a sufficient distance back from the plow and inspected for damage. If cable or wire damage is discovered, the damage should be repaired in accordance with the construction contract and specifications.

6.3 Care should be exercised to prevent damage to exposed cables or wires during the construction period. Construction work should be scheduled to keep such exposure to a minimum. Where cables or wires are being placed along the construction route, all trenching and backfilling for both inline and short lateral trenches should be completed each day so as not to leave the cables or wires exposed overnight. Cables or wires left exposed are susceptible to damage. Cables or wires left exposed are also considered hazards to vehicles, pedestrians, and animals.

6.4 Where outside plant housings are used, caution should be exercised to avoid damaging the cables or wires when:

- a. Joining the lateral trenches to the plow slot;
- b. Installing the outside plant housings; and
- c. Forming the cables or wires in the outside plant housings.

The stakes or stub poles of outside plant housings should be installed before the cables or wires are placed in the lateral trenches.

6.5 Cables or wires should be installed in outside plant housings as soon as practicable. The installation work should be completed within one week after the cables or wires have been plowed or trenched in the ground. However, no trenches or other excavations should be left open overnight unless the openings are protected by a method specified in the contract.

6.6 Buried plant connections using dissimilar metals should be avoided to eliminate the possibility of galvanic corrosion. Therefore buried plant connections should be made using only tinned coated metals.

7. REPAIR OF CABLES OR WIRES DAMAGED DURING CONSTRUCTION

7.1 Minor damage to the outer jackets, where the shields or armors of the cables or wires have not been bent, abraded, or penetrated should be repaired in accordance with Bulletin

1753F-401(PC-2), RUS Standard for Splicing Copper and Fiber Optic Cables.

7.2 Where shields or armors have penetrated the outer jackets of cables or wires, the damaged sections should be enclosed in direct buried filled splice cases or outside plant housings. The outer jackets, shields, or armors of the damaged sections should be removed as though preparing for splicing. The shields or armors should then be bonded together. Damage to the copper conductors or their insulations or optical fibers or their buffer tubes should be repaired in accordance with Bulletin 1753F-401(PC-2), RUS Standard for Splicing Copper and Fiber Optic Cables.

7.3 Cables or wires found to be damaged after installation should be repaired. If the damage is considered minor, the damage should be repaired in accordance with Bulletin 1753F-401(PC-2), RUS Standard for Splicing Copper and Fiber Optic Cables. If the damage is considered major, the damage should be repaired either by replacing the damaged sections with new cables or wires spliced to the undamaged sections of the cables or wires or repaired in accordance with the method specified in the contract.

7.4 All outside plant housings or direct buried filled splice cases added because of repairs should be numbered and shown on the construction drawings. However, they should not be included in the final inventory for compensation purposes as specified by the RUS 515 Contract and RUS Bulletin 345-150 (RUS Form 515a).

8. PREPARATION FOR SPLICING OR TERMINATION

8.1 Buried filled copper cables or wires should be spliced in accordance with Bulletin 1753F-401(PC-2), RUS Standard for Splicing Copper and Fiber Optic Cables and enclosed in RUS accepted or technically accepted outside plant housings or direct buried filled splice cases.

8.2 Buried filled fiber optic cables should be spliced in accordance with Bulletin 1753F-401(PC-2), RUS Standard for Splicing Copper and Fiber Optic Cables and enclosed in RUS accepted or technically accepted filled fiber optic splice cases. These splice cases should then enclosed in either RUS accepted or technically accepted handholes or outside plant housings specifically design for fiber optic systems.

8.3 When terminal blocks are used in outside plant housings, only RUS accepted or technically accepted filled terminal blocks should be used.

8.4 The front covers of Type "H" outside plant housings and the dome covers of Type "M" outside plant housings should be bolted

in the closed position at the time the housings are installed. The covers of both type outside plant housings should also be kept in closed position at all times except when work is being performed within the outside plant housings.

9. INSTALLATION PROCEDURES FOR FILLED CABLES IN COLD WEATHER

9.1 Flexibility of filled copper cables or wires and filled fiber optic cables should not be a problem at normal operating temperatures. However, flexibility may be affected when the cables are exposed to lower temperatures. The flexibility of filled copper cables or wires and filled fiber optic cables could be sharply reduced at temperatures below 40°F (4.4°C). At temperatures below 40°F (4.4°C), almost twice the force may be needed to bend the filled copper cables or wires and filled fiber optic cables. Filled cables or wires and filled fiber optic cables should be inspected each morning to determine if the cables or wires are flexible enough for plowing when night time temperatures drop below 30°F (-1.1°C). When filled cables or wires and filled fiber optic cables have been stored outdoors and subjected to cold nights, considerable time may be lost each morning waiting for the cables or wires to warm up even though the day time temperature may be above 40°F (4.4°C). During the spring and fall of the year, the filled copper cables or wires and filled fiber optic cables may be stored in heated warehouses prior to placement in the ground. This storage in heated warehouses allows the filled copper cables or wires and filled fiber optic cables to be transported to the project site as needed and installed while the cables or wires are still flexible.

9.2 Some filling compounds used in the cores of filled copper cables or wires may become stiff as the temperature decreases making it difficult to separate the cable or wire pairs. In general, filled copper cable or wire installations below 40°F (4.4°C) could be slow, difficult, and possibly even halted unless special precautions are taken to offset the effects of the lower temperatures.

9.3 Filling compounds used in loose tube buffers of filled fiber optic cables should not become stiff as the temperature decreases. This should allow the optical fibers to be easily separated at low temperatures.

9.4 As mentioned in Paragraph 9.2, the copper cable or wire pairs may become difficult to separate as the temperature decreases. At temperatures as low as 20°F (-6.7°C), the copper cable or wire pairs may be separated by flexing the free ends of the cable or wire cores and separating a few pairs at a time. It is also interesting to note that the filling compounds at a temperature of 20°F (-6.7°C) are more user friendly to work with than at elevated temperatures. Consequently, the copper cable or

wire pairs may be spliced without wiping the pairs free of filling compound.

10. ASSEMBLY UNITS

10.1 Detailed descriptions of all standard buried plant assembly units are given in RUS Bulletin 345-150, Specifications and Drawings for Construction of Direct Buried Plant (RUS Form 515a).

10.2 Where standard buried plant assembly units are insufficient to provide for unique buried plant construction requirements, detailed "nonstandard assembly units" should be created to meet those requirements. The buried plant nonstandard assembly units should be approved by RUS prior to the bidding of the project.

11. DIRECTIONAL BORING

11.1 Directional boring in buried plant construction should be considered as an alternative method of installing cables or wires under highways, streets, driveways, across lawns, etc., to avoid the expensive costs of repairing and restoring the above mentioned items to their pre-construction appearances.

11.2 Directional boring should also be considered for installing cables or wires under streams, lakes, or rivers, when in the opinion of the borrower or borrower's resident engineer, the use of aerial inserts are economically or environmentally cost prohibited.

11.3 When directional boring is used in the buried construction process, the installation should be performed in accordance with boring equipment manufacturer's recommendations.

12. FIGURE EIGHTING CABLE

12.1 When "figure eighting" of cables or wires is required during the buried construction process, the "figure eighting" of the cables or wires should be performed either manually or mechanically.

12.2 When performed manually, the cable or wire should be pulled off the reel and "figure eighted" in a large open area free of obstructions. The bend radius of the "figure eight" for copper cable or wire should not be less than 10 times the cable's outside diameter. For fiber optic cable, the "figure eight" bend radius should not be less than 20 times the cable's outside diameter.

12.3 When "figure eighting" is performed by a "figure eighting" machine, the equipment manufacturer's instructions should be followed.

13. AERIAL INSERTS

13.1 Aerial inserts in buried plant construction should be used over streams and similar obstructions when, in the opinion of the borrower or the borrower's resident engineer, cables or wires cannot be installed either by plowing, trenching, directional boring, or protected by guard assemblies. Every effort should be made to avoid using aerial inserts because the aerial inserts are susceptible to storm damage and power contacts. When aerial inserts are prone to possible contact with power conductors operating at 300 volts or higher or there is a high probability of lightning exposure to the aerial insert, fuse links should be installed at both ends of the aerial insert. Fuse links should consist of short lengths of color matched conductors that are at least two (2) American Wire Gauge (AWG) sizes finer (numerically higher) than the finest (numerically highest) gauge size of aerial and buried cables or wires being installed.

13.2 All assembly units such as poles, guys, anchors, etc., used for the installation of aerial inserts in buried plant construction are described in RUS Bulletin 345-153, Specifications and Drawings for Construction of Pole Lines, Aerial Cables and Wires (RUS Form 515f).

14. NUMBERING AND IDENTIFICATION

14.1 Every outside plant housing installed along the construction route should be marked with route letters, housing numbers, warning decals, and, when required, the load point numbers (when loaded lines are determined by RUS to be economically feasible and the overall system design complies with the Modernization Plan [7 CFR 1751, Subpart B]).

14.2 Every direct buried filled splice case installed along the construction route should be identified. The identification of the direct buried filled splice cases should be accomplished by using either above ground warning signs or electronic locating devices.

15. ACCEPTANCE TESTING

15.1 After installation, buried copper cables or wires should be tested in accordance with RUS Bulletin 345-63, RUS Standard for Acceptance Tests and Measurements of Telephone Plant (PC-4) and the RUS Form 515 Contract.

15.2 After installation, buried fiber optic cables should be tested in accordance with the procedures listed in the contract.

FIGURE 1

Typical Cable or Wire Plowshare with Fixed Feed Tube

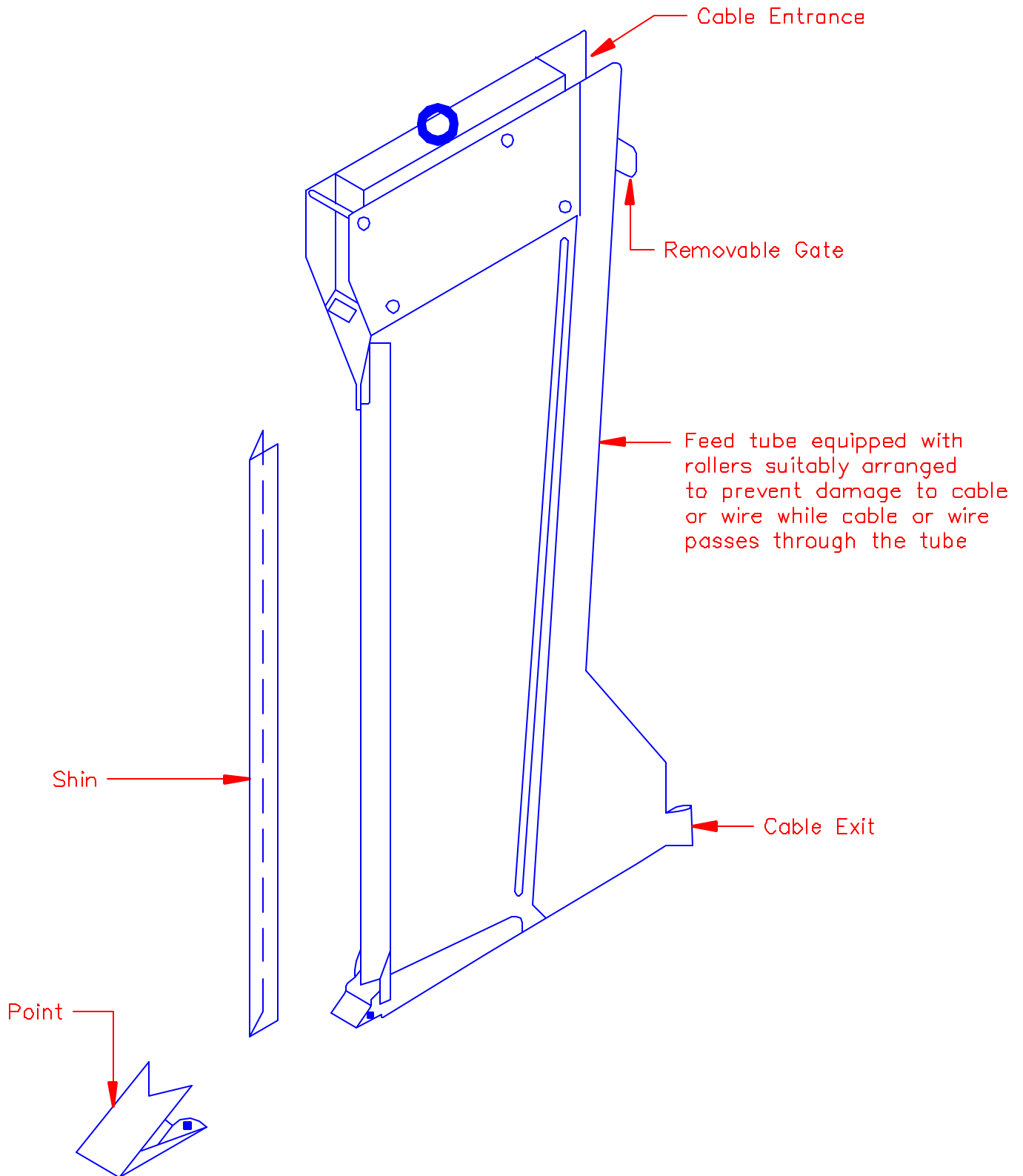


FIGURE 2
Plowshare with Vertical Shin

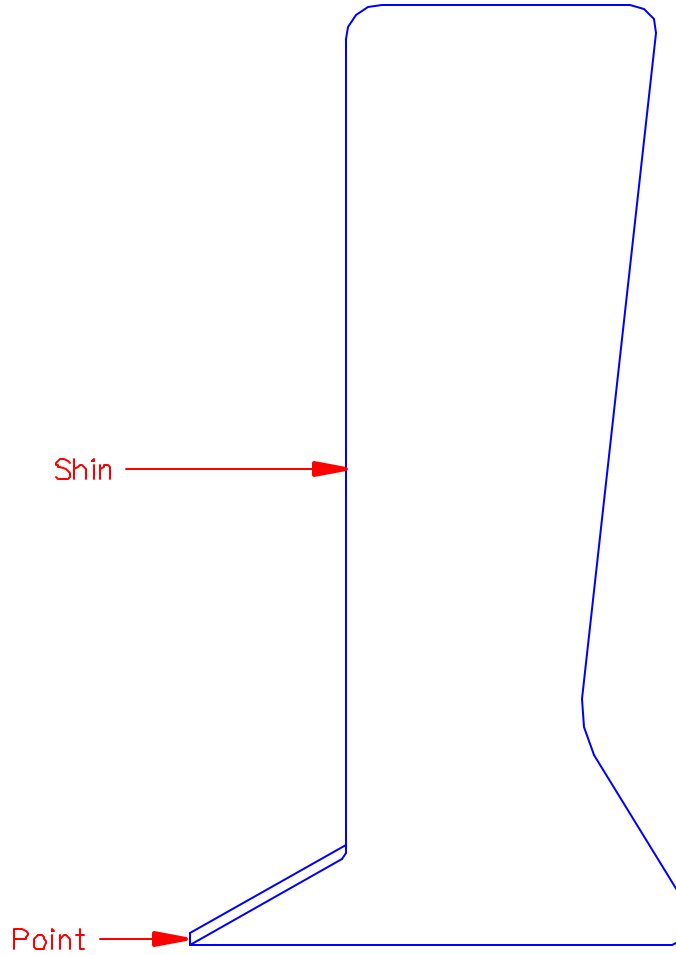


FIGURE 3

Plowshare with Shin Angled Back From Plow-Point

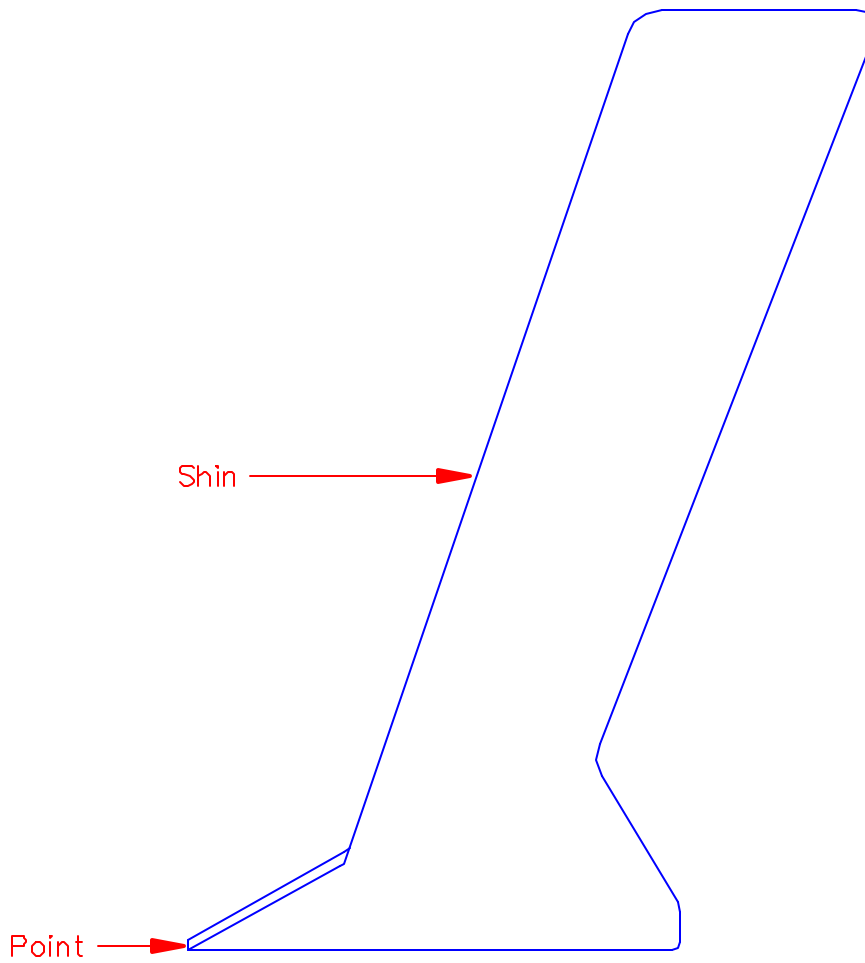


FIGURE 4
Plowshare with Shin Angled Toward Plow-Point

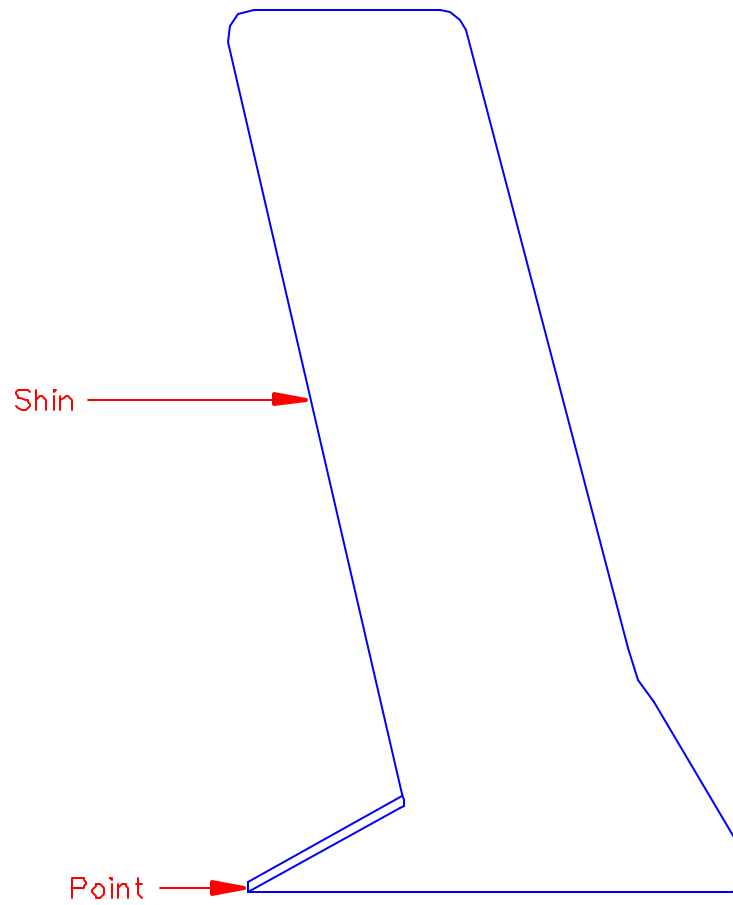


FIGURE 5

Plowshare with Hinged Feed Tube

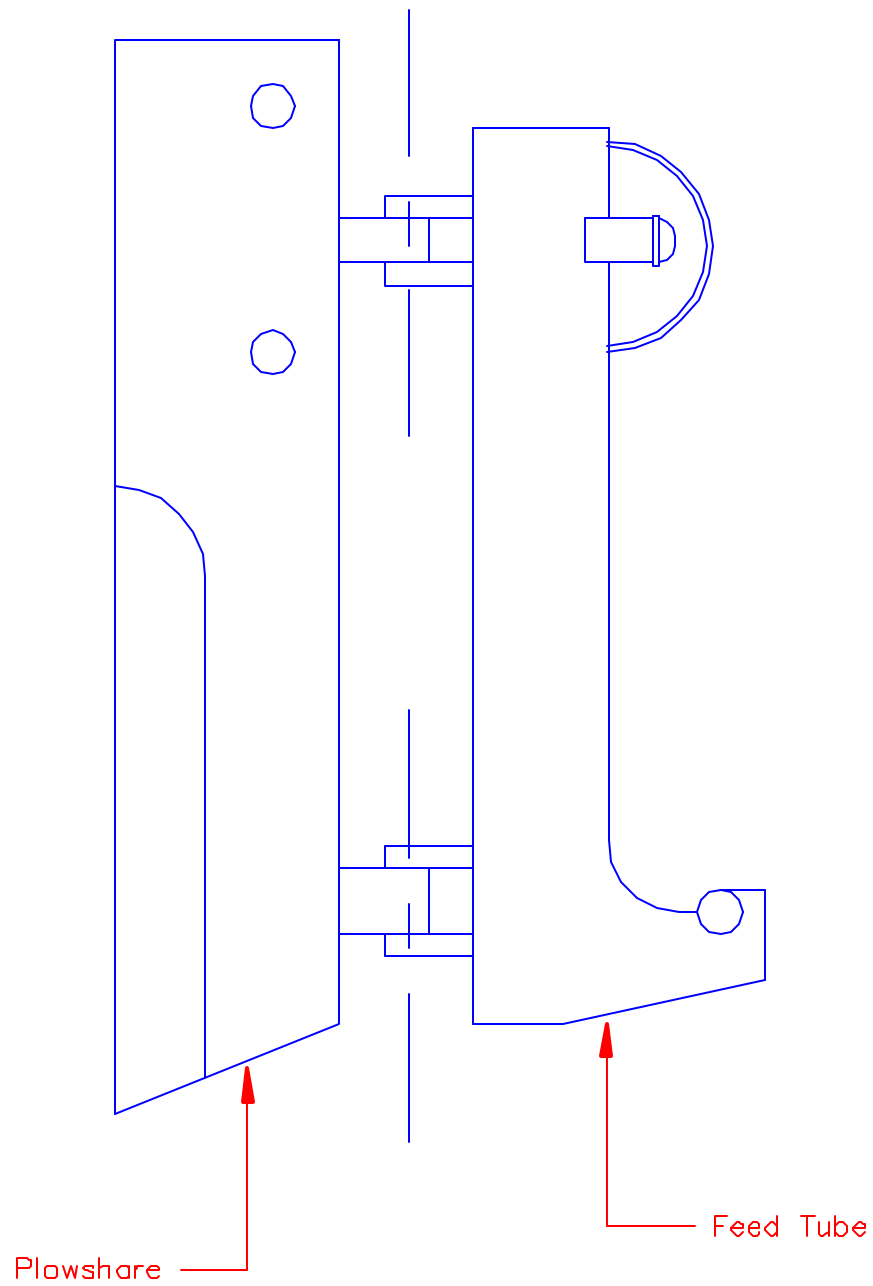


FIGURE 6
Plowshare with Floating Feed Tube

