Technical Report No. 284

A SUMMARY OF FIELD COLLECTING AND LABORATORY PROCESSING EQUIPMENT AND PROCEDURES FOR SAMPLING ARTHROPODS AT PAWNEE SITE

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ABSTRACT

A summary is written of field collecting and laboratory processing equipment and procedures for sampling arthropods at Pawnee Site, the US/IBP Grassland Biome intensive site. The design of the equipment and procedures described was based on arbitrarily dividing the arthropod community into three principal groups, i.e., aboveground arthropods, soil macroarthropods, and soil microarthropods. Sampling equipment and procedures for each arthropod group are described individually in detail including diagrams and drawings. The location and design of sampling macroplots are described as well as the extent of sampling of various treatment types. The sorting, counting, identifying, and weighing of various arthropod groups are discussed.

The inadequacies of the systems used are recognized and discussed and some supporting techniques are suggested.

INTRODUCTION

Intensive investigations into seasonal fluctuations of arthropod populations at Pawnee Site (Jameson 1969) have been conducted on various treatment types since the 1970 growing season. Various types of equipment and procedures have been used, including some unique to the project and some generally well established. An attempt is made here to summarize for reference purposes the principal equipment and methodology that has been used to date at the Pawnee Site, henceforth referred to as the Site.

For the purpose of field sampling and later data analysis, the arthropod community was arbitrarily divided into three areas or groups; and sampling methodology was developed for each. The three groups were defined as follows: (1) *Aboveground arthropods*--all those on or around standing vegetation; (2) *Soil macroarthropods*--those arthropods occurring below the soil litter layer and large enough to be sieved from the soil with a 1-mm-opening sieve; and (3) *Soil microarthropods*--those arthropods occurring in or below the soil litter layer and capable of passing through a 1-mm-opening sieve. Obviously, these definitions are awkward and allow for substantial overlap of effort in making population estimates. To some degree the problem of overlap has been lessened by the above-defined groups being specifically concerned with certain taxonomic groups rather than all possible types produced by an arbitrary mechanical separation.

All field sampling has been conducted on designated macroplots within larger treatment areas. These macroplots, most being 0.5 to 2.5 acres in size, were each divided or gridded into numerous sampling areas or microplots. Each microplot was large enough to allow for repeated use without actually resampling a given area of soil surface. Examples

of gridded macroplots are given in Fig. 1, 2, 3, and 4. Just prior to a given sample date five microplots were selected by use of a random numbers table, and the actual sample locations were marked in the field with metal stakes. New microplots were selected at each sampling date; however, no microplot was reused until all microplots within the macroplot had been used in the given growing season. Generally, one macroplot was set up for each replication of a treatment type.

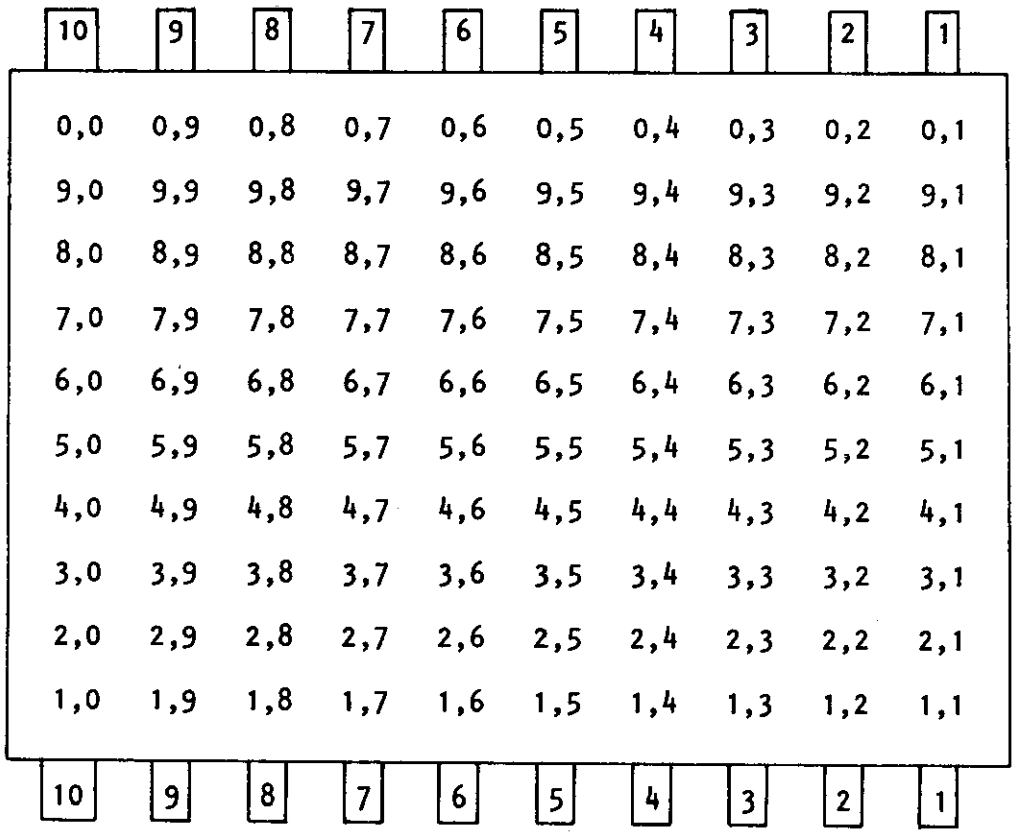
Macroplots have been established at the Site on numerous treatment types including various levels of grazing (Smith and Striffler 1969), supplementary stressing with nitrogen and water (Sims et al. 1971), and insecticide and herbicide treated areas (Grow 1973, McEwen and Ells 1973). With only a few exceptions, at each sample date five samples for each defined arthropod group were taken per replicate of a treatment--one sample for each defined arthropod group at each of the five selected microplots. All samples were labeled with a standard field tag (Fig. 5). Table 1 gives a summary of the treatment types, when and how they have been sampled.

ABOVEGROUND ARTHROPODS

Field Equipment and Methodology

Sampling of aboveground arthropods was based on a system whereby a trap of known size was dropped on a preselected location to enclose the arthropods without flushing them, after which they were removed from the trap by a vacuum. The trap, referred to as a quick trap, was a circular cage that enclosed a 0.5-m^2 area. The trap (Fig. 6, 7, and 8) was originally designed by Dr. Ellis Huddleston of Texas Tech University, Lubbock,

STUDY PLOT (WATERSHED) 1



Lowest Edge of Plot

Pasture - 23 East

Treatment - Heavily grazed

Replicate - 1

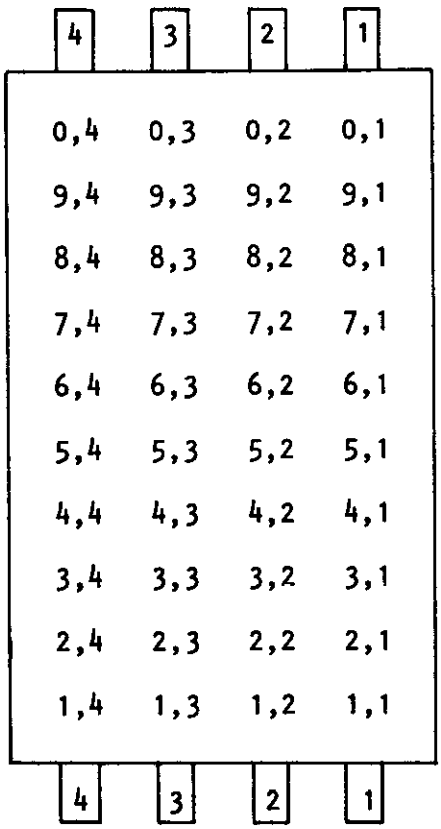
Area - 1 square acre

Number of sample points - 100

Exposure - North

Fig. 1. Example of a sampling macroplot.

STUDY PLOT (WATERSHED) 2



Pasture - 23 East

Treatment - Ungrazed

Replicate - 1

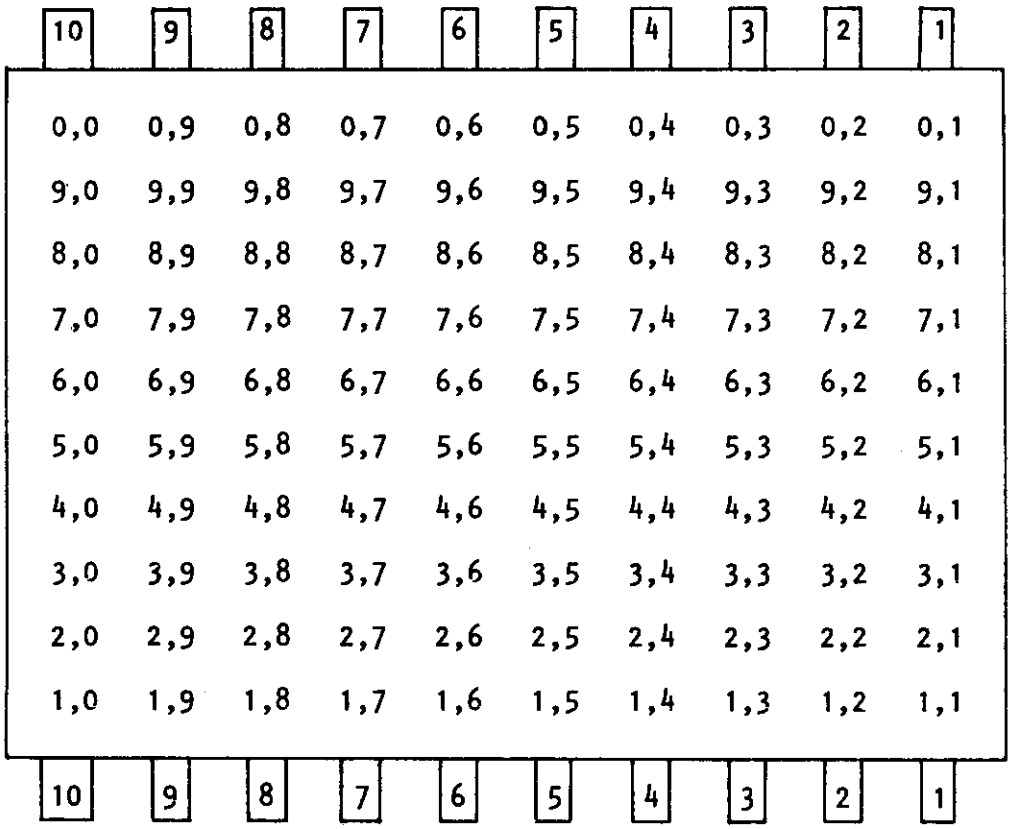
Area - 4/10 acre

Number of sample points - 40

Exposure - South

Fig. 2. Example of a sampling macroplot.

STUDY PLOT (WATERSHED) 3



Lowest Edge of Plot

Pasture - 23 East

Treatment - Heavily grazed

Replicate - 2

Area - 1 square acre

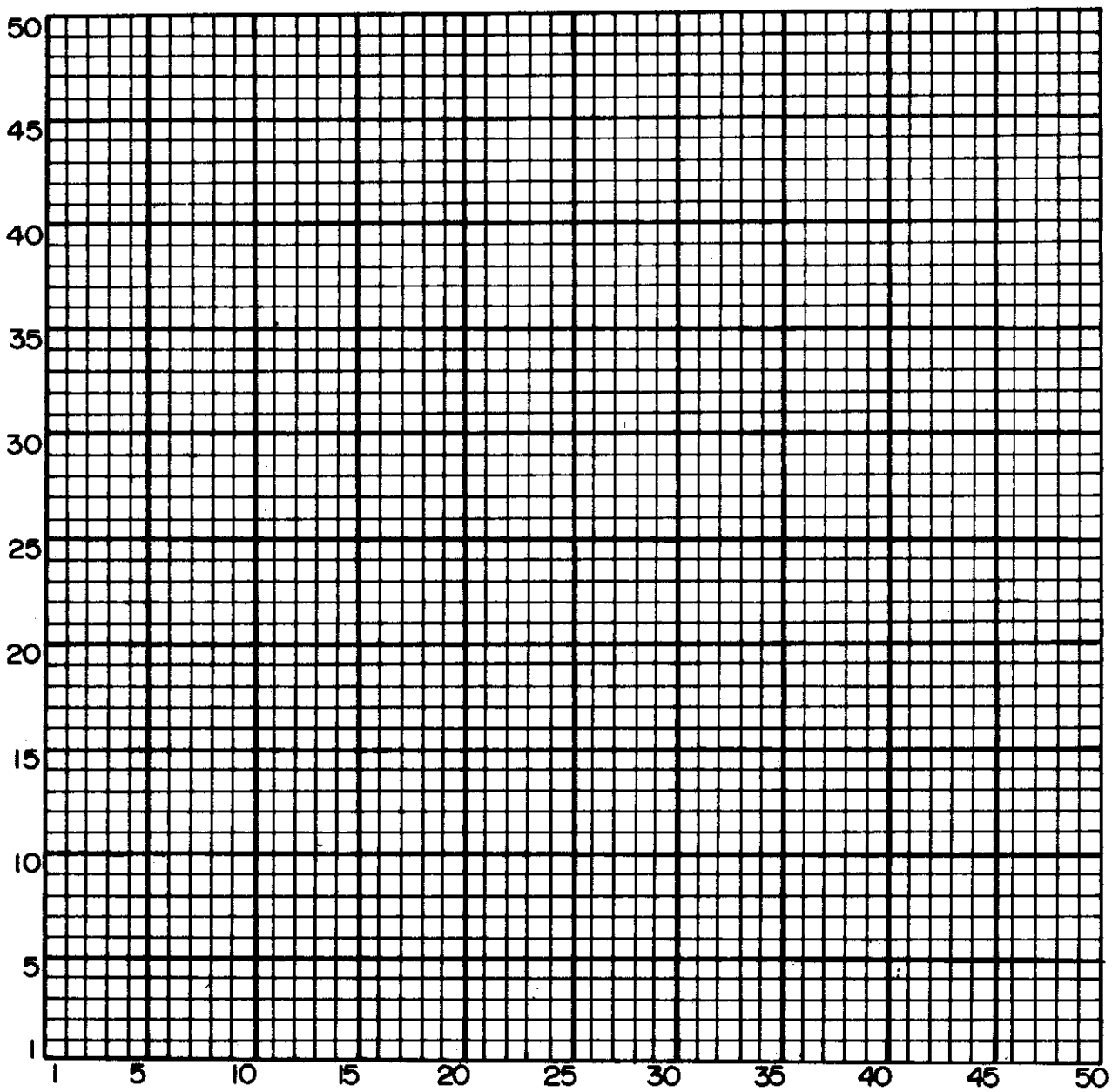
Number of sample points - 100

Exposure - South

Fig. 3. Example of a sampling macroplot.

ECOSYSTEM STRESS AREA

Plot Number 9



Treatment:

Replicate:

Fig. 4. Example of a sampling macroplot.

FIELD SAMPLE LABEL, 1971

Gives the number or letter of the appropriate treatment of the macroplot.

Treatment

1	Ungrazed	D	ESA, Control
2	Lightly grazed	E	ESA, Irrigated
3	Moderately grazed	F	ESA, Nitrogen fertilized
4	Heavily grazed	G	ESA, Irrigated plus fertilized
5	Current year ungrazed, previously heavily grazed	H	Control (Insecticide)
6		I	Dursban (Insecticide)
7		J	Dursban plus Supracide (Insecticide)
8		K	Silvex (Herbicide)
9		L	Dalapon plus Silvex (Herbicide)
A	Diet light	M	Dalapon (Herbicide)
B	Diet medium	X	Toxaphene (BSFW)
C	Diet heavy	Y	Malathion (BSFW)
		Z	Control (BSFW)

Data Type _____ Site _____ Collector's Initials _____

Initials of person filling out tag.

Date: Day ____ Mo ____ Year ____ Time _____

Mountain Standard Time (always).

Treatment _____ Replicate _____

Macroplot number.

Pasture No. _____ Plot No. _____

Section or half-section number where the macroplot is located.

Sample Type _____

Quadrat _____ Sample location _____

Specific location of sample point within a macroplot.

Host _____

This will give the cover vegetation of soil core samples.

This will give the type of sample taken (soil core, vacuum, etc.). It will also give the stage or division of the sample--1 or 2 for the two-stage vacuum sample or 0-6" or 6-12" for the depth increments of deep soil cores.

Fig. 5. A standard field label used for arthropod sampling at Pawnee Site during the years 1970-1974.

Table 1. A summary of treatment types at Pawnee Site showing how and when each was sampled during the years 1970-1974.

Treatment Designation	Treatment Description	No. of Replicates	Macroplot Number	Year	Sample Types Taken						
					Aboveground Arthropods		Belowground Macroarthropods		Belowground Microarthropods		
					One-stage Vacuum	Two-stage Vacuum	0-15 cm	0-30 cm	0-5 cm	0-10 cm	0-60 cm
1	Ungrazed	2	2,8	1970	X		X	X	X		
				1971		X	X	X	X	X(late)	
1	Ungrazed	2	12,13	1972		X	X	X		X	
2	Lightly grazed	2	4,5	1970	X		X	X	X		
				1971		X	X	X	X	X(late)	
				1972		X	X	X		X	X
				1973							X
				1974							X
3	Moderately grazed	2	6,7	1970	X		X	X	X		
				1971		X	X	X	X	X(late)	
4	Heavily grazed	2	1,3	1970	X		X	X	X		
				1971		X	X	X	X	X(late)	
				1972		X	X	X		X	
5	Current year ungrazed, previously heavily grazed	2	10,11	1971		X	X	X	X	X(late)	
				1972		X	X	X		X	X
				1973							X
				1974							X
D	ESA, Control	2	9/3,9/5	1970	X		X	X	X		
				1971		X	X	X	X	X(late)	
				1972		X	X	X		X	
				1973		X	X			X	
				1974		X	X			X	

Table 1. Continued.

Treatment Designation	Treatment Description	No. of Replicates	Macroplot Number	Year	Sample Types Taken						
					Aboveground Arthropods		Belowground Macroarthropods		Belowground Microarthropods		
					One-stage Vacuum	Two-stage Vacuum	0-15 cm	0-30 cm	0-5 cm	0-10 cm	0-60 cm
E	ESA, Irrigated	2	9/2,9/9	1970	X		X	X	X		
				1971		X	X	X	X	X(late)	
				1972		X	X	X		X	
				1973		X	X			X	
				1974		X	X			X	
F	ESA, Fertilized	2	9/7,9/10	1970	X		X	X	X		
				1971		X	X	X	X	X(late)	
				1972		X	X	X		X	
				1973		X	X			X	
				1974		X	X			X	
G	ESA, Irrigated plus Fertilized	2	9/4,9/8	1970	X		X	X	X		
				1971		X	X	X	X	X(late)	
				1972		X	X	X		X	
				1973		X	X			X	
				1974		X	X			X	
H	Control (Insecticide)	3	1,7,9	1972	X		X			X	
I	Dursban (Insecticide)	3	2,5,8	1972	X		X			X	
J	Dursban plus Supracide (Insecticide)	3	3,4,6	1972	X		X			X	
K	Silvex (Herbicide)	3	3,5,7	1972	X		X			X	
				1973	X		X			X	

Table 1. Continued.

Treatment Designation	Treatment Description	No. of Replicates	Macroplot Number	Year	Sample Types Taken						
					Aboveground Arthropods		Belowground Macroarthropods		Belowground Microarthropods		
					One-stage Vacuum	Two-stage Vacuum	0-15 cm	0-30 cm	0-5 cm	0-10 cm	0-60 cm
L	Dalapon plus Silvex (Herbicide)	3	2,4,9	1972	X		X			X	
				1973	X		X			X	
M	Dalapon (Herbicide)	3	1,6,8	1972	X		X			X	
				1973	X		X			X	
X	Toxaphene (BSFW)	2	1,2	1972		X	X				
				1973		X	X				
Y	Malathion (BSFW)	2	3,4	1972		X	X				
				1973		X	X				
Z	Control (BSFW)	2	5,6	1972		X	X				
				1973		X	X				

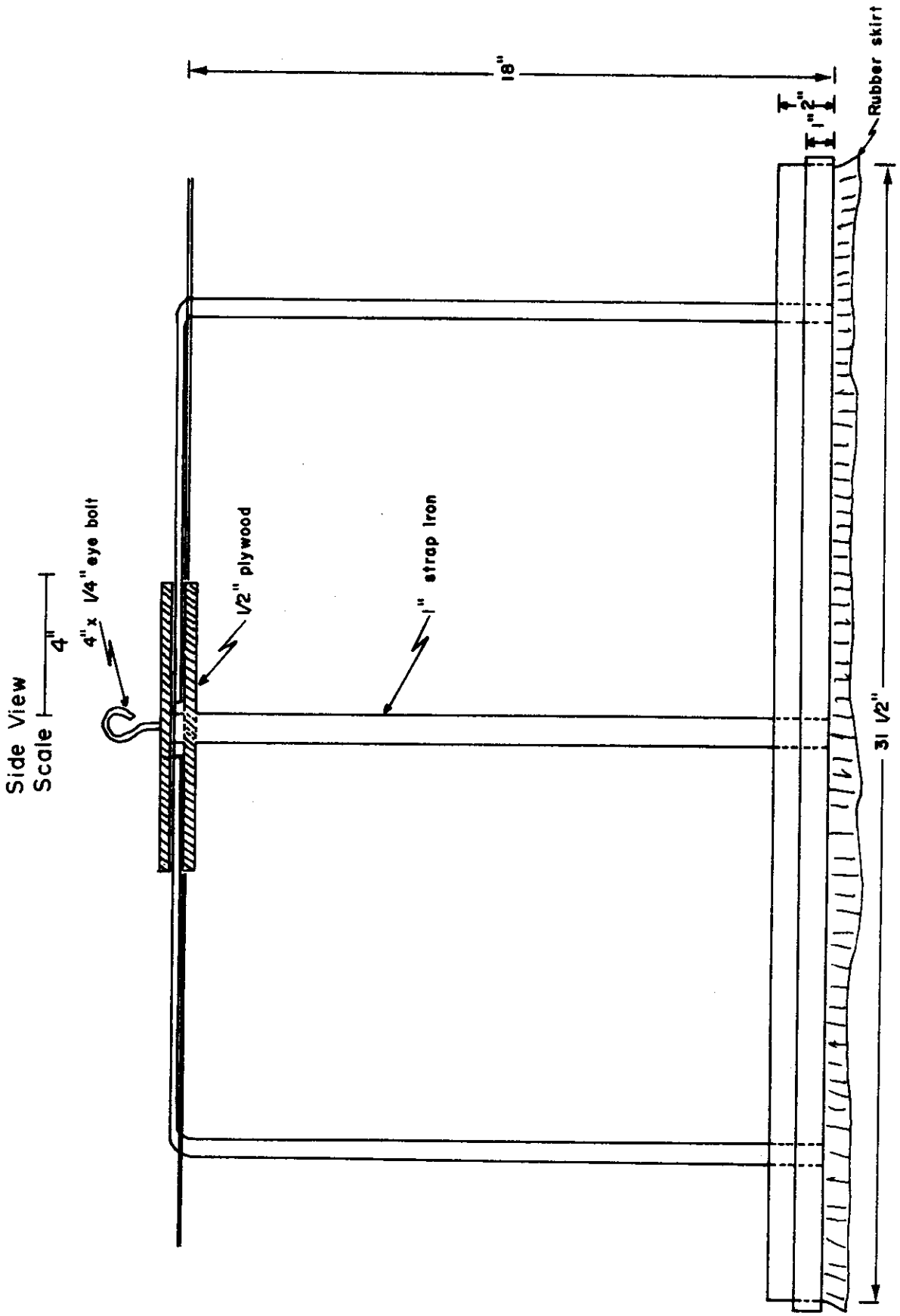


Fig. 6. Quick trap frame, side view.

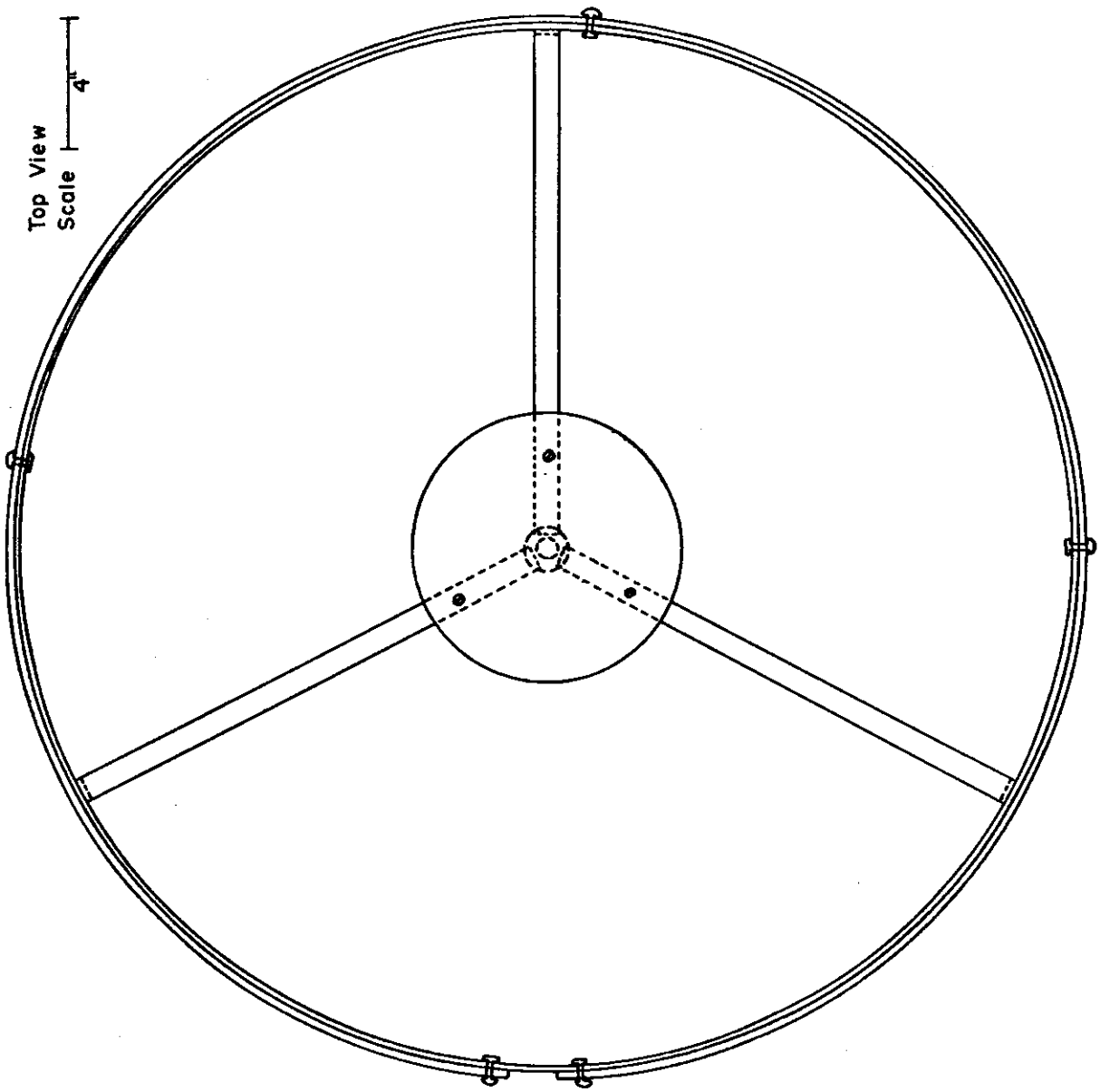


Fig. 7. Quick trap frame, top view.

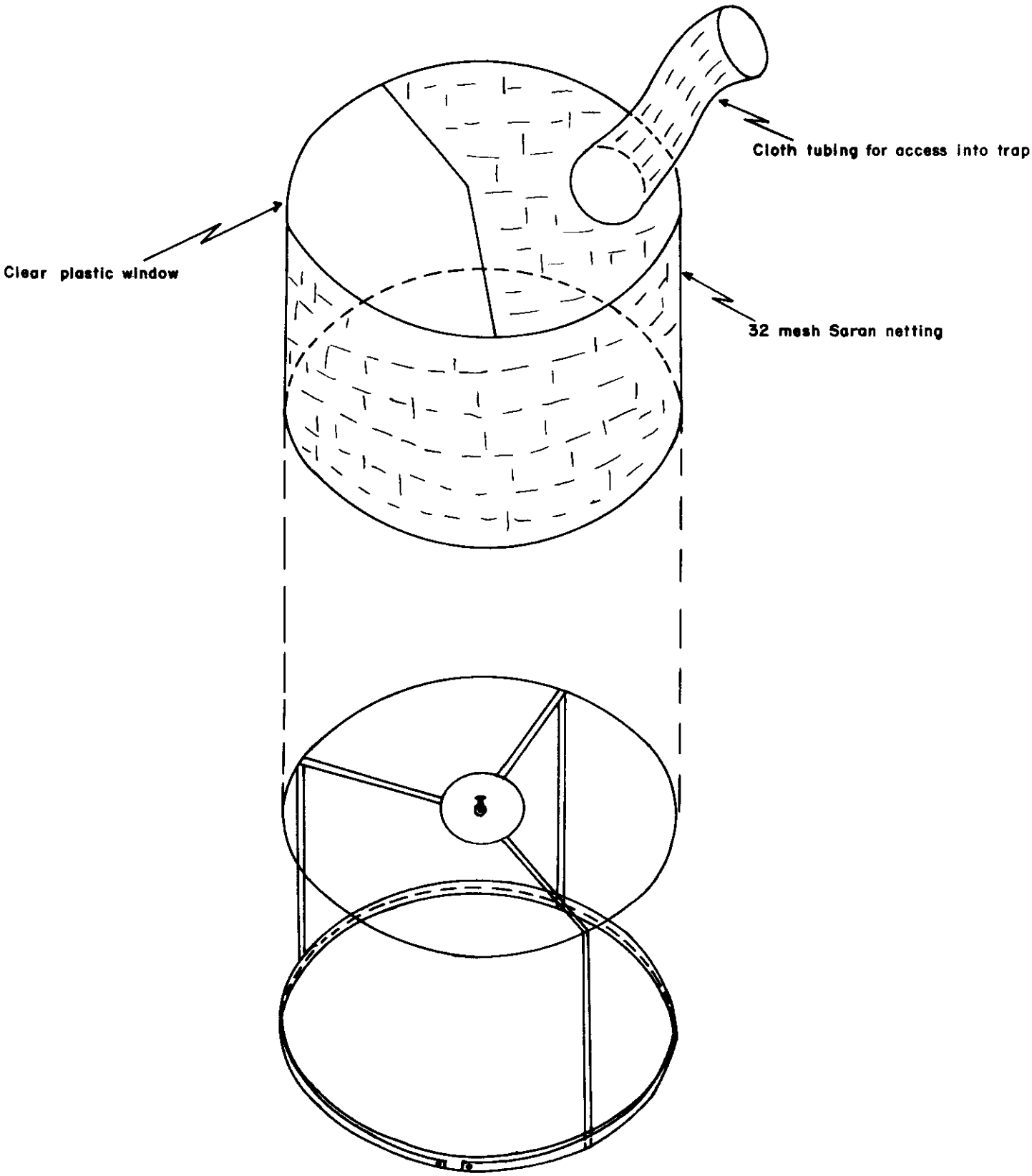


Fig. 8. Exploded view of quick trap and net.

Texas, and consisted of a metal frame covered by 18-mesh (18 openings per linear inch) nylon netting. The trap was later modified by replacing the 18-mesh netting with 32-mesh saran netting which is available commercially (Chicopee Manufacturing Company, Cornelia, Georgia). It was necessary to use finer netting to prevent very small insects from escaping. To help insure that the trap would fit the soil surface contour, a rubber skirt was attached to the lower edge.

To drop the quick trap over the preselected sample area, an 18', tubular, stainless steel boom was mounted on a two-wheeled cart (Fig. 9, 10, and 11), allowing the trap to be dropped from the boom after being maneuvered into position. The trap is dropped or emplaced by rapidly lowering it to the ground with a 35' length of ½" nylon rope. The cart-boom system was originally designed by Dr. T. O. Thatcher, then of Colorado State University, Fort Collins, Colorado, and later modified by the author. The cart-boom system was developed as a substitute for using a metal tripod to drop the quick trap since using tripods required presetting one trap per sample location 24 hr prior to sampling. Using the cart-boom system then eliminated the need for a large number of traps and tripods as well as presetting the traps at each sampling. The cart-boom system has been found to give equally good or better population estimates for most arthropod groups in a shortgrass prairie than the tripod method (Leetham, unpubl. data) primarily because the mere presence of a foreign object (the tripod and trap) will cause many of the ground-crawling arthropods to move away from the sample area. It is recognized that the mobility of the cart can flush some of the flying insects before the trap can be dropped; however, this was not found to be a significant problem.

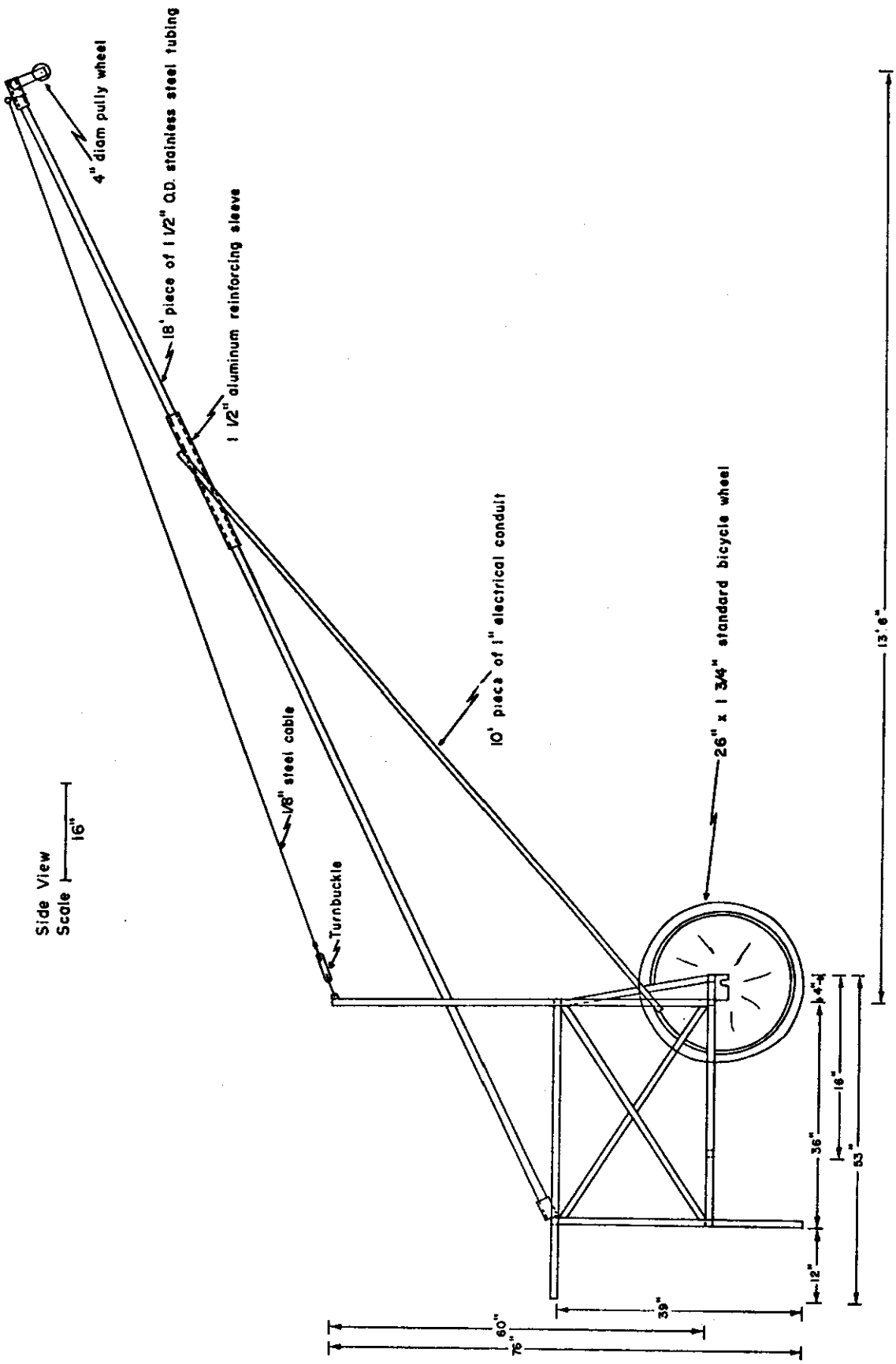


Fig. 9. Two-wheeled quick trap cart, side view.

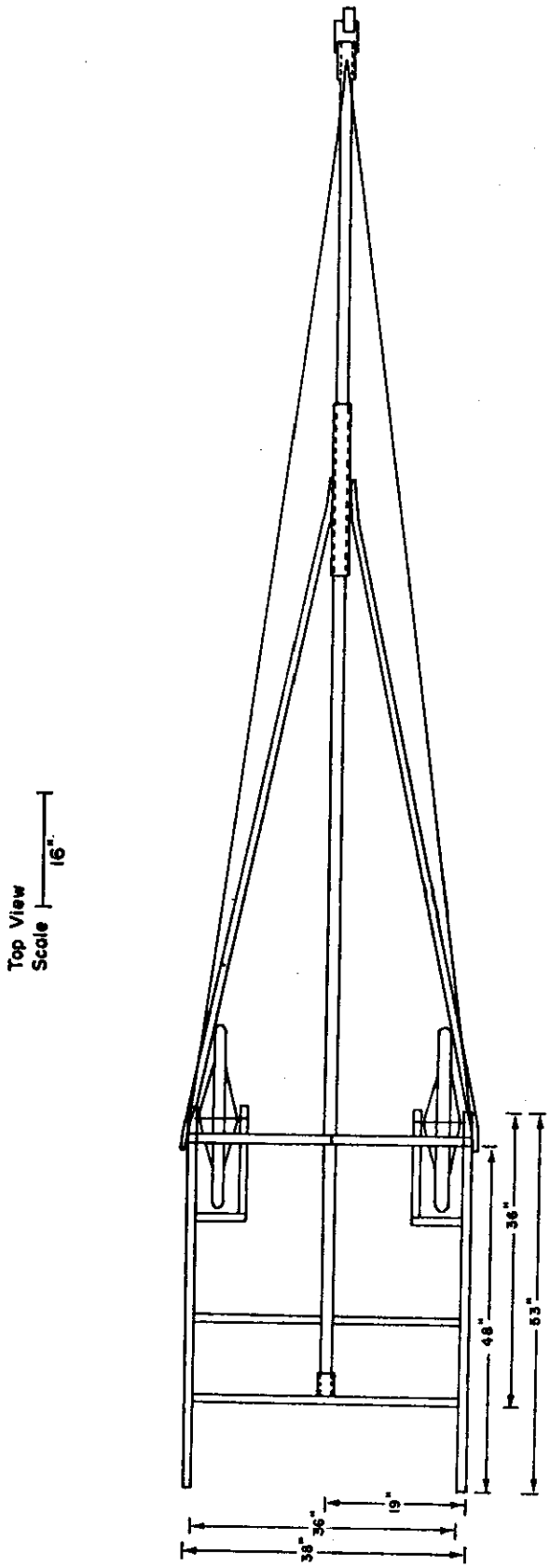


Fig. 10. Two-wheeled quick trap cart, top view.

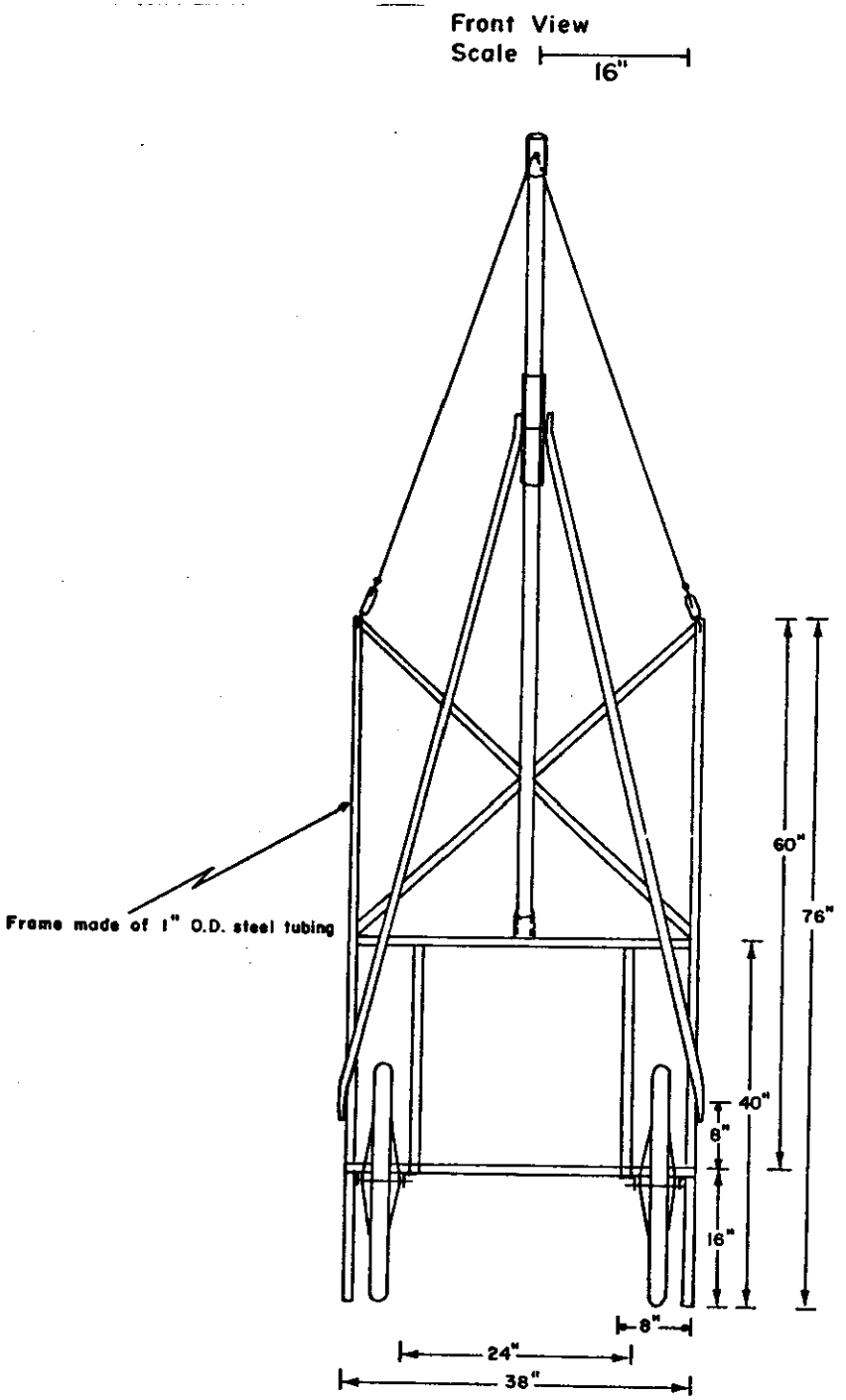


Fig. 11. Two-wheeled quick trap cart, front view.

Removal of the arthropods from the quick trap was accomplished by using a heavy vacuum system capable of removing the litter from the soil surface. During the initial field season of 1970 a commercially available vacuum system, the D-Vac Insect Vacuum (D-Vac Co., P.O. Box 2095, Riverside, California), was used. The complete vacuum system was mounted on the two-wheeled cart to facilitate transportation from area to area. Beginning in the 1971 field season the D-Vac system, with the exception of the fiberglass collecting head, was discarded in favor of a larger capacity system composed of a four-cycle, gasoline engine (3 hp Briggs and Stratton) and a larger squirrel-cage type fan or blower (Dayton Blower, Model 2C888, available at W. W. Grainger, Inc., Denver, Colorado). To facilitate easy starting of the engine, a pulley system using a centrifugal clutch pulley was set up between the engine and the fan. This system is illustrated in Fig. 12 and 13. To facilitate vacuuming within the quick trap, a reducing cone and a 10' length of 4" diameter, flexible, metal-reinforced, neoprene heating duct was used as an extension of the D-Vac collecting head (Fig. 14).

Field Collecting Procedures

Field sampling of aboveground arthropods began by attaching the quick trap to the cart-mounted boom, moving the cart into position, and dropping the trap on the preselected sampling area. When approaching a sample location with the trap and cart, care was taken to avoid casting any shadows over the area before the trap was dropped. The accuracy of the drop was affected by slope, wind, etc., but generally the trap could be dropped where intended. After trap emplacement, the vegetation within was recorded by species, phenological stage, and

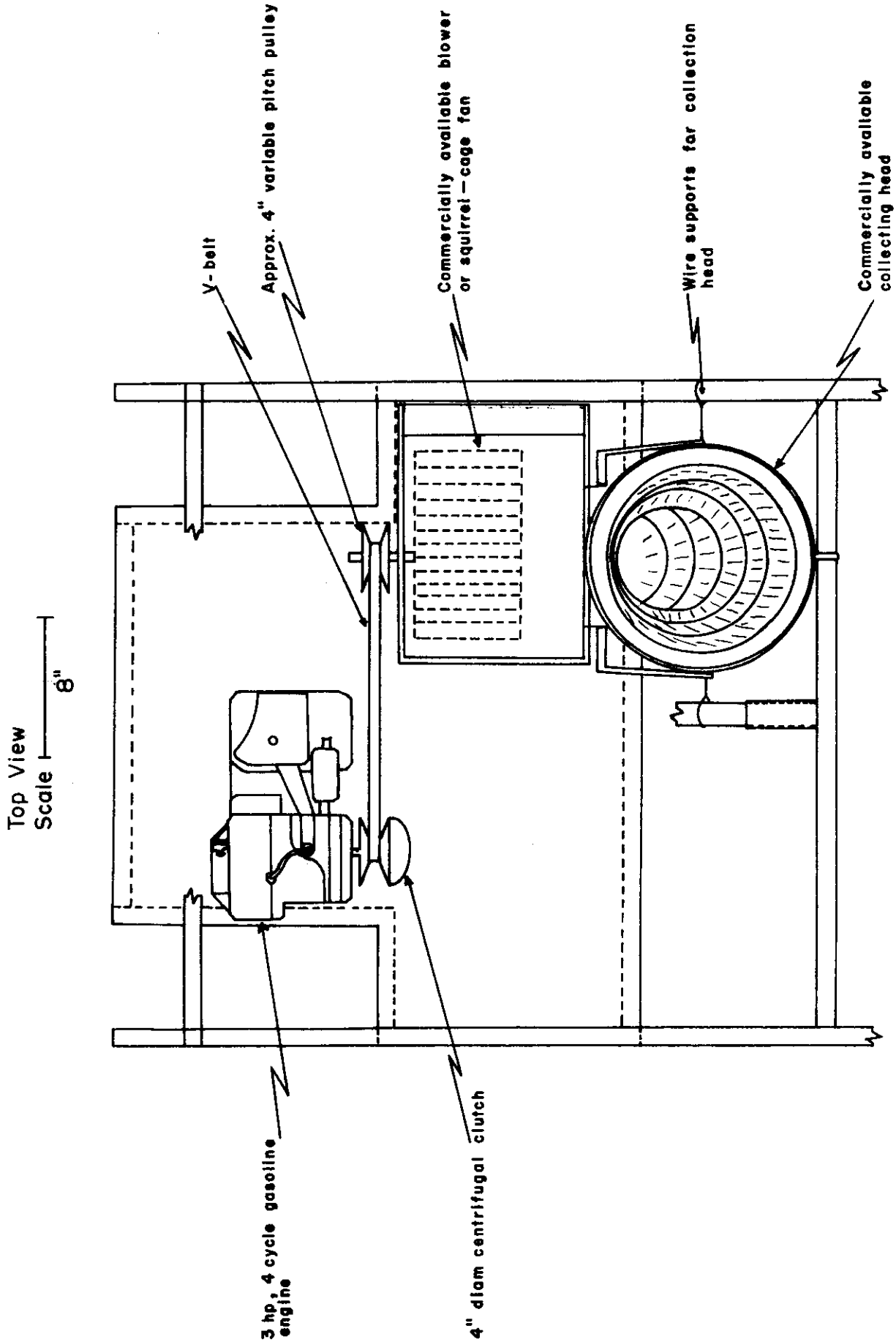


Fig. 12. Vacuum system as mounted on cart, top view.

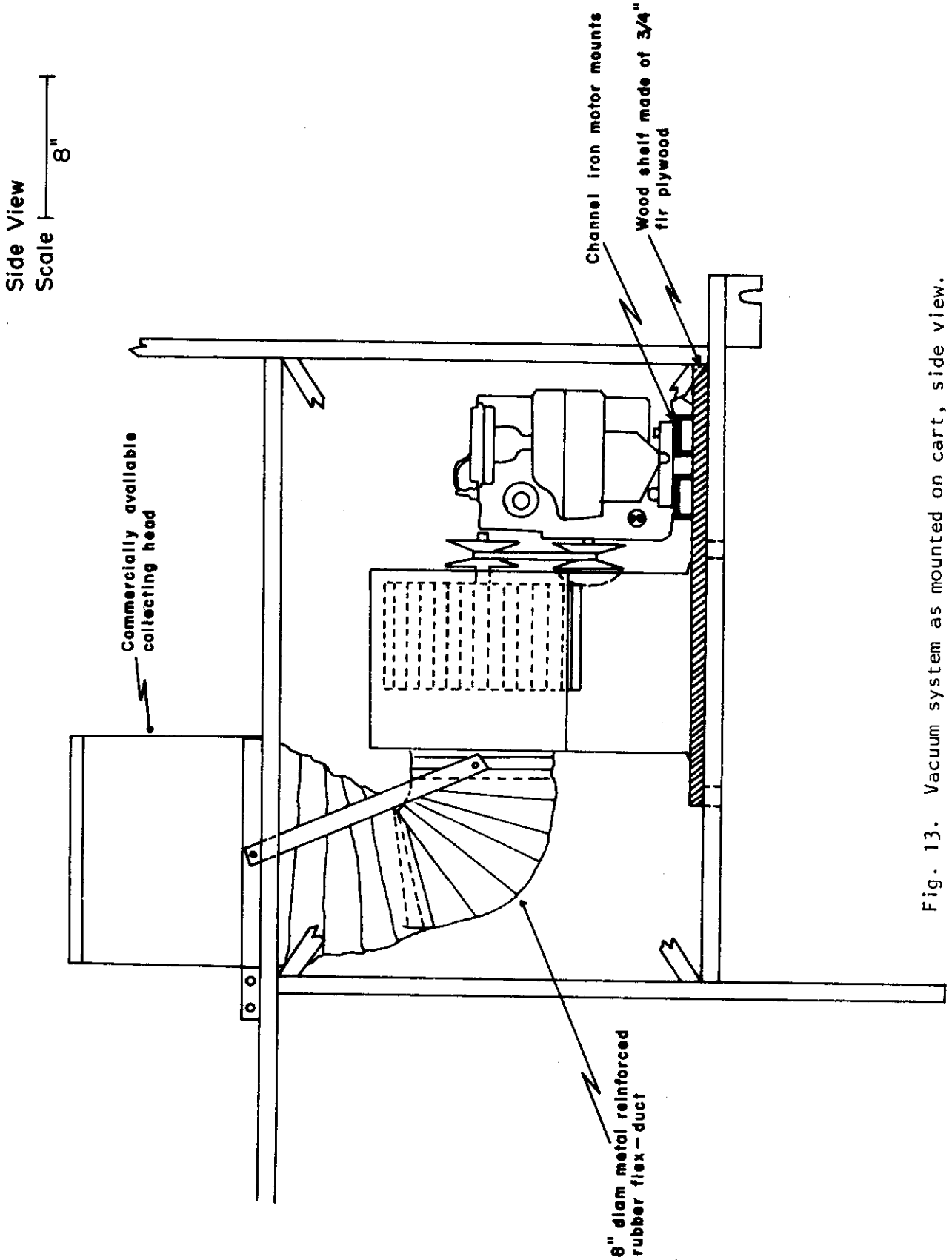


Fig. 13. Vacuum system as mounted on cart, side view.

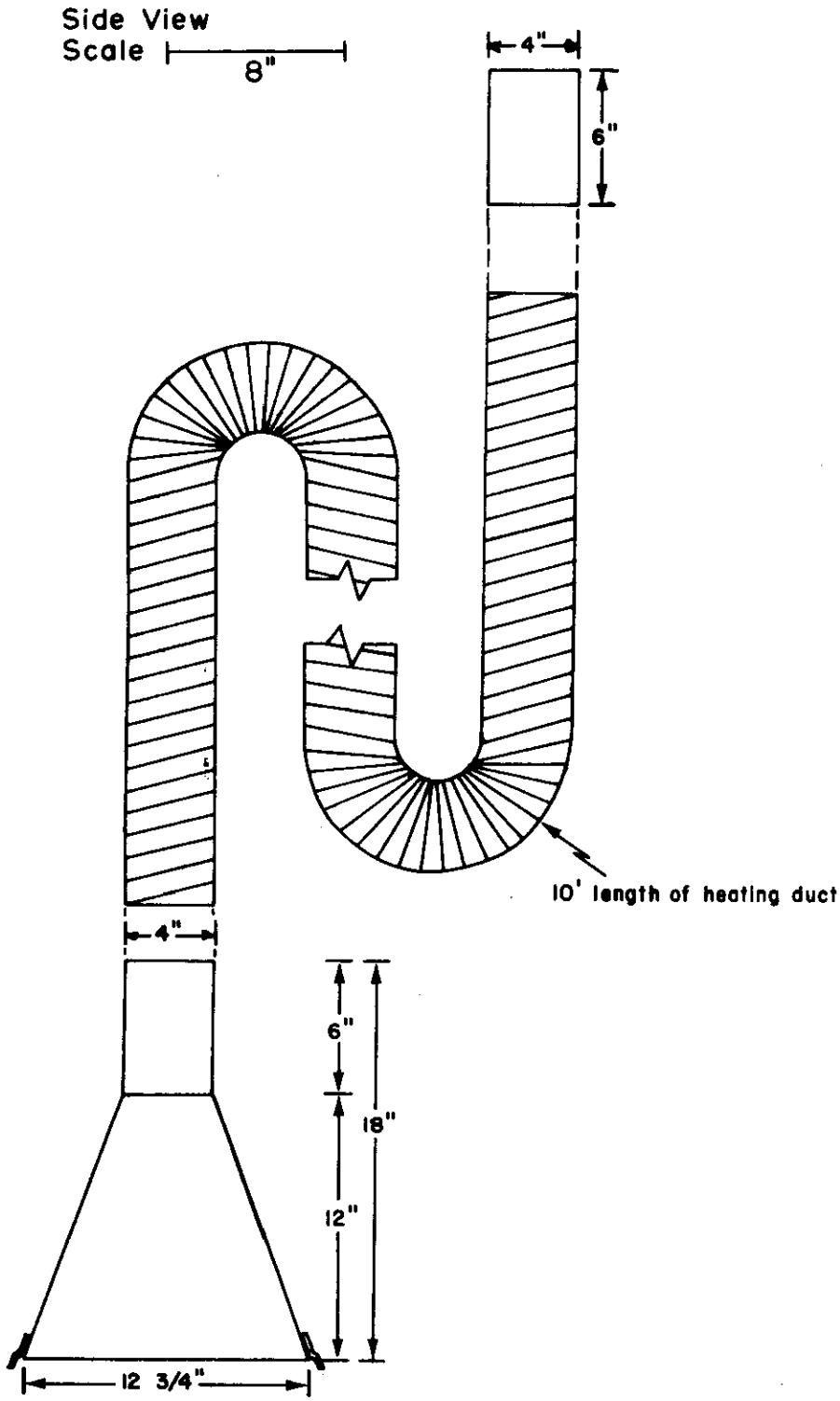


Fig. 14. Reducing cone and flexible hose, side view.

estimated field wet weight. The weight estimates were later corrected by correlating with separate, clipped plots of the same size. Following vegetation recording, the arthropods were vacuumed from the trap in two stages--the first stage being a light vacuum designed to lightly vacuum the vegetation and trap walls for arthropods while picking up as little litter as possible; the second stage being where all vegetation and litter material was clipped and vacuumed from the trap leaving bare soil and at most some plant crowns. The two vacuum stages were bagged and handled separately.

This sampling procedure has been followed in all field seasons except 1970, when there was no recording of vegetation nor two-stage vacuuming. After trap emplacement all arthropods, vegetation, and litter were vacuumed from the trap in one operation.

Laboratory Equipment and Procedures

During the 1970 field season the one-stage vacuum samples were hand sorted to separate the arthropods from the debris. It was necessary to sort the samples as soon as possible after taking since live insects were easier to separate from the debris. To aid in the hand sorting, a set of graduated sieves was used to separate the sample material into various particle sizes. The sieve sizes were (in mesh sizes): 22.43 mm; 11.1 mm; 5.613 mm (3.5 mesh); 2.794 mm (7 mesh); 1.397 mm (12 mesh); 0.495 mm (32 mesh); and 0.246 mm (60 mesh).

In 1971 changes were made in the extraction processes to increase efficiency and add uniformity to the recovery of the arthropods. The first-stage or light-vacuum-sample material was frozen, transferred to a 40 dram plastic vial, and stored frozen until it could be hand sorted

under a binocular, disecting microsocope. The more voluminous second-stage vacuum was subjected to Berlese or Tullgren-type extraction immediately after being taken. It was felt very undesirable to store these samples for any length of time. The funnel design used at the Site is shown in Fig. 15, 16, and 17. The funnels used were constructed on the Colorado State University campus using 24 gauge galvanized sheet metal. The internal shelf was constructed of two sheets or discs of metal; each disc having a series of 2" × 1/8" slots. The slots in one disc were offset from those in the other so that debris could not fall directly through the shelf. This type of shelf is referred to as an autosegregator.

As a heat source within the funnel, a 25 W regular white light bulb was used for most sample dates. When cold ambient temperatures required it, a 75 or 100 W bulb was used in place of the 25 W bulb (the work area where the funnels were kept was an unheated building).

The principle of the Berlese extraction was to maintain sufficient heat within the upper chamber of the funnel where the sample was placed to cause desiccation of the sample material and migration of the arthropods down to the catch container, but not hot enough to kill them before they could migrate. Sample material was normally extracted for 48 hours, but occasionally more time was required for extremely wet sample material. In cases where the bulk of a given sample was large, the material was divided and extracted in separate funnels since it was felt that the sample material should never exceed a depth of 2" on the funnel shelf. To do so would impede movement of the arthropods from the sample. The actual efficiency of this sytem of extraction was never determined.

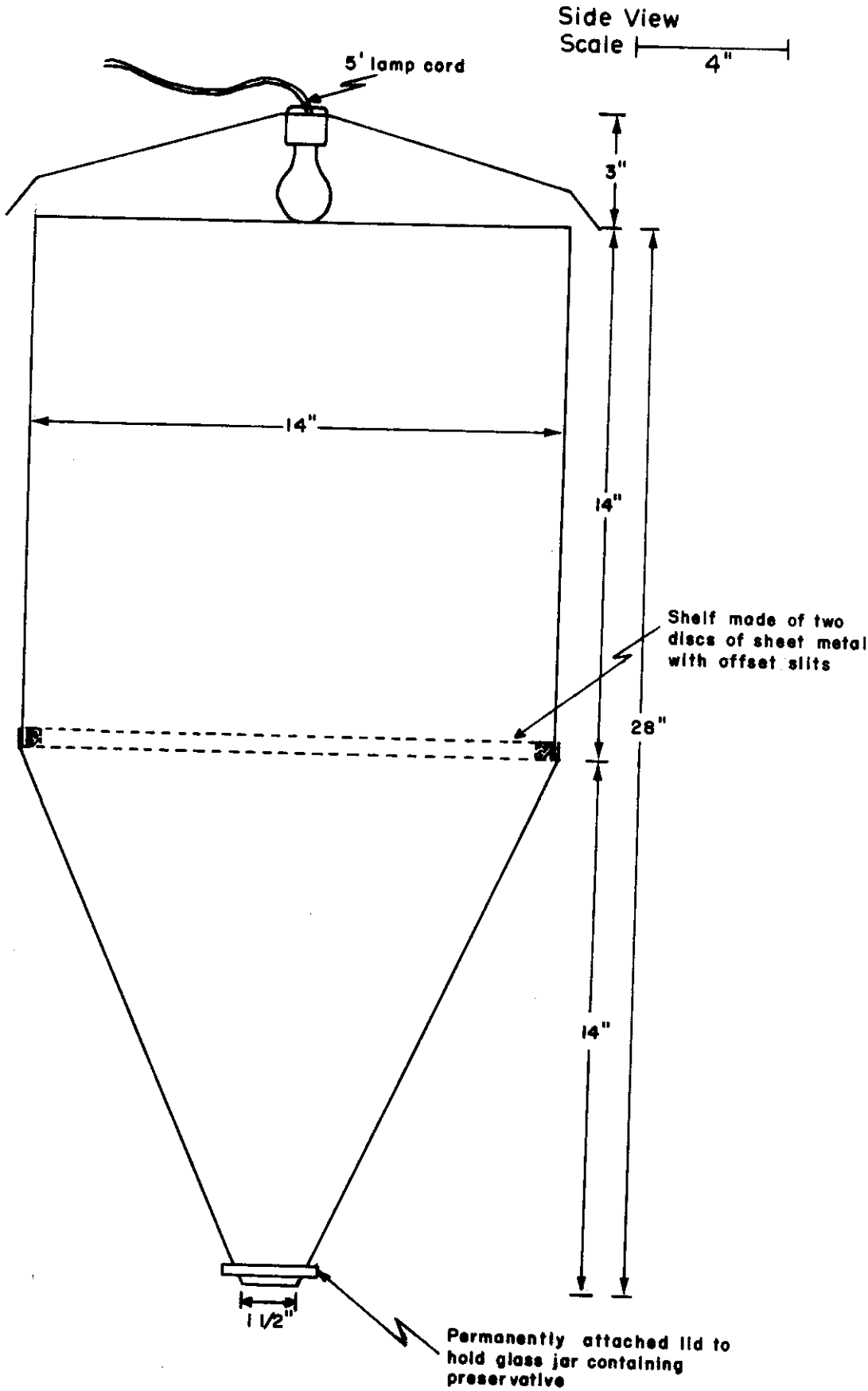


Fig. 15. Berlesé funnel, side view.

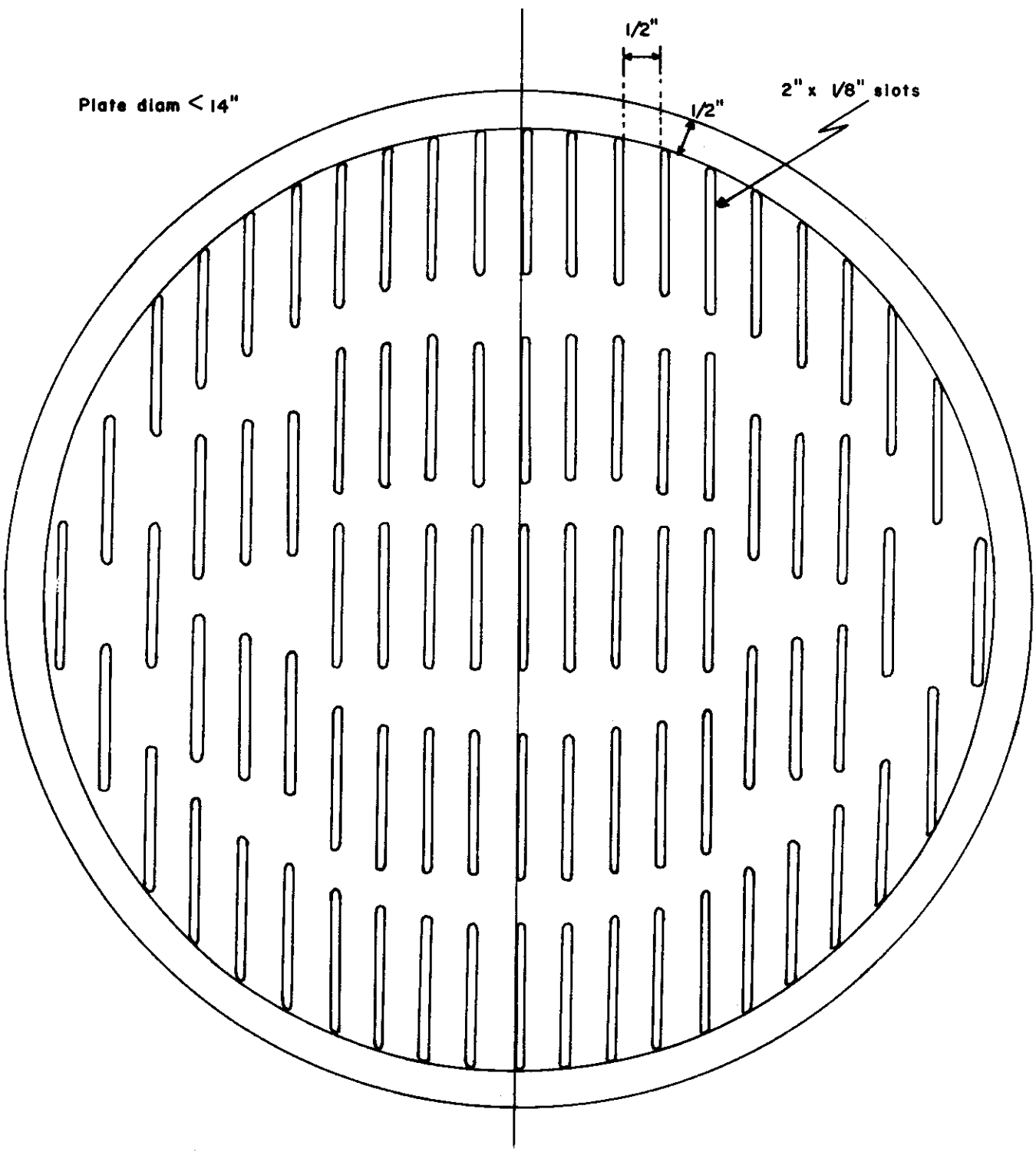


Fig. 16. Top plate of autosegregator, top view.

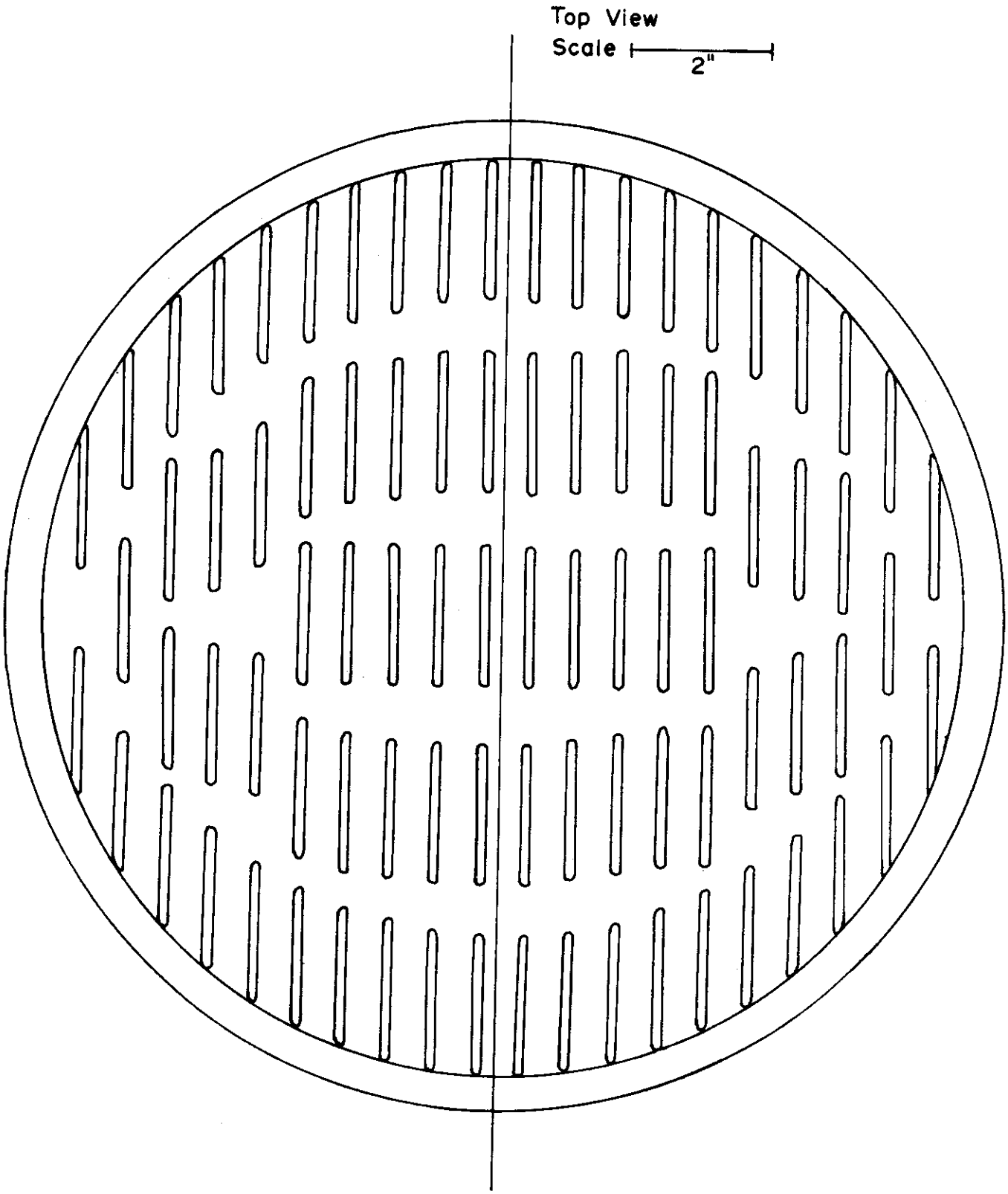


Fig. 17. Bottom plate of autosegregator, top view.

All collected material from the aboveground collections was sent to the University of Wyoming, Laramie, Wyoming, for sorting, counting, identification, and dry weight biomass determinations (Lavigne et al. 1972, Lavigne and Kumar 1974, Kumar et al. 1975). A reference collection of Pawnee Site arthropods is being maintained there for any future reference.

SOIL MACROARTHROPODS

Field Equipment and Methodology

Soil macroarthropod sampling has been based completely on taking a soil core of known volume and mechanically extracting the arthropods by wet sieving. When the field equipment and techniques were first being developed, two criteria were used: (1) the samples had to be of sufficiently large volume to insure obtaining the scattered soil fauna; and (2) a large enough number of samples had to be taken to allow some statistical analyses of the data. As a result, the 12.5-cm diameter by 30-cm long soil coring tube (Fig. 18, 19, and 20) was designed and built (Giddings Machine Shop, Fort Collins, Colorado). The system included the coring tube, a 16- to 18-lb. driver, and a cap and guide bar.

Field Collecting Procedures

As has been mentioned previously, the soil macroarthropod sampling was done in conjunction with the vacuum samples for aboveground arthropods. Most soil cores were to 15-cm depth; however, on specified dates during the 1970, 1971, and 1972 seasons cores were taken to 30-cm depth and divided into two 15-cm increments. After the selected sample location had been vacuumed for aboveground arthropods, the coring tube was placed in the center of the circular denuded area and driven to the desired

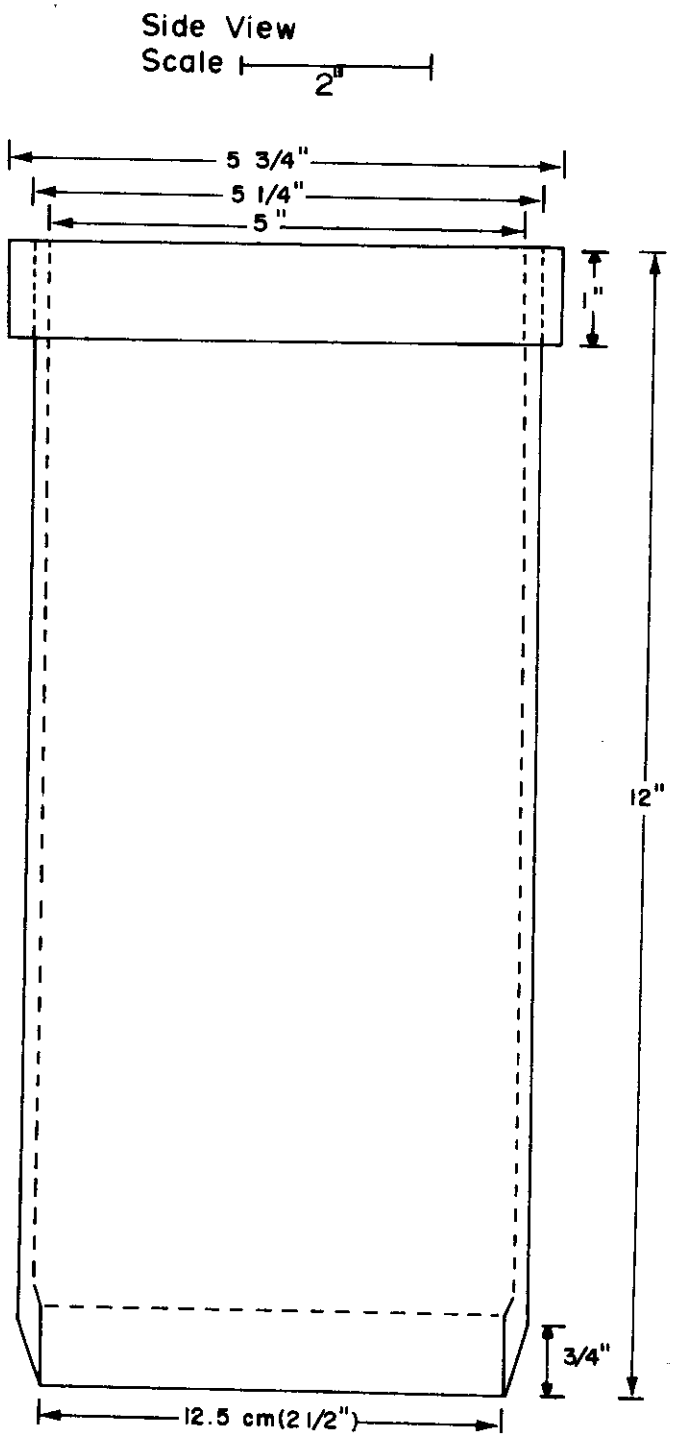


Fig. 18. Coring tube for soil macroarthropod sample, side view.

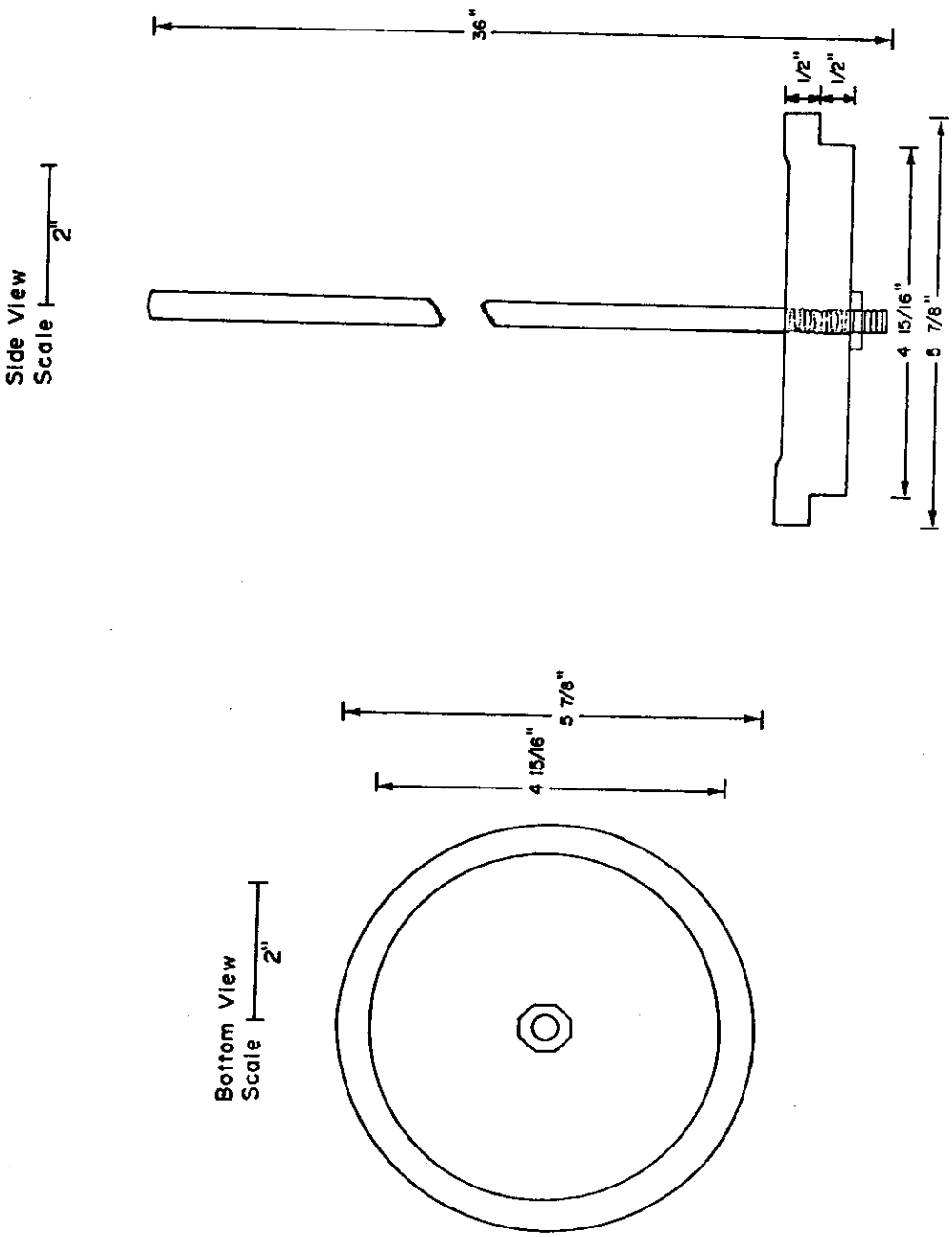


Fig. 19. Guide plate for soil macroarthropod sampler, bottom view and side view.

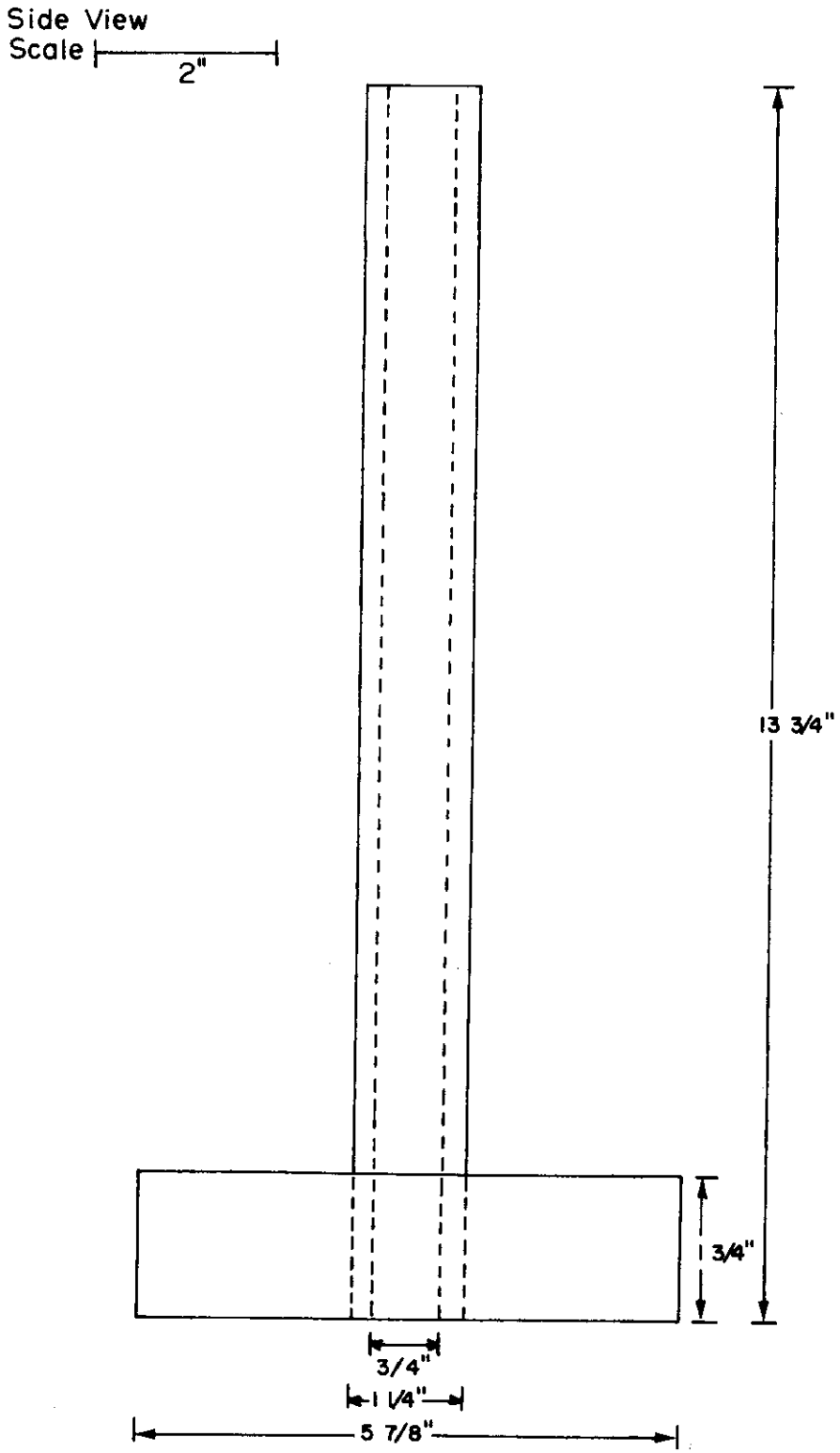


Fig. 20. Driving hammer for soil macroarthropod sampler, side view.

depth. The tube could be removed from the soil by shovel or when driven to 15 cm in soft or moist soil it could be kicked to one side and pulled from the soil. After removal from the soil, the core sample could be pushed from the tube, bagged with an identifying label, and transported to the laboratory.

Laboratory Equipment and Methodology

The soil arthropods were extracted from the core sample by a wet sieving and flotation process somewhat similar to the Salt-Hollick Technique (Salt and Hollick 1944). The cores were first soaked and broken apart with water in plastic buckets after which the whole solution was sieved through a 1-mm-opening sieve (16 mesh). All the retained material, including arthropods, plant parts, and soil particles and stones, was then placed in a saturated solution of magnesium sulfate ($MgSO_4$). This high specific gravity solution would readily separate the organic material from the inorganic. The floating organic material was then sieved from the solution by using nylon organdy cloth as a sieve. The organic material was then bagged for later hand sorting under binocular microscopes. The actual efficiency of this system was never determined. As with the aboveground arthropod samples, the material was sorted, counted, and identified at the University of Wyoming where a reference collection is being maintained (Kumar et al. 1975). Dry weight biomass measurements were also made at the University of Wyoming (Lloyd and Grow 1971, Lloyd et al. 1973).

SOIL MICROARTHROPODS

Field Equipment and Methodology

Soil microarthropod sampling has been based completely on a system wherein soil core samples of known volume were taken, retained in a

relatively undisturbed condition, and the arthropods separated by a dynamic (live) extraction system. Since live extraction was used it was deemed necessary to take the soil sample in such a way as to maintain the soil microstructure, thereby facilitating the movement of the arthropods from the soil by way of any established passageways.

Initially, in 1970 soil microarthropod sampling was limited to the top 5 cm of soil, with each soil core being extracted as a whole. Beginning in September 1971 all sampling was extended to 10-cm depth with each soil core being divided into two 5-cm increments, each of which was extracted separately. This became the standard sampling depth. Beginning in 1972 certain grazing treatments (light grazed--Treatment 2, and current year ungrazed--Treatment 5, see Table 1) were sampled to 60-cm depth with each soil core being divided into twelve 5-cm increments, each individually extracted.

In order to take soil cores and retain them in a relatively undisturbed condition, soil coring instruments were constructed such that the soil core could be automatically retained in an aluminum sleeve which would prevent damage to the sample during handling. Each coring tube was machined so that the cutting edge diameter matched the inside diameter of the aluminum sleeve. At Pawnee Site sleeves of 2" outside diameter by 5-cm length by 0.049" thick wall were used resulting in a soil core of 4.8-cm or 1 7/8" diameter by 5-cm length or multiple increments of these dimensions in the case of 10- or 60-cm deep cores (Fig. 21 and 25).

Fig. 21 and 22 show the basic design of the coring instruments used to take 5- and 10-cm deep samples. In each case, the cutting bits

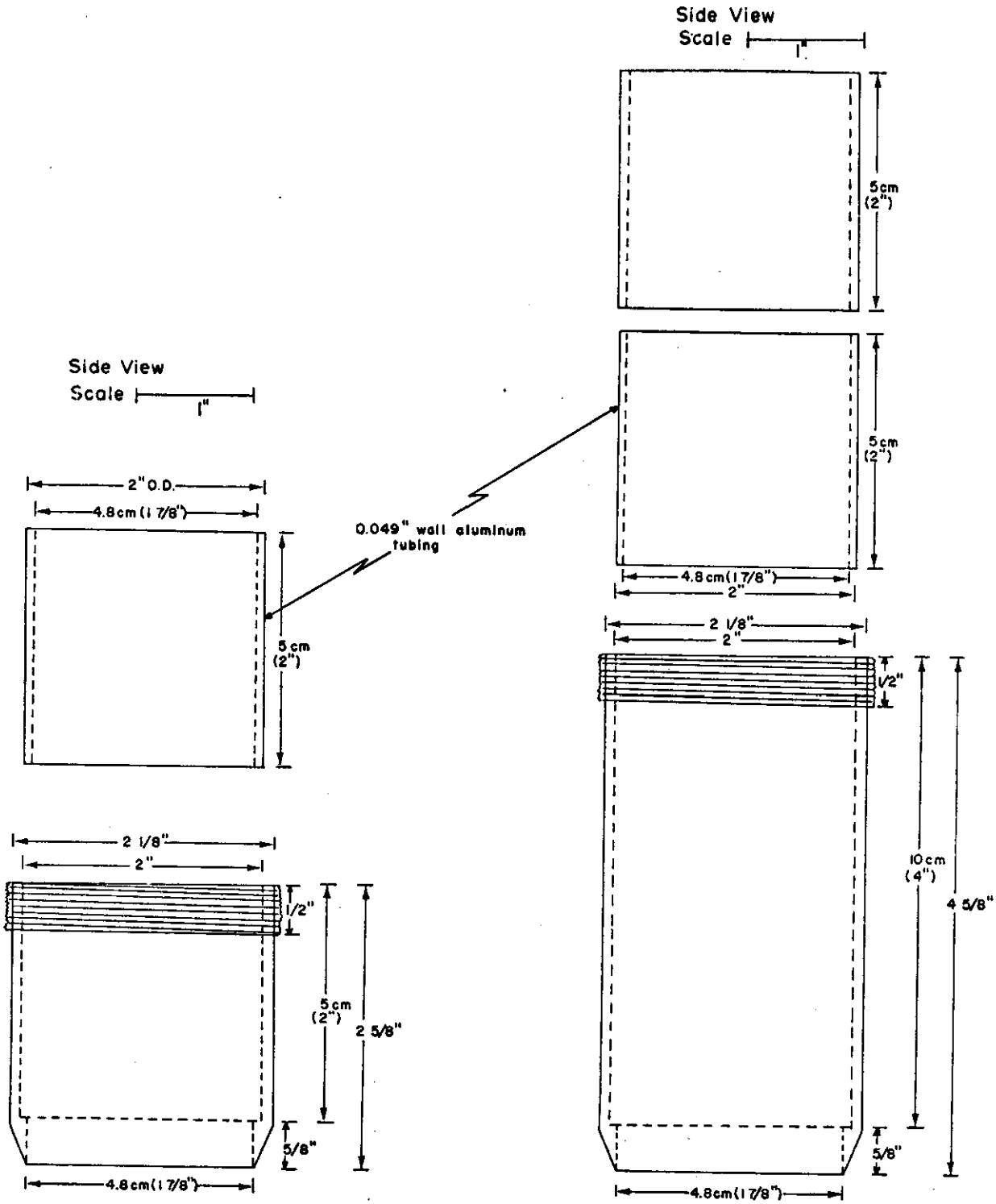


Fig. 21. Coring tube and sleeve(s) for soil microarthropod sampler, side view.

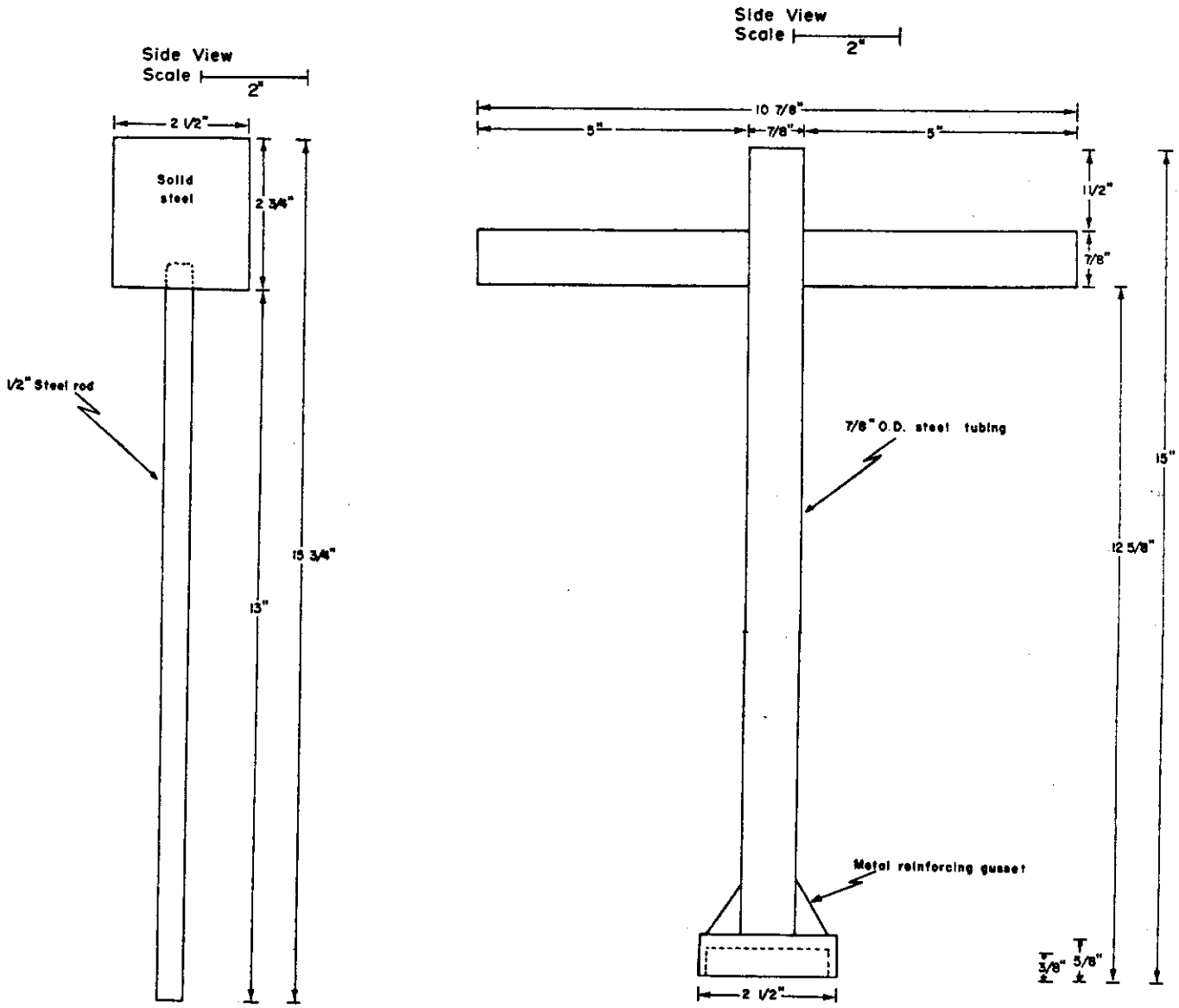


Fig. 22. Driving hammer and T-handle for soil microarthropod sampler, side views.

or tubes were machined to hold the aluminum retaining sleeve(s) such that it formed the inner wall of the tube. When taking a soil sample, the cutting bit plus sleeve(s) were attached to a T handle and driven into the soil to the desired depth with the 2- to 3-lb. driver (Fig. 22). After removing from the soil, the bit was unscrewed and the aluminum sleeve(s) and core sample were removed. In the case of the 10-cm deep sample, the core was divided into 5-cm increments by cutting between the sleeves.

Fig. 23, 24, and 25 show the design of the split-barreled coring tube used to take 60-cm deep cores. The system includes a split-barrel tube with specially designed and machined cutting and driving pieces. The split barrel, with its 2" inside diameter and 24" length, very conveniently holds twelve 5-cm long sleeves. Fig. 25 is an exploded diagram of the split barrel, the cutting and driving pieces, and aluminum sleeves. To take a soil sample, the coring tube was driven into the soil with a gasoline engine-driven impact hammer called a "Cobra" which is a commercially available breaking-pounding-drilling tool (Atlas-Copco Corporation, Germany). It was necessary to have a special pounding bit forged (Louis' Little Forge, Denver, Colorado) for the "Cobra" in order to drive the split-barreled tube into the soil (Fig. 26). As with the macroarthropod coring tool, the microarthropod coring tools were constructed by Giddings Machine Shop, Fort Collins, Colorado.

Field Sampling Procedures

As with the soil macroarthropod sampling, the soil microarthropods were sampled along with the aboveground arthropod samples. However, unlike the macroarthropods the microarthropod cores were taken just

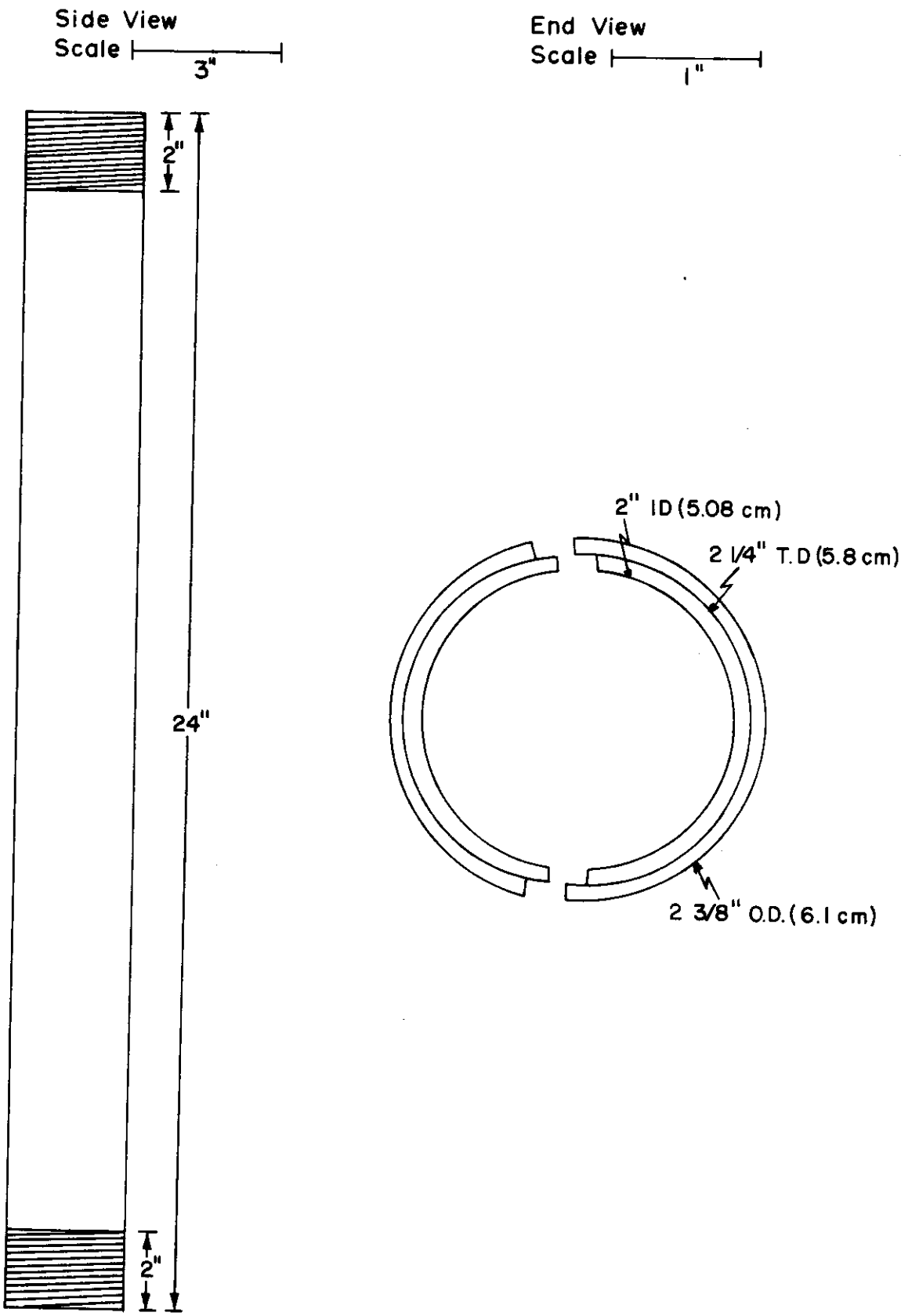


Fig. 23. Split-barreled soil coring tube, side view and end view.

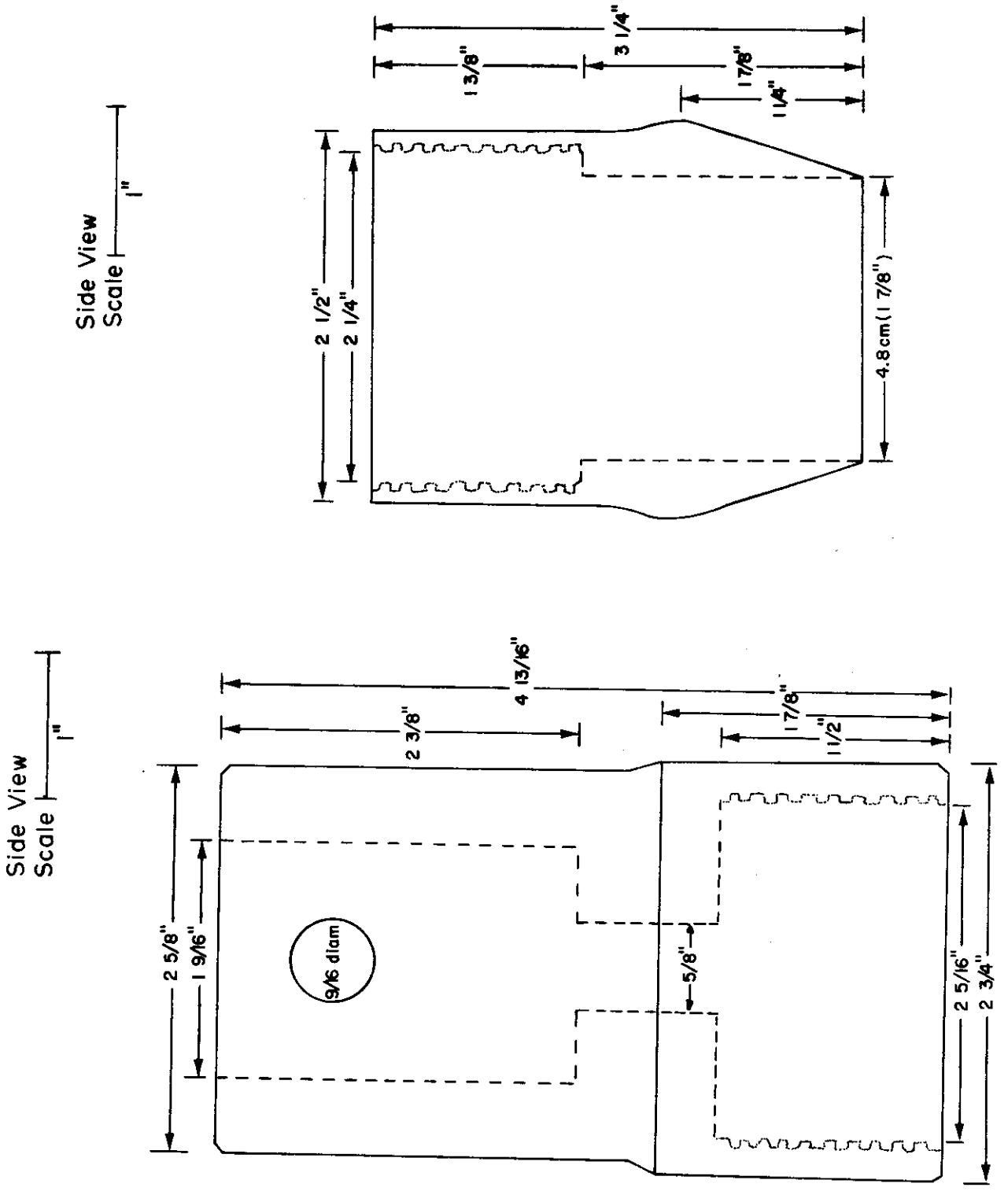


Fig. 24. Adaptor cap and cutting head for split-barreled soil coring tube, side views.

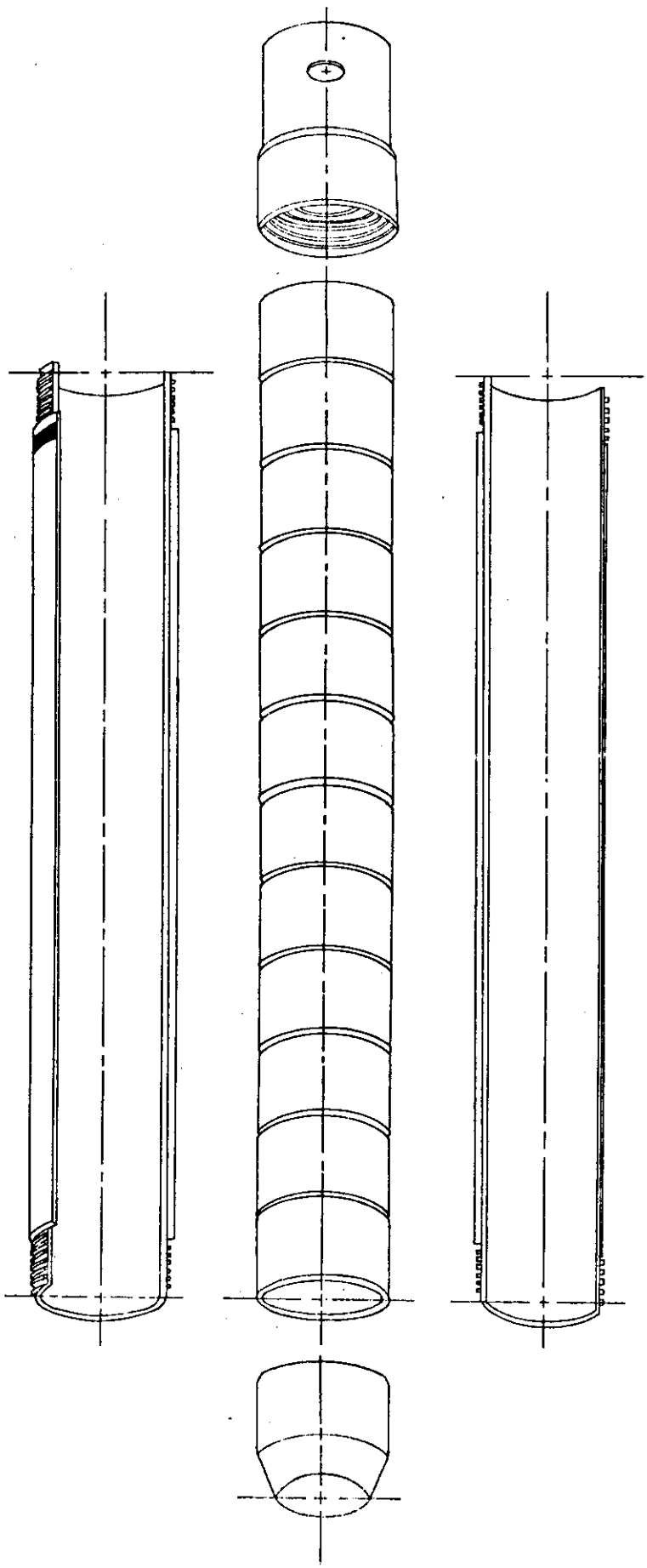


Fig. 25. Exploded diagram of split-barreled soil coring tube.

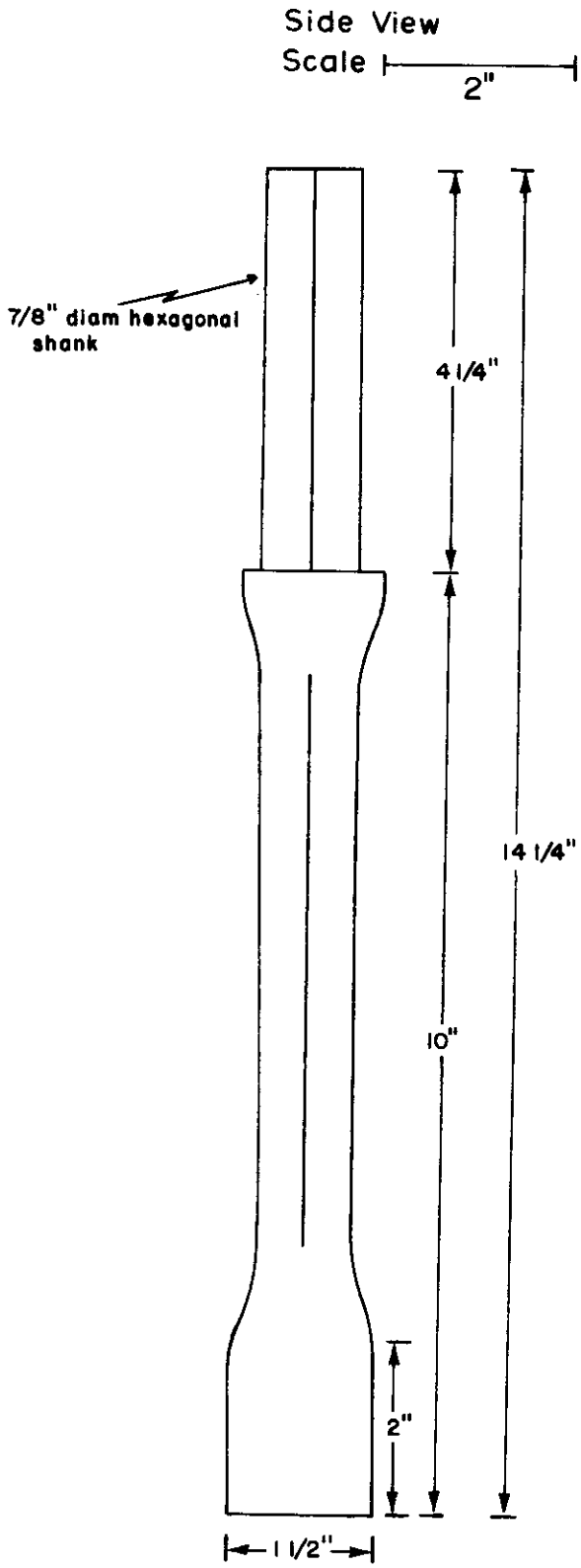


Fig. 26. Driving piece for pneumatic impact hammer, side view.

outside the circular vacuumed area since many of the microarthropods live in or close to the surface litter material which should be included in the sample. The soil cores were taken at a preselected distance and direction outside the vacuumed area.

Once the sample location was selected, all standing vegetation was clipped at the soil litter surface and the area was wetted with water using a mist sprayer. The wetting was designed to reduce or eliminate the disturbance or eventual loss of the surface material during coring and later handling. After wetting, the coring tool was then driven into the soil by hand (5-cm and 10-cm cores) or "Cobra" (60-cm cores). The small core tubes could be removed from the soil by hand, but the 60-cm tube required the use of a Handyman Jack to lift it out. Once removed from the soil, the core sample was cut into 5-cm increments, each being retained in an aluminum sleeve, labeled, and wrapped in aluminum foil for transport to the laboratory. Normally, the soil samples were immediately extracted for the microarthropods, but in cases where storage was necessary they were kept at 10°C.

Laboratory Equipment and Procedures

As mentioned before, the extraction method used at the Site was a dynamic (live) extraction using a Tullgren-type system designed by Merchant and Crossley (1970). The basic objective of the technique was to create a temperature-humidity gradient within the soil sample, ultimately desiccating the sample completely. The net result was the unidirectional movement of the arthropods down to a catch container with preservative (70% ethyl alcohol). Fig. 27, 28, and 29 show the design

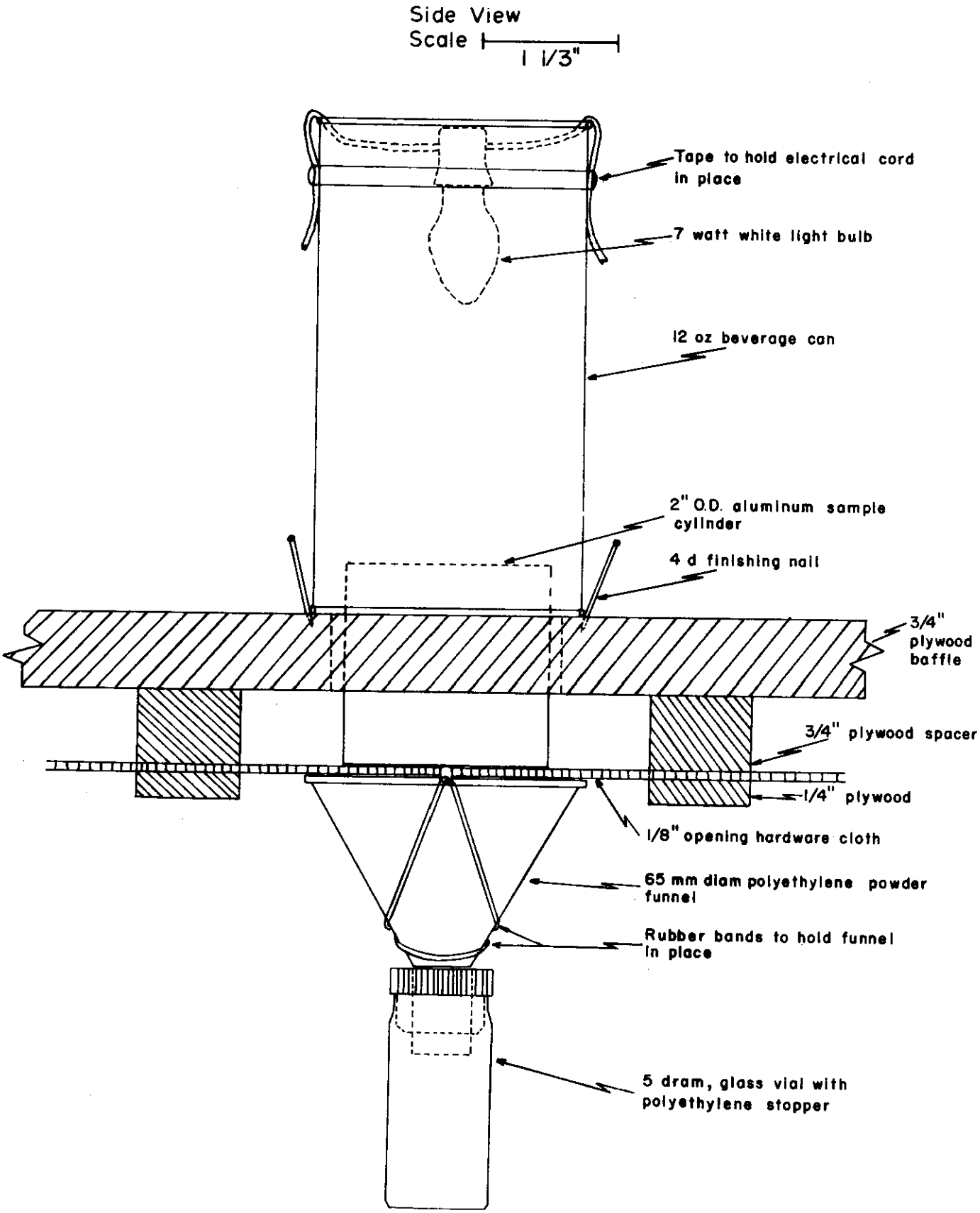


Fig. 27. Detail of soil microarthropod extraction system, side view.

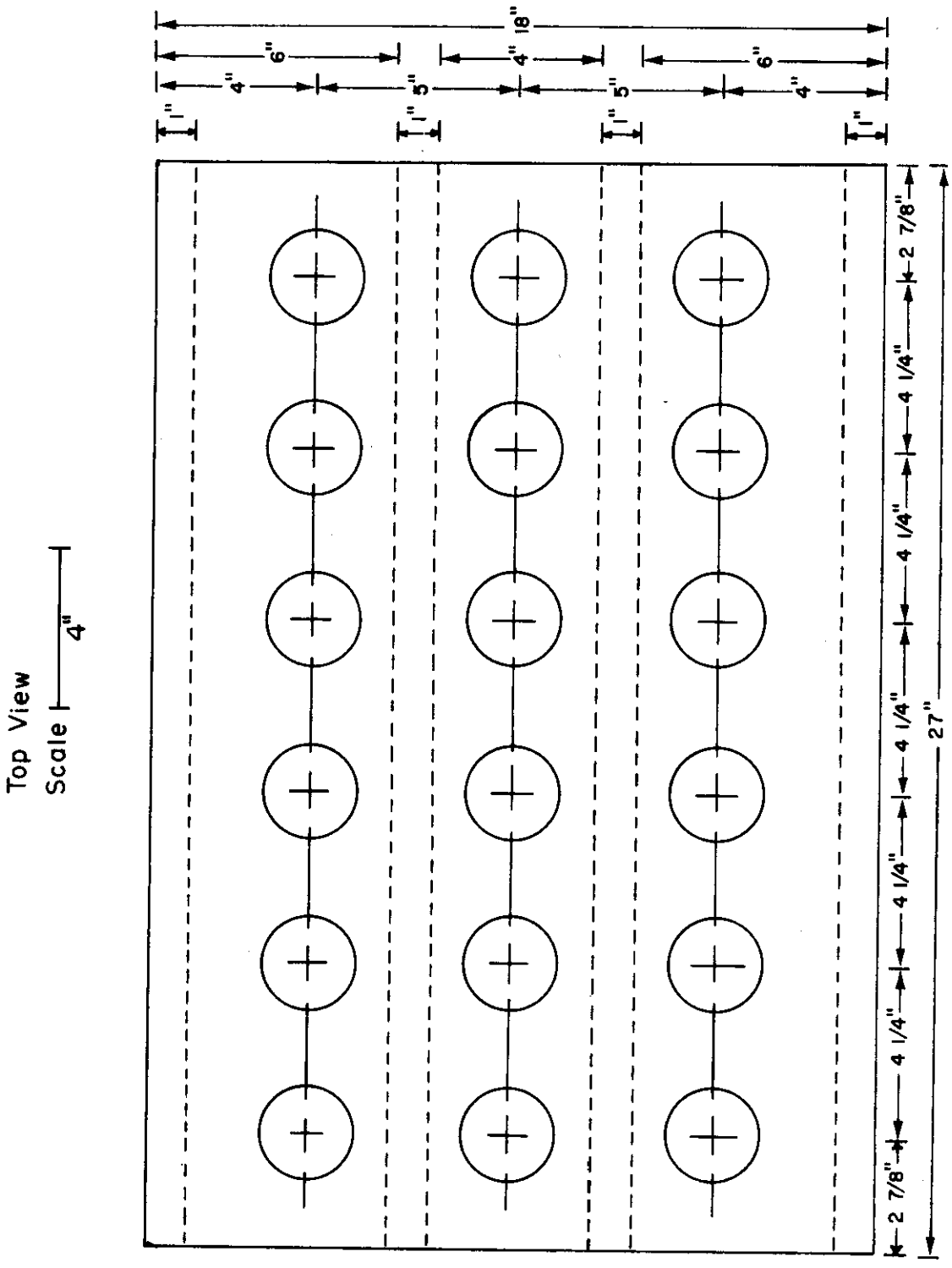


Fig. 28. Wood baffle for soil microarthropod extractor, top view.

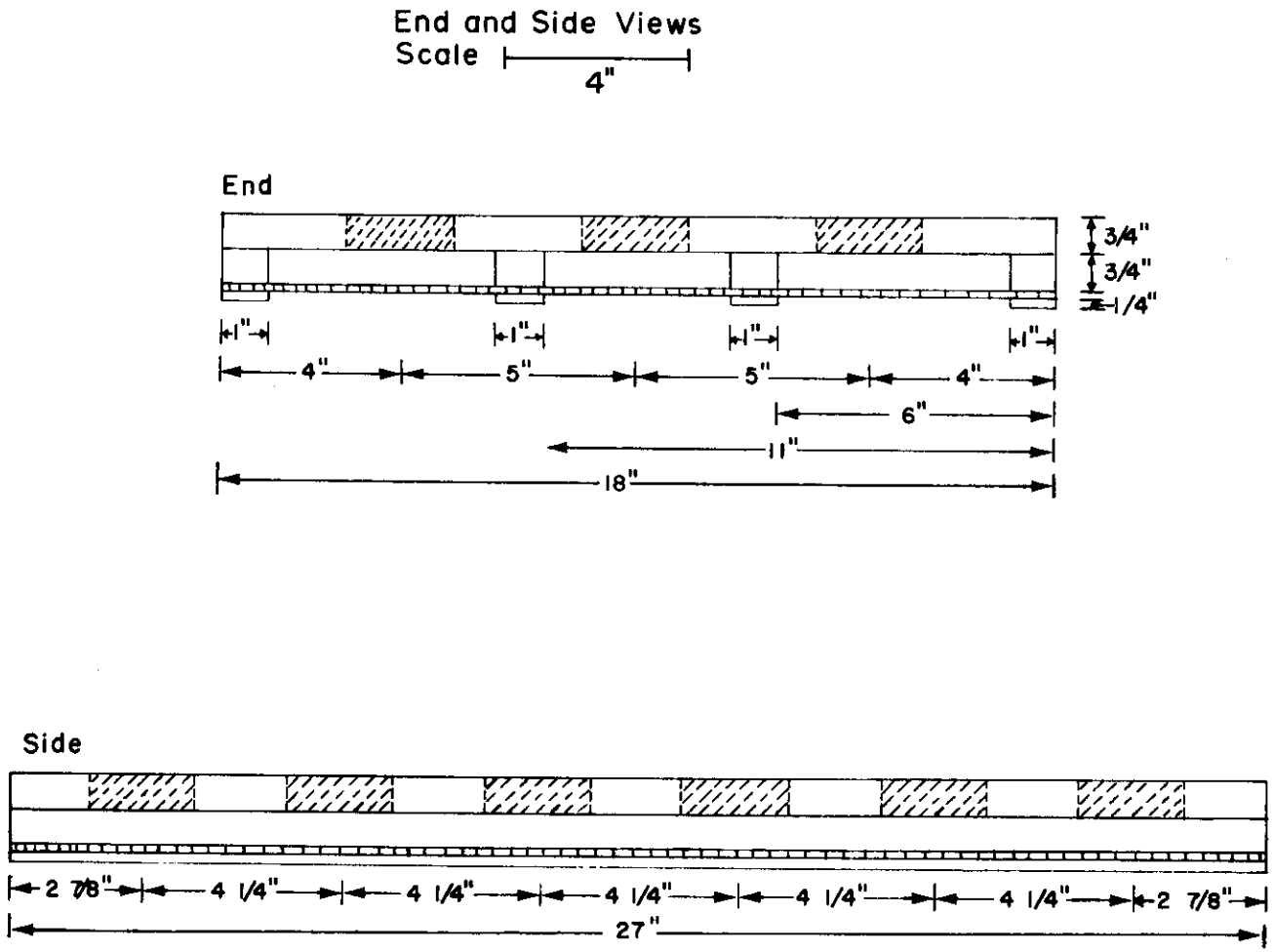


Fig. 29. Wood baffle for soil microarthropod extractor, end and side views.

of the extractor used at the Site. Basically, the extraction equipment was designed to heat one end of the soil core while simultaneously cooling the opposite end. From Fig. 27 it can be seen that a soil sample can be placed in the extractor such that one end is heated by a 7 W white light bulb while the opposite end protrudes below the wood baffle and is exposed to the ambient air. By placing the whole extractor under refrigeration, the exposed end of the core can be cooled, thus setting up a steep temperature gradient. As the soil desiccates from the heated end, a humidity gradient is also created. Merchant and Crossley (1970) originally used a regular refrigerator as a cooling chamber. However, at the Site a large capacity system was needed, so large 45°F reach-in coolers were used. These coolers gave the added advantage of close control of internal ambient air temperature. Shelves of extractors were designed to fit the coolers. These coolers were able to maintain an internal ambient air temperature of 10°C during extraction when the top of each core sample was heated to 40 to 45°C. The exposed end of each core was very near the internal ambient air temperature, thus producing a 30 to 35°C temperature gradient. Merchant and Crossley (1970) recommend, as a minimum, a 25°C gradient within the soil core for best results. During extraction each soil core section was placed inverted in the extractor and extracted for a minimum of 7 days (168 hr), which normally was sufficient time to completely desiccate all soil cores.

The efficiency of this system has not been determined due to the extreme difficulty in establishing an absolute number of microarthropods per unit volume of soil. Many of the soil microarthropods are very

small and fragile and do not lend themselves readily to mechanical extraction techniques. A comparative study by Edwards and Fletcher (1971) found a system similar to that used at Pawnee to retrieve the greatest number of soil microarthropods, but the study produced no absolute efficiency figure for any extraction technique, mechanical or dynamic.

Once the soil samples were completely desiccated, the extracted microarthropods were sorted, counted, and identified at the Site. All sorting, counting, and most identifications were done under binocular dissecting microscopes (Baush and Lomb Stereozoom 7). For detailed observation and for the reference collection, specimens were mounted in Hoyer's mounting media (Krantz 1971) on glass microslides. Detailed observations of mounted specimens were made by use of a phase-contrast equipped compound microscope (Wild M20 Binocular). A reference collection is being maintained at the Pawnee Site.

Dry weight biomass determinations were made for most groups or categories of soil microarthropods identified. To obtain the biomass weights, large numbers of each group or category were dried and weighed to the nearest microgram using a Cahn Ratio Electrobalance (Model G, No. 1614). All weighing was done in the 20-mg range on the balance, allowing the accuracy to the nearest microgram. Special weighing pans were constructed from 0.001 gauge aluminum foil by cutting 16-mm circular discs and pressing them into a concave spot plate. Each pan weighed approximately 11.6 mg with a fluid capacity of 0.2 ml. Porcelain spot plates were used as holders for the pans during all handling.

The basic procedure was to obtain a tare weight of the weighing pan, add a known number of specimens of a given group, oven-dry at 65°C for 24 hr and reweigh. Pan tare weights were obtained by first washing the pans and spot plates in acetone, oven-drying both at 65°C for a minimum of 1.0 hr, cooling both in a desiccator for ½ hr, then weighing. The tare weight of a given pan did not change regardless of time of exposure or repeated exposure to the heat.

Since all microarthropod specimens were previously preserved and stored in 70% ethyl alcohol (EtOH), the transfer of specimens to a pan was done by first centrifuging them into the bottom of a tapered centrifuge tube to compact them into as small a volume as possible. The specimens were then transferred to the weighing pan in 0.2 ml EtOH or less by using a glass pipette. It was determined that the 0.2 ml EtOH did not affect the weight obtained for the given group. Once transferred to the weighing pans, all specimens were dried at 65°C for 24 hr (although it was found that the specimens were dry after only 2 hr), after which they were cooled in desiccators for ½ hr, then weighed. Large numbers of specimens rather than indivduals of each group or category were weighed because it was impossible to weigh many of the small types individually on the available equipment.

CONCLUSION

It is recognized that the here-in-described techniques and equipment have many limitations which must be kept in mind when any resulting data are analyzed. However, under the expressed goals of IBP where total numbers and biomass of arthropods are desired, these techniques

and equipment are some of the best available and certainly provide a starting point for eventual development of more efficient methods. Because these techniques and equipment can introduce biases or leave gaps in the data, other sampling techniques should and have been employed to provide supporting information on the arthropod populations. These include sweep-net sampling, pit-fall-trap sampling, yellow pan sampling (trapping insects attracted to yellow colored pans), etc. With all these techniques and procedures, an initial estimate and description of the invertebrate community in a shortgrass prairie is currently being made.

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