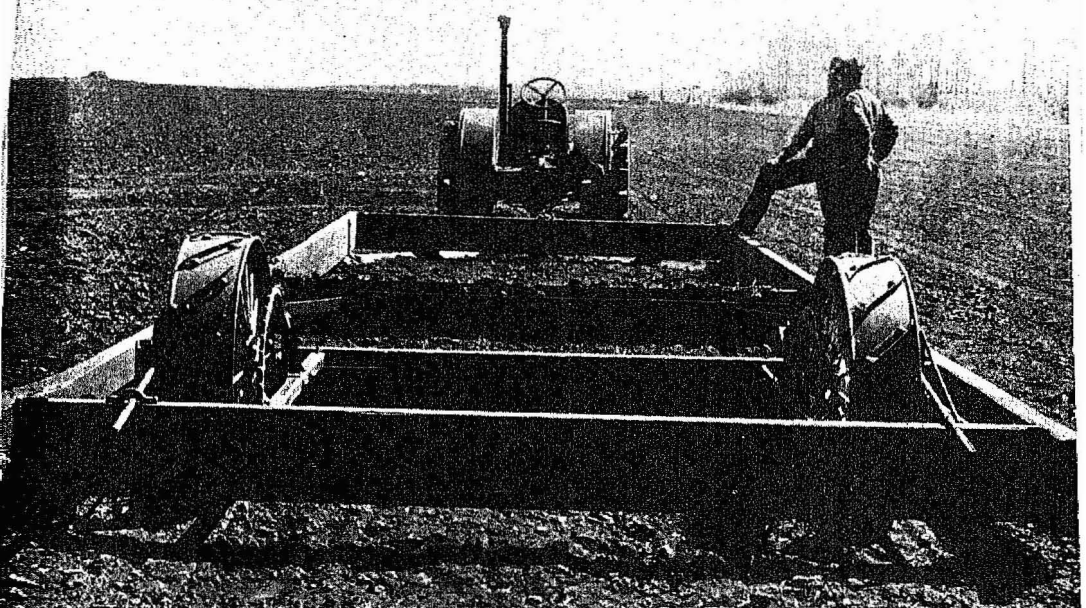
BULLETIN NO. 180 DECEMBER 1939

IRRIGATION STRUCTURES AND EQUIPMENT

O. W. MONSON G. H. BINGHAM



MONTANA EXTENSION SERVICE
BOZEMAN, MONTANA

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Irrigation Structures and Equipment

By
G. H. Bingham and O. W. Monson

INTRODUCTION

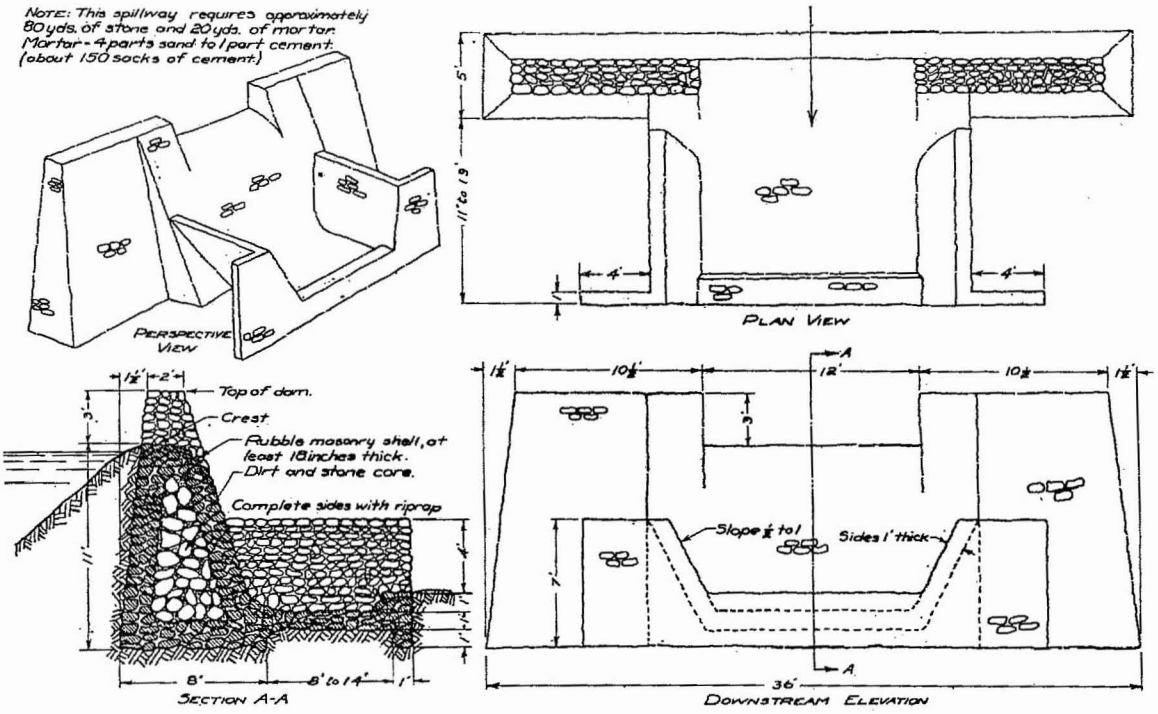
Successful irrigation depends upon the complete control of comparatively large streams of water. From the time water is diverted from a stream or coulee until it is absorbed by the soil in the farmer's field, it must be under control of the irrigator. Without control there will be damage from erosion or from seepage.

Control begins at the diversion dam, which is a structure built into the stream or channel to divert the desired amount of water to the farmer's ditch, and permit surplus or high water to by-pass without damage to structure or channel. At critical points in the ditch through which the water is conveyed to the farm, headgates, checks and drops, wasteways and other structures must be installed so that washouts and channel erosion can be prevented, and so that the water can be conveyed to the parts of the field where needed.

Irrigation control structures are often expensive, but the cost can generally be reduced by simplifying the design and by using rock, logs, brush and earth wherever possible instead of lumber, steel and cement. The rock, brush, and earth must be used in liberal quantities sufficient to provide the strength necessary for the safety of the structure.

When the water reaches the farm it can be conveyed to the various fields and distributed uniformly over the land only when ditches are properly located and built. The land should be carefully graded or leveled so that the water will spread evenly and not stand in puddles and ponds nor leave dry patches unirrigated. Here again, the cost may be reduced to a minimum by using homemade equipment wherever possible. However, if brush and dirt dams are to be safe and if homemade equipment is to give satisfaction, basic principles of design and construction must be followed.

This bulletin is prepared with the idea of assisting the farmer with suggestions of simple structures and homemade equipment and also illustrates types of practical commercial equipment that are available.



RUBBLE MASONRY SPILLWAY FOR AN EARTH DAM

Fig. 1.

DAMS

a. **Masonry.**—Fig. 1 shows the general plan and proportions of a rock masonry dam which, with minor changes, can be adapted to a wide variety of conditions. It is of the overflow type and the center section of the dam serves for a spillway for flood waters whenever the flow in the creek exceeds the capacity of the diversion canal. This type of dam is recommended wherever rock and boulders are accessible within convenient reach of the dam site. The dimensions given for the dam provide for a minimum use of cement in order to cut down cash outlay. To offset this saving on cement, a liberal use of rock is recommended in order to give strength and stability to the structure.

For the shell of the dam, use clean stone laid up in cement mortar. The mortar should be fairly rich. **Not over 6 gallons of water should be used per sack of cement, with only enough sand to make a good mortar.** If the sand is wet, cut the amount of water to 5½ gallons per sack. Sand must be clean and sharp. Comparatively small amounts of vegetable matter and dirt will reduce the strength of the mortar.

The downstream sides and wing walls should also be laid up in mortar with a minimum thickness of 12 inches. The floor or apron should be increased to 18 inches thick if the drop exceeds 4 feet. The length of the apron should be at least twice the amount of drop, with a minimum of 8 feet. For the structure illustrated in Fig. 1, having a drop of 8 feet, the apron should be 16 feet long and 18 inches thick. Note also that a check wall at the lower end provides for a water cushion, and the water discharges at slightly below the grade level in the creek.

The capacity of the spillway is 10.5 cubic feet per second per foot of crest.

Concrete Dam

Fig. 2 shows a design for a reinforced concrete diversion check dam with 4 bays. When building concrete structures for water control, it is highly important that attention be given to the selection of sand and gravel used and to the proportioning of the concrete mixture. Only clean sand and gravel, free from vege-

table matter and dirt, should be used. A small amount of dirt will neutralize a considerable amount of cement.

It is important also to use a rich mixture. To skimp on the amount of cement used is really a waste, because the resulting structure will not stand up under the erosive action of water and weather. A 1:2½:5 mixture represents a good proportion of cement and aggregate. That is, 1 part cement, 2½ parts sand and 5 parts gravel. The most reliable basis for designating a mixture, however, is the so called cement-water ratio. By this is meant limiting the amount of water used per sack of cement. For the structure shown in Fig. 2, it is recommended that not more than 6 gallons of water be used per sack of cement, using only enough sand and gravel to make a good workable mixture.

Reinforcing by steel is used to strengthen the structure. This steel is placed on the side of the wall subject to tensile stresses. The rods should be imbedded in the concrete 1 inch deep. Side walls and floors also need a small amount of reinforcing to protect against excessive erosion. This can be supplied in the form of hog wire fencing imbedded in the concrete 1 inch deep.

Other important features in the construction of a concrete diversion dam, as shown in Fig. 2, are the cut-off walls. The upstream wall in particular, should extend down into solid material from 2 to 3 feet. The downstream cut-off wall should extend deep enough to prevent backwash under the floor. If the structure is to be built upon a pervious formation, such as sand or gravel, drainage must be provided to carry away water which percolates under the structure, tending to cause uplift when the flash boards are in place. This is carried away by means of a 4-inch tile laid under the floor with an outlet branch as shown in Fig. 2.

Concrete structures should be expected to be expensive, but there is no justification for skimping in the materials used; since this usually results in failure and a waste of the entire structure rather than in any net saving.

A simple test to determine the suitability of sand or gravel for use in concrete is to fill a bottle, such as a fruit jar, one-half full of sand or gravel; then fill it completely with water and

shake thoroughly. After this, allow the bottle to stand several hours to settle. After settling, so that the water has cleared up, the material will be well sorted out: the gravel will be on the bottom, the sand next, then the dirt, and the vegetable matter will be on top. If any considerable amount of vegetable matter and dirt appears, it must be washed or screened out before the sand or gravel will make good concrete.

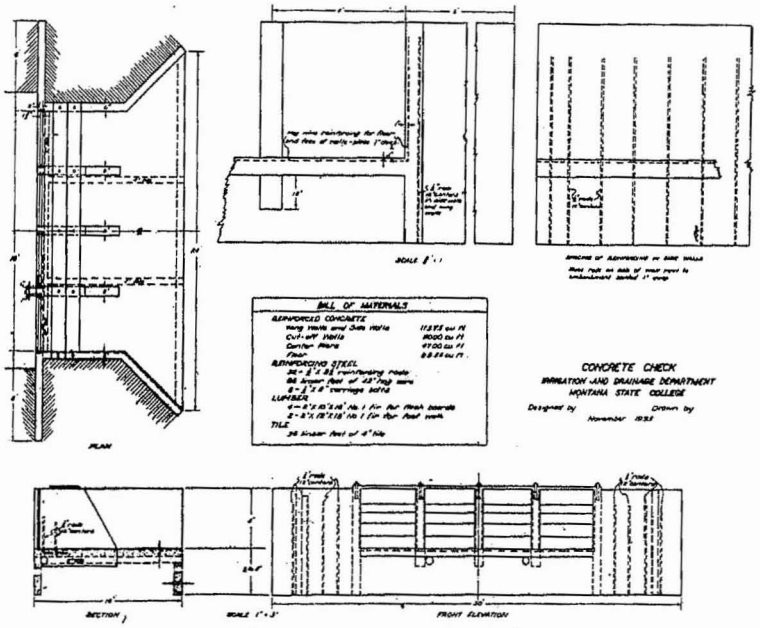


Fig. 2—Concrete Diversion Dam.

Bill of Materials

Reinforced Concrete
- Wing Walls and Side Walls ..... 113.75 cu. ft.
- Cut-off Walls ..... 50.00 cu. ft.
- Center Piers ..... 47.00 cu. ft.
- Floor ..... 85.25 cu. ft.

Reinforcing Steel
- 32 — ½″x5½′ reinforcing rods.
- 66 linear feet of 42″ hog wire.
- 8 — ½″x8″ carriage bolts.

Lumber
- 4 — 2″x10″x16′ No. 1 fir for flash boards.
- 2 — 2″x12″x18′ No. 1 fir for foot walk.

Tile
- 36 linear feet of 4″ tile.

Brush And Rock Dam

Fig. 3 shows a type of construction for a diversion dam which is adapted to many parts of Montana. The governing principle in its design is the use of local materials. Only rock, brush and native logs are used. Therefore, it is possible to build this dam with little, if any, cash outlay. The dam is built by placing alternate layers of rock and willows, backed up with earth fill, with each succeeding layer set back to give a stairway effect to the spillway. It should be constructed with a general slope of 2 to 1; that is, a 1 foot rise to 2 feet run. The rock

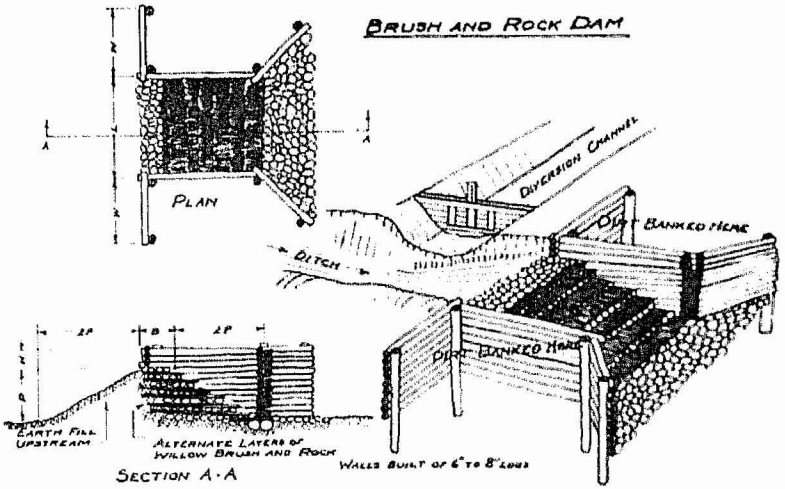


Fig. 3.

serve to hold the willows in place and anchor them into the dam. They also give weight and stability to the structure. The dam is made impervious by an earth fill on the upstearm side, which is also built on a slope of 2 to 1. The earth fill should be built up at the same time that the brush and rock are placed, so that the brush ties in and forms a good bond with the earth dam. The head wall, side walls, and wing walls are constructed of logs notched together at the corners. Binding them with wire strengthens the construction.

The crest of the dam should be built high enough to divert the required amount of water when the stream is low. The diversion channel must be protected with a headgate so that

the amount diverted may be controlled, especially during high water. A double wall and double wing headgate is better than a single wall structure. At the lower end of the spillway the channel should be heavily riprapped the full width for a distance of 4 to 6 feet. This riprapping should be placed below the grade line of the channel so that the water will be discharged below the grade, and thereby prevent erosion or backwash.

This type of structure is to be recommended wherever brush, rock and logs are available convenient to the dam site. If carefully constructed, such a structure should be safe for conditions where the height or fall does not exceed 10 feet. Since the materials used are cheap, these should be used in liberal proportions.

HEADGATES

Fig. 4 shows the general plan for a wooden headgate capable of handling a large flow of water. It has two 5-foot gates and should have a capacity of about 100 cubic feet per second. It is recommended that 2-inch material be used throughout and, to add to the durability of the structure, this lumber should be creosoted before nailing in place. The posts used may be of any native wood, instead of the sawed 6x6's illustrated in Fig. 4. These posts also should be creosoted to preserve them against decay. Heavy cross bracing is necessary to keep the walls from warping and being pushed inward.

An important feature is the setting of the posts to a depth of at least 3 feet to hold the structure firmly in place. It is also important to build cut-off walls and wing walls down into the bed of the canal sufficient to prevent washing under the structure. Unless the posts are deeply set, firmly tamped and anchored in place, the whole structure is liable to be raised by the water's getting under the floor and uplifting or floating it away.

An added feature to the design shown in Fig. 4 would be the use of a wheel and screw stem on each of the gates to facilitate opening and closing them. It may also be necessary to protect the downstream end by riprapping with stone to prevent backwash and undercutting. The floor of the structure should be set level with or even slightly below the bottom of the channel. This tends to reduce the danger of undercutting and erosion around the structure.

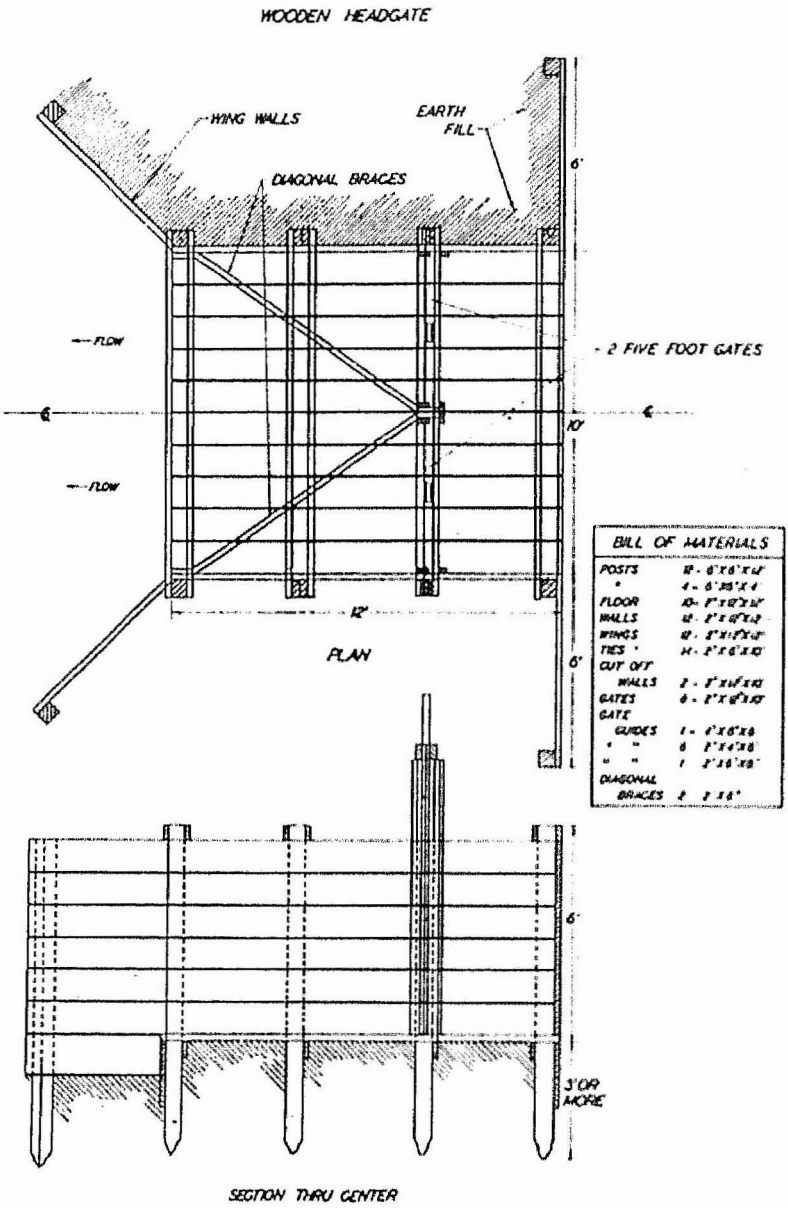

WOODEN HEADGATE
WING WALLS
EARTH FILL
DIAGONAL BRACES
FLOW
FLOW
2 FIVE FOOT GATES
6'
10'
12'
PLAN
BILL OF MATERIALS
POSTS
FLOOR
WALLS
WINGS
TIES
CUT OFF WALLS
GATES
GATE GUIDES
DIAGONAL BRACES
6'
3' OR MORE
SECTION THRU CENTER

Fig. 4.

Concrete Headgate

Fig. 5 shows a plan for a concrete headgate to be placed in a main ditch for diversion into a farm lateral. The use of this structure provides complete control of the water, both in the canal and in the lateral. It saves a great deal of work, as well as unnecessary digging of the ditch banks, when diverting water from a main ditch.

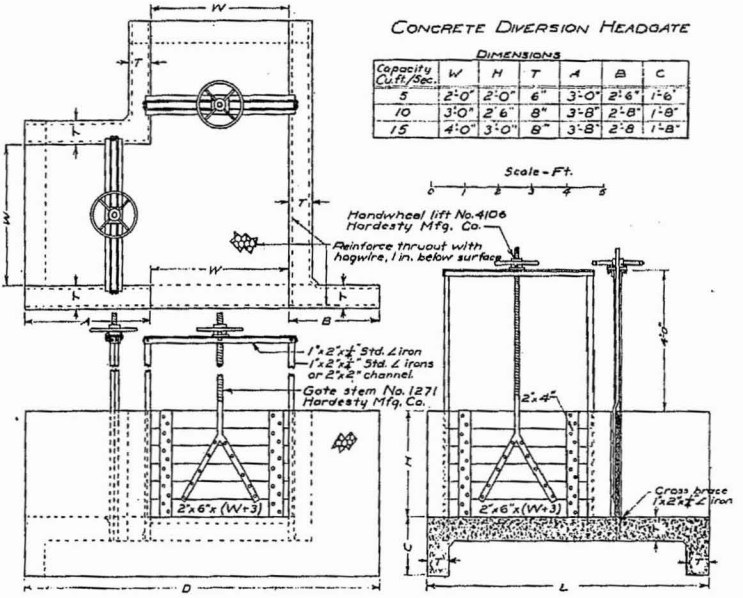


Fig. 5.

The headgates are made of wood, controlled with a screw stem and handwheel. Concrete in this headgate structure should be made of clean, sharp sand and gravel containing no vegetable matter or dirt. Full dimensions should be used, to provide stability to the structure. Placing of heavy chicken wire or hog wire imbedded 1 inch in the concrete will add greatly to its strength without increasing the cost very much. Cut-off walls should extend into the ground sufficiently to prevent undercutting. A minimum of 1½ feet is recommended. When mixing the concrete, not more than 6 gallons of water per sack of cement should be used.

Concrete Checks And Drops

Fig. 6 shows the dimensions and plan of construction of a simple concrete drop and check. This structure consists of only a single wall built at right angles to the stream or canal. A notch through the center provides passage of the water when not in use. Grooves in the wall, into which flash boards can be fitted, provide for checking or raising the water surface when desired

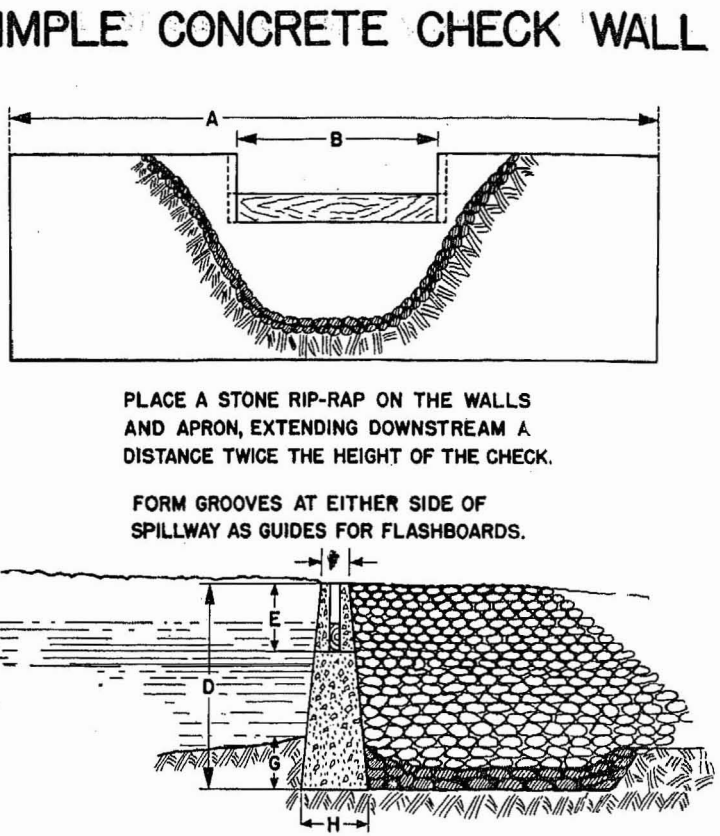


Fig. 6.

for diversion. Since this check does not have the bracing effect of side walls, it must be rather wide and thick in order to be stable. To protect the channel against erosion, a heavy rip-rapping of rocks should be placed on the lower side. This may

A	B	D	E	F	G	H
14'-0"	4'-0"	4'-0"	1'-6"	0'-8"	1'-6"	1'-8"
19'-0"	6'-0"	6'-0"	2'-0"	0'-8"	1'-6"	2'-0"
24'-0"	8'-0"	8'-0"	3'-0"	0'-8"	2'-0"	3'-0"

Table to accompany figure 6, page 12, Ext. B. 180

slope up to the crest of the check, or simply be placed in the bottom of the channel onto which the water may fall. It is important that the water should be discharged at grade level to prevent eddies and undercutting.

In building concrete structures, the farmer is cautioned against undue economy in the use of cement. Either sufficient cement should be used to make a durable structure, or else its use should be abandoned entirely; as too much economy in the mixture or in the dimensions of the structure may result in total failure and loss. The mixture should be based upon the use of 6 gallons of water per sack of cement. No steel reinforcing need be used although heavy hog wire in the upper face of the wall will add greatly to its strength. The dimensions given in the table indicate the proportions to which the concrete check should be built under various conditions.

Wooden Drop And Check

Fig. 7 shows a wooden drop and check for use in a comparatively small ditch. It is built of 2-inch lumber, which should be treated with creosote before nailing in place. This structure is adapted for use in farm laterals where an excessive amount of slope occurs. Its use will prevent erosion in the lateral as well as providing control of water when diverting it out onto the field.

Two by four flash boards are used to raise the water surface to the desired height. These flash boards fit into guides or grooves nailed to the side walls.

Another important point in the construction of a wooden check is that it must be securely anchored. Posts to which the structure is fastened should be set deeply and be firmly tamped in place.

The floor of the drop should be slightly below the grade of the ditch; so that the water will be discharged at grade level. This prevents backwash and undercutting. The structure illustrated in Fig. 7 has a water cushion by placing the floor about four inches below grade. A 2x4 is nailed across at the outlet end. The top of the 2x4 should be at grade level.

Following are recommended dimensions for various capacities:

Suggested Dimensions

	Ditch Capacity		
	2 c. f. s.	5 c. f. s.	10 c. f. s.
A	30″	36″	39″
B	12″	18″	24″
C	12″	24″	42″
D	up to 36″ as needed		
H	12″	24″	24″
O	9″	9″	12″
L	48″	72″	72″
W	20″	32″	50″

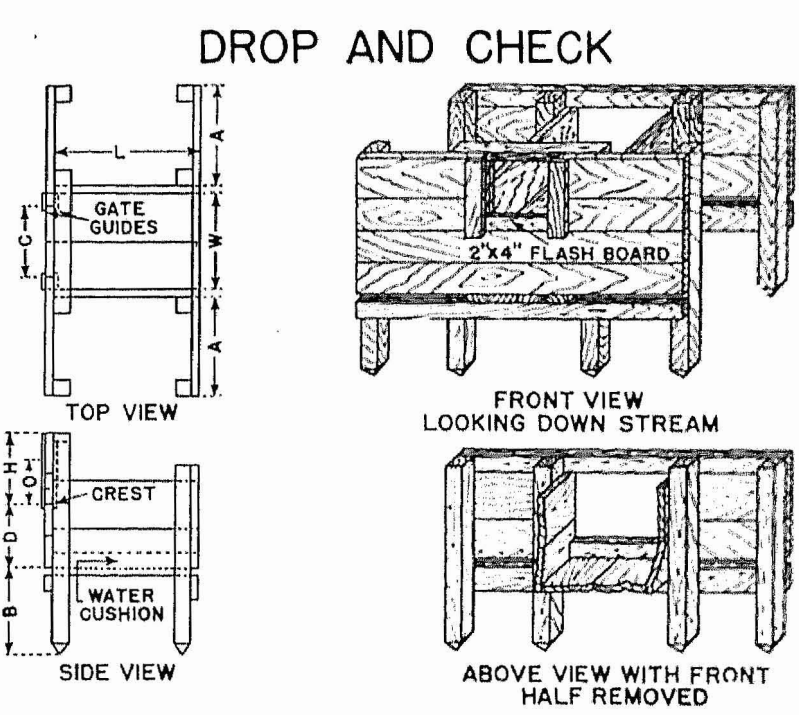
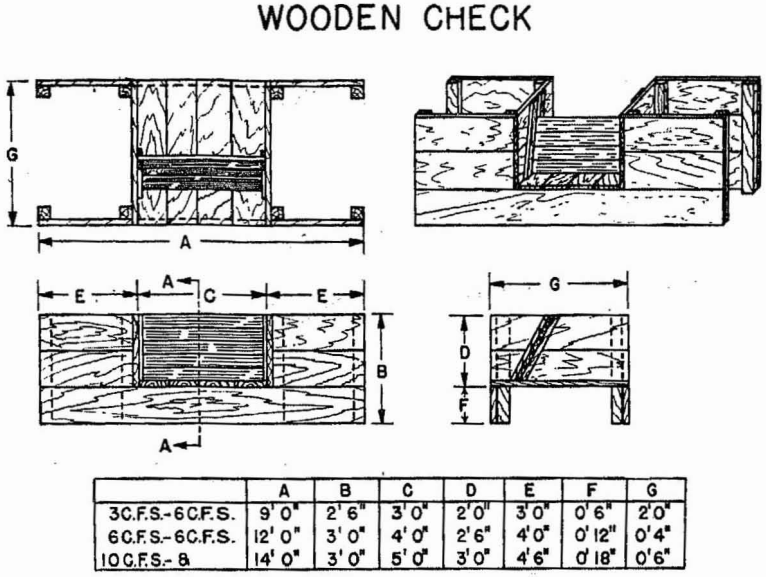


Fig. 7.

Wooden Check

Fig. 8 shows a wooden check for use in a farm lateral or head ditch. Its purpose is to raise the level of the water in the ditch to make it flow out onto the field. It consists of 2 cut-off walls extending into the banks and bottom of the ditch, securely imbedded so as to prevent the water from cutting around. The water level is controlled by placing flash boards in the grooves of the side walls. These grooves are built on a slant. This prevents the flash boards from floating out when put in place, since the presure of the water will hold them down.



	A	B	C	D	E	F	G
3C.F.S.-6C.F.S.	9' 0"	2' 6"	3' 0"	2' 0"	3' 0"	0' 6"	2' 0"
6C.F.S.-6C.F.S.	12' 0"	3' 0"	4' 0"	2' 6"	4' 0"	0' 12"	0' 4"
10C.F.S.- 8	14' 0"	3' 0"	5' 0"	3' 0"	4' 6"	0' 18"	0' 6"

Fig. 8.

It is highly important that the cut-off wall be set deep enough into the bottom of the ditch to prevent undercutting. For gumbo soils a minimum of 12 inches is recommended for the F dimension, and for large structures 18 inches is justified as given in Fig. 8. For the construction of this check, 2-inch lumber should be used; as lighter material would rot out very quickly. Treating of the lumber with creosote before nailing in place is desirable.

A Wooden Turnout

Fig. 9 shows a wooden turnout for use in connection with the wooden check shown in Fig. 8. This turnout may be built of old lumber usually found around any farmstead. Such structures should be provided for each place at which water is diverted from the headditch. Their use prevents the cutting of the bank and also provides much better control than is possible when banks are cut and sod is used for the checking of the stream.

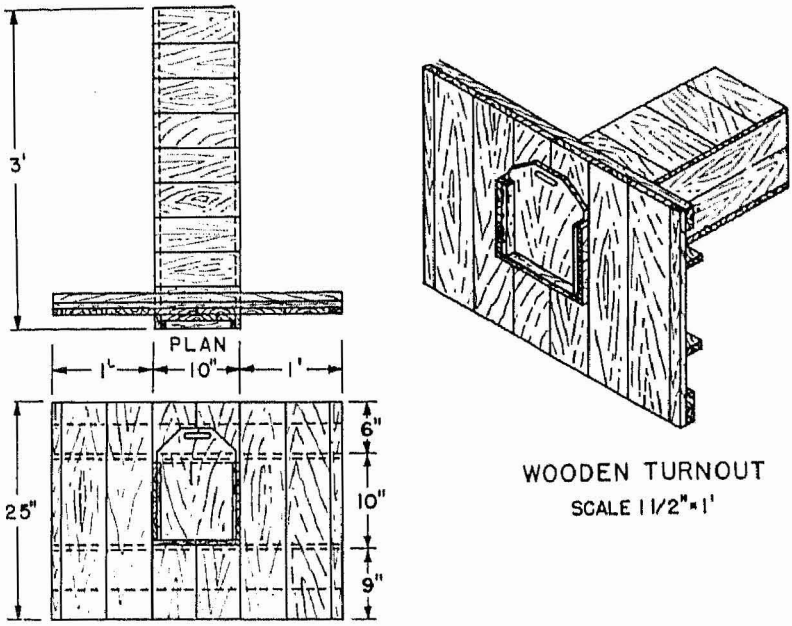


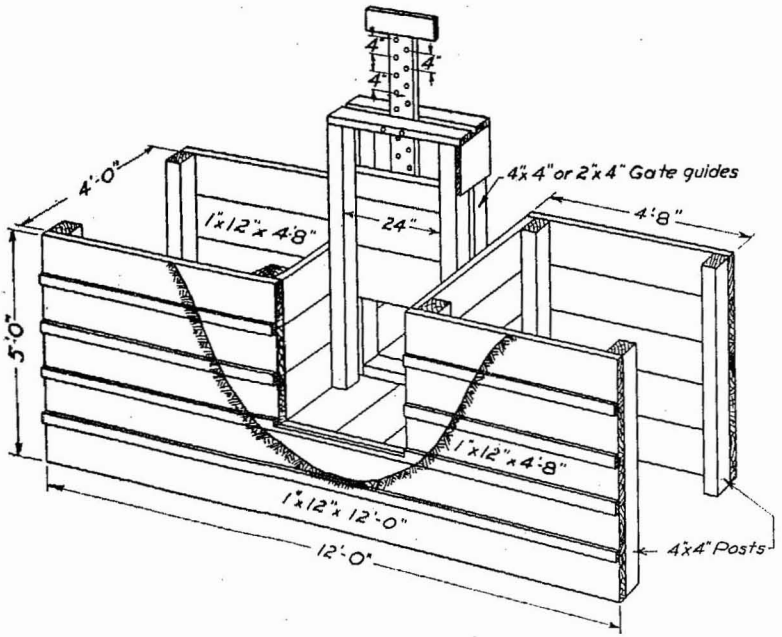
Fig. 9.

This turnout may be built of 1-inch material, since it is small and can be easily replaced when rotted out. If 2-inch material is available, its use is justified. These boxes may be built complete during idle season, to a standard size, and installed later as needed. If treated with creosote, the length of life of the structures is greatly extended.

MEASURING DEVICES

Adjustable Submerged Orifice Headgate

Every farm ditch should be provided with a measuring device: a weir, a rating flume, or a submerged orifice. In this way the farmer will know whether or not he is getting the amount of water to which he is entitled. Also, the ditchrider will be able to give much better service if all laterals and turnouts are provided with measuring devices so that the amount of water delivered may be measured rather than estimated.



ADJUSTABLE SUBMERGED ORIFICE HEADGATE

Fig. 10.

Fig. 10 shows an adjustable submerged orifice headgate, with the dimensions of the wing walls as well as the gate. By means of Fig. 11, the flow through the orifice headgate may be determined. The slanting lines represent various gate openings. For example, consider a gate with 2"x4" gate guides. If such a gate is raised 6 inches, which gives an opening of 1 square foot, the flow would be 3 second feet when the difference between the

upstream and downstream water surface is 0.25 of a foot, or 3 inches, and 1.5 second feet if the gate is raised 3 inches so as to give an opening of ½ square foot, with the same head.

The submerged orifice is adaptable in flat country where there is not sufficient fall away from the ditch to permit the use of a weir.

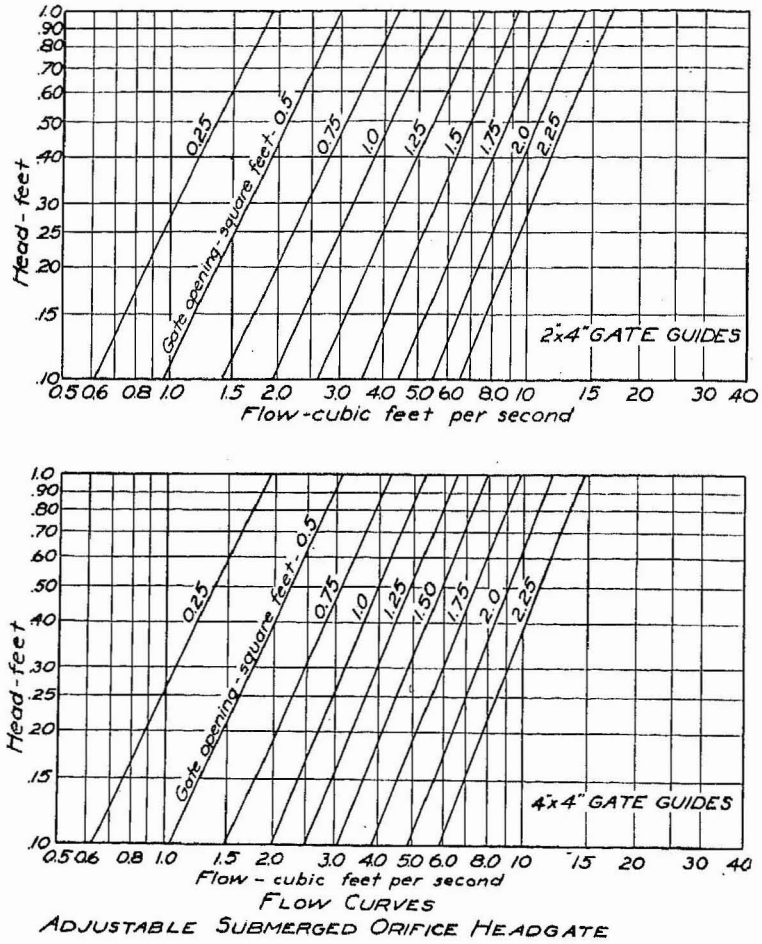
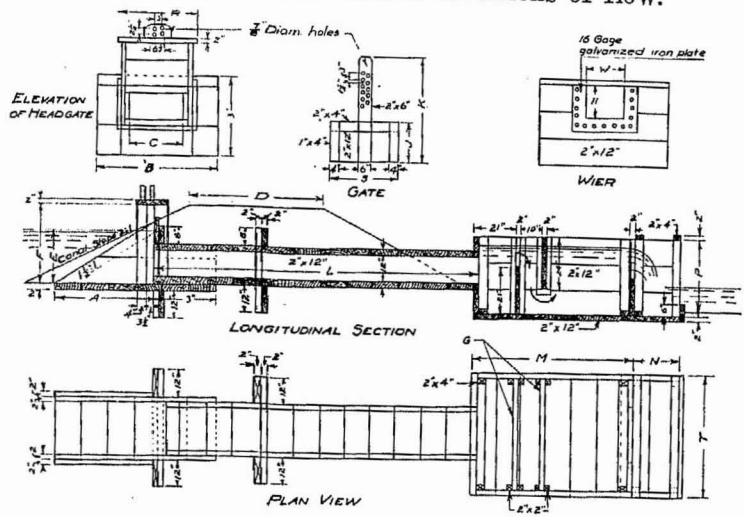


Fig. 11.

For a more complete description of water measuring devices see Montana Agricultural Experiment Station, Circular No. 126 by H. E. Murdock.

Wooden Delivery Gate and Measuring Weir

Fig. 12 shows a wooden delivery gate and measuring weir combined. This structure may be used wherever there is sufficient fall away from the canal to permit the use of an overflow weir. It is made entirely of 2-inch material and the proportions or dimensions are given for various conditions of flow.



WOODEN DELIVERY GATE AND MEASURING WIER

Fig. 12.

Here again it would be advisable to treat lumber with creosote in order to prevent decay.

The accompanying table gives dimensions for various capacities.

The use of this delivery gate and measuring weir requires that the ground level be from 12 to 24 inches lower than the water surface in the canal in order to allow free fall over the weir.

Capacity c. f. s.	Dimensions in inches W	H	P	T	M	N	C	S
1	12	10	24	36	48	24	12	16
2	18	12	24	42	48	24	12	16
3	24	12	28	48	48	24	18	22
4	24	12	30	48	60	30	24	28
6	24	16	30	54	60	30	30	34
8	36	16	36	60	72	36	36	40
10	36	16	36	60	72	36	42	46

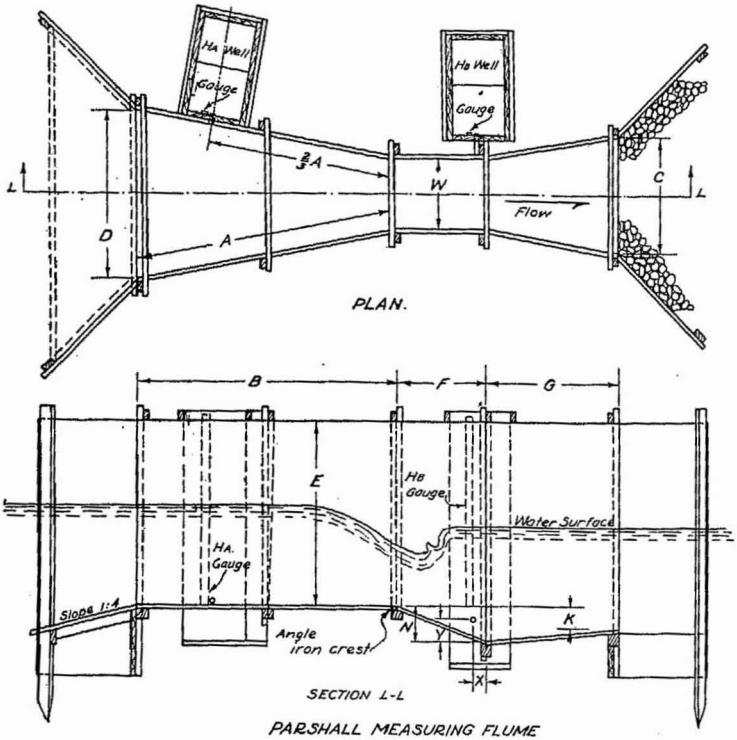
To determine the flow of water through the weir, see table 1, Ditch Rider's Handbook by H. E. Murdock, Montana Agricultural Experiment Station.

Parshall Measuring Flume

Fig. 13 shows the plan and sectional view of an improved Parshall measuring flume. This measuring device combines the advantages of a submerged orifice by requiring only a small loss of head, and of the overflow weir in its simplicity of operation. Another advantage, is the fact that it does not silt or clog up easily. It is adaptable for a wide range in flow and, when carefully constructed according to the dimensions given, provides an acurate means of measuring irrigation water.

Flumes with a throat width of less than 1 foot may be constructed of 1-inch lumber. Larger structures should be built of 2-inch material. Important features in the construction of the Parshall flume are: (1) the making of the throat width to exact dimensions, (2) the proper drop in the throat section, (3) correct rise in the diverging section, (4) the placing of the gage wells at the proper positions. When installing it in the ditch or canal, it is important that the floor of the converging section be absolutely level, both lengthwise and crosswise. It is generally necessary to set the flume with the floor or crest elevated above the canal bottom to prevent excessive submergence.

Submergence is measured at the gage wells located as shown. When the depth in the Hb well is more than .7 of the depth in Ha well, a correction must be applied to the flow. By raising the floor of the flume it is possible to avoid this excessive submergence. In such cases, only the depth in Ha will need to be measured. These measurements, when referred to the accompanying table, give the flow in cubic feet per second through the flume. A measuring stick installed in well "a" may have the correct flow for various depths printed upon it. This simplifies the use of the flume.



PARSHALL MEASURING FLUME
SCALE AS SHOWN

DIMENSIONS & CAPACITIES OF PARSHALL MEASURING FLUME

W	A	2/3 A	B	C	D	E	F	G	K	N	X	Y	Free-Flow Capacity	
													Maximum	Minimum
Ft.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft.	Ft.	In.	In	In	In.	Sec.Ft.	Sec.Ft
0.25	1 6 3/8	1 1/4	1 6	7	10 3/8	1 3	.5	1.	1	2 1/4	1	1 1/2	1.2	0.03
.50	2 7/8	1 4 5/8	2	1 3 1/2	1 3 1/2	1 6	1.	2.	3	4 1/2	2	3	2.9	.05
.75	2 10 3/8	1 11/8	2 10	1 3	1 10 5/8	2	1	1.5	3	4 1/2	2	3	.57	1
1.	4 6	3	4 4 3/8	2	2 9 1/4	3	2.	3.	3	9	2	3	16.	.4
2.	5	3 4	4 10 3/8	3	3 11 1/2	3	2.	3.	3	9	2	3	33.	.7
3.	5 6	3 8	5 4 1/2	4	5 1 3/8	3	2.	3.	3	9	2	3	50	10
4.	6	4	5 10 3/8	5	6 4 1/4	3	2.	3.	3	9	2	3	68.	13

Fig. 13.

FREE FLOW THROUGH PARSHALL MEASURING FLUMES

(Courtesy Colorado Agric. Exp. Station)

Upper Head		Throat Width						
Feet	Inches (approx.)	3 ins.	6 ins.	9 ins.	1 foot	2 foot	3 foot	4 foot
		Flow in cubic feet per second						
0.10	1 3/16	0.028	0.05	0.09				
0.15	1 13/16	0.053	0.10	0.17				
0.20	2 3/8	0.082	0.16	0.26	0.35	0.66	0.97	1.26
0.25	3	0.117	0.23	0.37	0.49	0.93	1.37	1.80
0.30	3 5/8	0.154	0.31	0.49	0.64	1.24	1.82	2.39
0.35	4 3/16	0.196	0.39	0.62	0.80	1.57	2.32	3.06
0.40	4 13/16	0.241	0.48	0.76	0.99	1.93	2.86	3.77
0.45	5 3/8	0.289	0.58	0.90	1.19	2.32	3.44	4.54
0.50	6	0.339	0.69	1.06	1.39	2.73	4.05	5.36
0.55	6 5/8	0.393	0.80	1.23	1.62	3.17	4.70	6.23
0.60	7 3/16	0.450	0.92	1.40	1.84	3.62	5.39	7.15
0.65	7 13/16	0.509	1.04	1.59	2.08	4.11	6.12	8.11
0.70	8 3/8	0.571	1.17	1.78	2.33	4.60	6.86	9.11
0.75	9	.....	1.31	1.98	2.58	5.12	7.65	10.2
0.80	9 5/8	.....	1.45	2.18	2.85	5.66	8.46	11.3
0.85	10 3/16	.....	1.59	2.39	3.12	6.22	9.30	12.4
0.90	10 13/16	.....	1.74	2.61	3.41	6.80	10.2	13.6
0.95	11 3/8	.....	1.90	2.84	3.70	7.39	11.1	14.8
1.00	12	.....	2.06	3.07	4.00	8.00	12.0	16.0
1.05	12 5/8	.....	2.22	3.31	4.31	8.63	13.0	17.3
1.10	13 3/16	.....	2.40	3.55	4.62	9.27	13.9	18.6
1.15	13 13/16	.....	2.57	3.80	4.94	9.94	14.9	19.9
1.20	14 3/8	.....	2.75	4.06	5.28	10.6	16.0	21.3
1.25	15	.....	.....	4.32	5.62	11.3	17.0	22.8
1.30	15 5/8	.....	.....	4.59	5.96	12.0	18.1	24.2
1.35	16 3/16	.....	.....	4.86	6.32	12.7	19.2	25.7
1.40	16 13/16	.....	.....	.....	6.68	13.5	20.3	27.2
1.45	17 3/8	.....	.....	.....	7.04	14.2	21.3	28.8
1.50	18	.....	.....	.....	7.41	15.0	22.6	30.3
1.55	18 5/8	.....	.....	.....	7.80	15.8	23.8	32.0
1.60	19 3/16	.....	.....	.....	8.18	16.6	25.1	33.6
1.65	19 13/16	.....	.....	.....	8.57	17.4	26.3	35.3
1.70	20 3/8	.....	.....	.....	8.97	18.2	27.6	37.0
1.75	21	.....	.....	.....	9.38	19.0	28.8	38.7
1.80	21 5/8	.....	.....	.....	9.79	19.9	30.1	40.5
1.85	22 3/16	.....	.....	.....	10.2	20.8	31.5	42.2
1.90	22 13/16	.....	.....	.....	10.6	21.6	32.8	44.1
1.95	23 3/8	.....	.....	.....	11.1	22.5	34.1	45.9
2.00	24	.....	.....	.....	11.5	23.4	35.5	47.8
2.05	24 5/8	.....	.....	.....	11.9	24.3	36.9	49.7
2.10	25 3/16	.....	.....	.....	12.4	25.3	38.4	51.6
2.15	25 13/16	.....	.....	.....	12.8	26.2	39.8	53.5
2.20	26 3/8	.....	.....	.....	13.3	27.2	41.3	55.5
2.25	27	.....	.....	.....	13.7	28.1	42.7	57.5
2.30	27 5/8	.....	.....	.....	14.2	29.1	44.2	59.6
2.35	28 3/16	.....	.....	.....	14.7	30.1	45.7	61.6
2.40	28 13/16	.....	.....	.....	15.2	31.1	47.3	63.7
2.45	29 3/8	.....	.....	.....	15.6	32.1	48.8	65.8
2.50	30	.....	.....	.....	16.1	33.1	50.4	67.9

V-Notch Weir

Fig. 14 shows a V-notch weir for use in small farm laterals. It is made by cutting a triangular notch in a wooden bulkhead. The depth of the notch may be from 8 to 12 inches, as shown in Fig. 14. This wooden bulkhead may be constructed of 1-inch material. Posts (2x4) should be placed at each end and on both sides of the notch. It must be set deep enough into the bottom of the ditch to prevent undercutting, and into the banks a sufficient distance to hold it firmly.

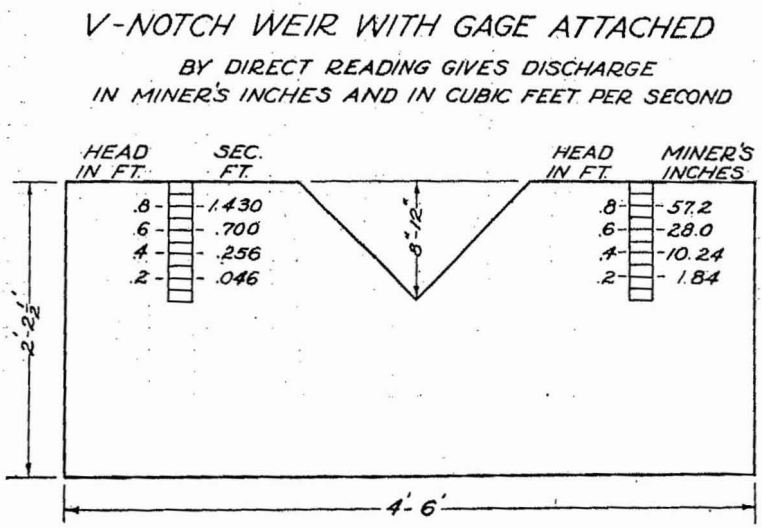


Fig. 14.

The amount of water going over the weir may be determined by direct reading gages as shown. These gages are made by laying off the head or depth of water through a triangular notch

weir as given in table below, and opposite each depth giving the flow, either in cubic feet per second or in miner's inches as shown. The head in feet is measured from the bottom of the weir notch.

DISCHARGE TABLE FOR 90-DEGREE TRIANGULAR NOTCH.

Head in feet	Head in inches	Discharge in second-feet	Head in feet	Head in inches	Discharge in second-feet	Head in feet	Head in inches	Discharge in second-feet
0.20	2 3/8	0.046	0.47	5 5/8	0.382	0.74	8 7/8	1.18
.21	2 1/2	052	.48	5 3/4	.403	.75	9	1.22
.22	2 5/8	.058	.49	5 7/8	.424	.76	9 1/8	1.26
.23	2 3/4	.065	.50	6	.445	.77	9 1/4	1.30
.24	2 7/8	.072	.51	6 1/8	.468	.78	9 3/8	1.34
.25	3	.080	.52	6 1/4	.491	.79	9 1/2	1.39
.26	3 1/8	.088	.53	6 3/8	.515	.80	9 5/8	1.43
.27	3 1/4	.096	.54	6 1/2	.539	.81	9 3/4	1.48
.28	3 3/8	.106	.55	6 5/8	.564	.82	9 13/16	1.52
.29	3 1/2	.115	.56	6 3/4	.590	.83	9 15/16	1.57
.30	3 5/8	.125	.57	6 13/16	.617	.84	10 1/16	1.61
.31	3 3/4	.136	.58	6 15/16	.644	.85	10 3/16	1.66
.32	3 13/16	.147	.59	7 1/16	.672	.86	10 5/16	1.71
.33	3 15/16	.159	.60	7 3/16	.700	.87	10 7/16	1.76
.34	4 1/16	.171	.61	7 5/16	.730	.88	10 9/16	1.81
.35	4 3/16	.184	.62	7 7/16	.760	.89	10 11/16	1.86
.36	4 5/16	.197	.63	7 9/16	.790	.90	10 13/16	1.92
.37	4 7/16	.211	.64	7 11/16	.822	.91	10 15/16	1.97
.38	4 9/16	.226	.65	7 13/16	.854	.92	11 1/16	2.02
.39	4 11/16	.241	.66	7 15/16	.887	.93	11 3/16	2.08
.40	4 13/16	.256	.67	8 1/16	.921	.94	11 1/4	2.13
.41	4 15/16	.272	.68	8 3/16	.955	.95	11 3/8	2.19
.42	5 1/16	.289	.69	8 1/4	.991	.96	11 1/2	2.25
.43	5 3/16	.306	.70	8 3/8	1.03	.97	11 5/8	2.31
.44	5 1/4	.324	.71	8 1/2	1.06	.98	11 3/4	2.37
.45	5 3/8	.343	.72	8 5/8	1.10	.99	11 7/8	2.43
.46	5 1/2	.362	.73	8 3/4	1.14	1.00	12	2.49

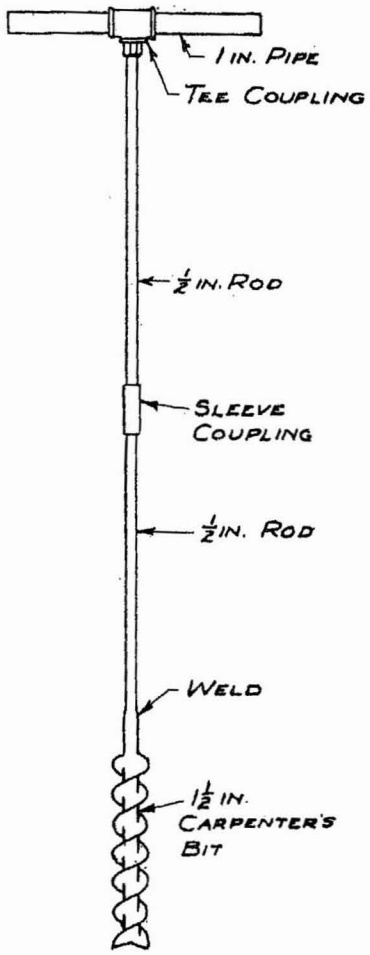
GRADING AND LEVELING

The amount of grading and equipment for leveling fields depends on the character of the soil, the topography, the method of irrigation and the area to be prepared. The surface of many fields, even in old irrigated areas, is too uneven for proper irrigation. Such land should be graded and leveled so that water can be spread uniformly and easily.

Soil Auger

A soil auger may be used to explore the subsoil and determine the depth to which grading may be safely undertaken. It is also used to determine the texture, structure, and depth of the soil in relation to irrigation practices and methods.

A simple type of soil auger is shown in Fig. 15. It consists of a spiral-shaped bit made from a 1½-inch carpenter's standard wood auger-bit welded to a handle made of 2 short pieces of 1-inch pipe fixed to a tee coupling. The screw-point and the side cutting edges of the carpenter's auger are removed in preparing the bit for boring. A post hole type auger also may be used.



SOIL AUGER

Fig. 15.

Deep Tillage Chisel

Loose soils will not generally require plowing before grading but for compact or heavy soils, disking or plowing is necessary. A chisel type implement may be used for this purpose as well as a substitute for a plow, under certain conditions. Fig. 16 illustrates how a plow may be converted into a deep tillage chisel. The moldboard and share are removed from the beam of the plow, and a steel point bolted onto it. This point can be made from any heavy steel such as **old plow beams** and front axles of automobiles.

Automobile axles are easier to shape than plow beams. In making the points it is necessary to maintain the proper angle of contact with the soil to insure penetration. The point should extend 8 inches beyond the end of the beam for most plows. Longer wear is provided by having the blacksmith weld some hard material such as "steelite" on the tip of the point.

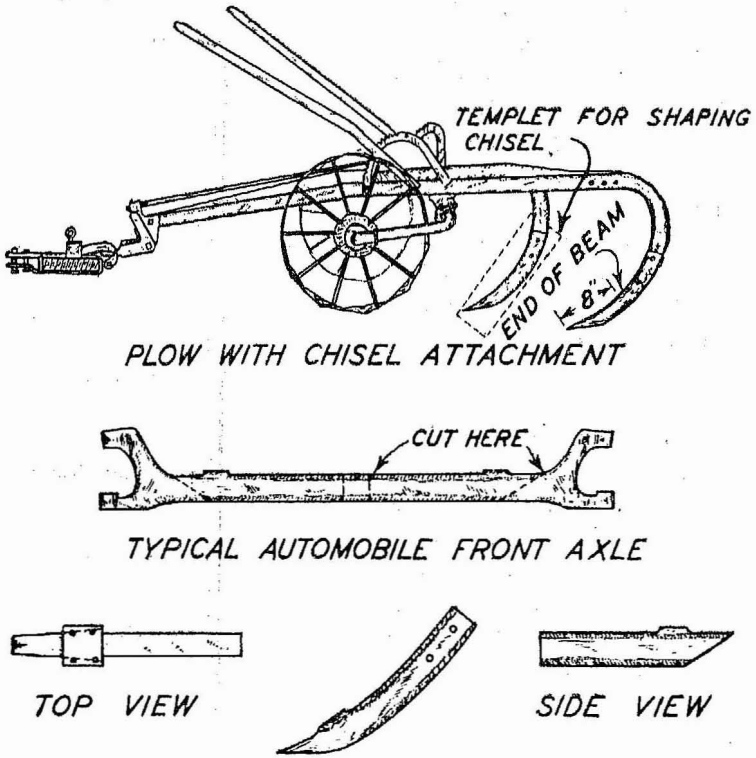


Fig. 16—Homemade deep tillage chisel.
(Courtesy Experiment Station, Idaho University).

Buck Scraper

For short hauls and small amounts of cut and fill the buck scraper may be used to advantage. The buck scraper is made of 2 — 2x12-inch planks fastened together as shown in Fig. 17, and shod on the cutting edge with a steel blade. The two upper views

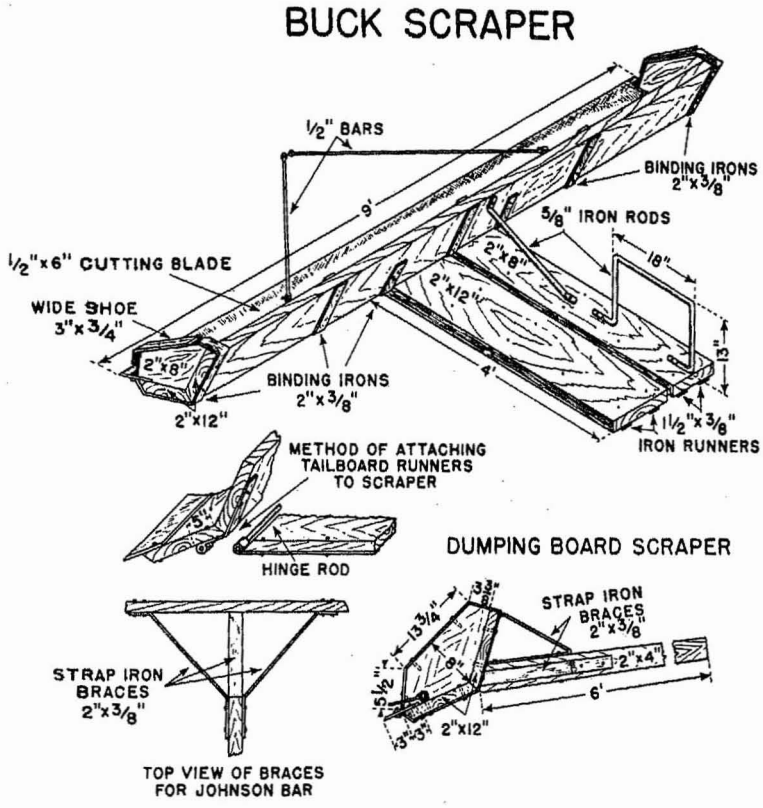


Fig. 17—Buck scraper.

show the tailboard on which the operator stands while loading or dumping with the dumping board. The lower views show an alternate arrangement with a 2x4-inch Johnson bar level to control loading and dumping. The length of the scraper depends upon the power available.

Log Grader

The log grader may be sawed out of a log or may consist of several planks bolted together in vertical position as shown in Fig. 18. The front plank is cut to a wedge shape and bolted on with the wide edge down. To do the best work the front plank must be shod with a steel plate. It can be made in any length desired according to the power available. The platform across

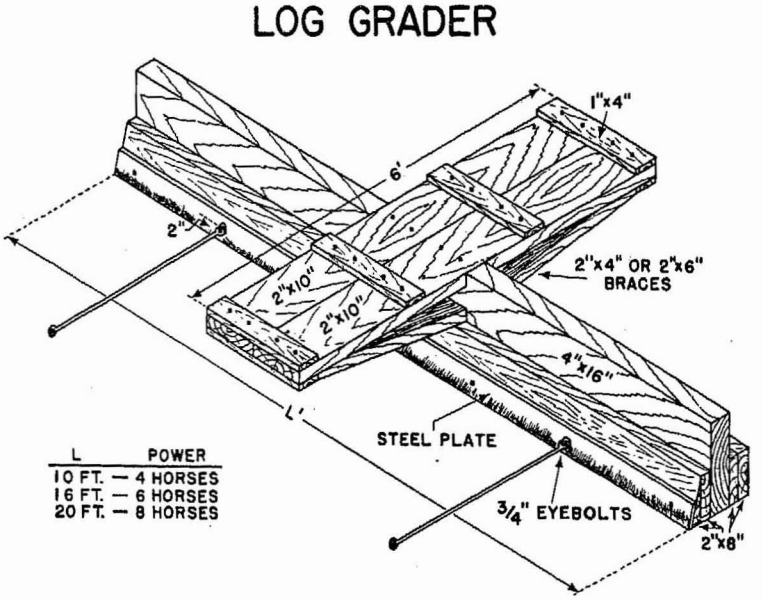


Fig. 18—Log grader.

the top serves as a control for loading and dumping. The driver steps forward to load, and backward to dump the load. This grader is best suited for short hauls. When pulled by a tractor, a 5-foot pole may be attached vertically to the platform to safeguard the operator.

Wheel Type Steel Scraper

The scraper shown in Fig. 19 is available in both tractor and horse drawn types and in a variety of sizes with steel or rubber-tired wheels. A seat is provided for the operator of the horse drawn type and the scraper is operated by foot levers. The tractor drawn type is controlled by the tractor operator. At small aditional cost, the horse drawn type may be converted into a tractor drawn outfit.

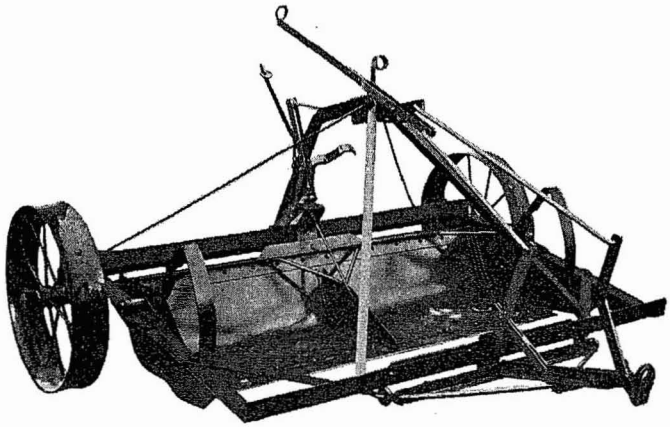


Fig. 19—Wheel type steel scraper.
(Courtesy Miskin Scraper Works, Ucon, Idaho).

The depth of cut is adjustable and the load may be dumped in one place or spread in a shallow layer. This scraper is adapted to grading, land leveling, canal work or reservoir construction. Although it does not carry its load entirely free from the ground, the wheels carry most of the load, thereby greatly reducing the draft. It works more like the Fresno scraper than the old wheel type.

Leveling

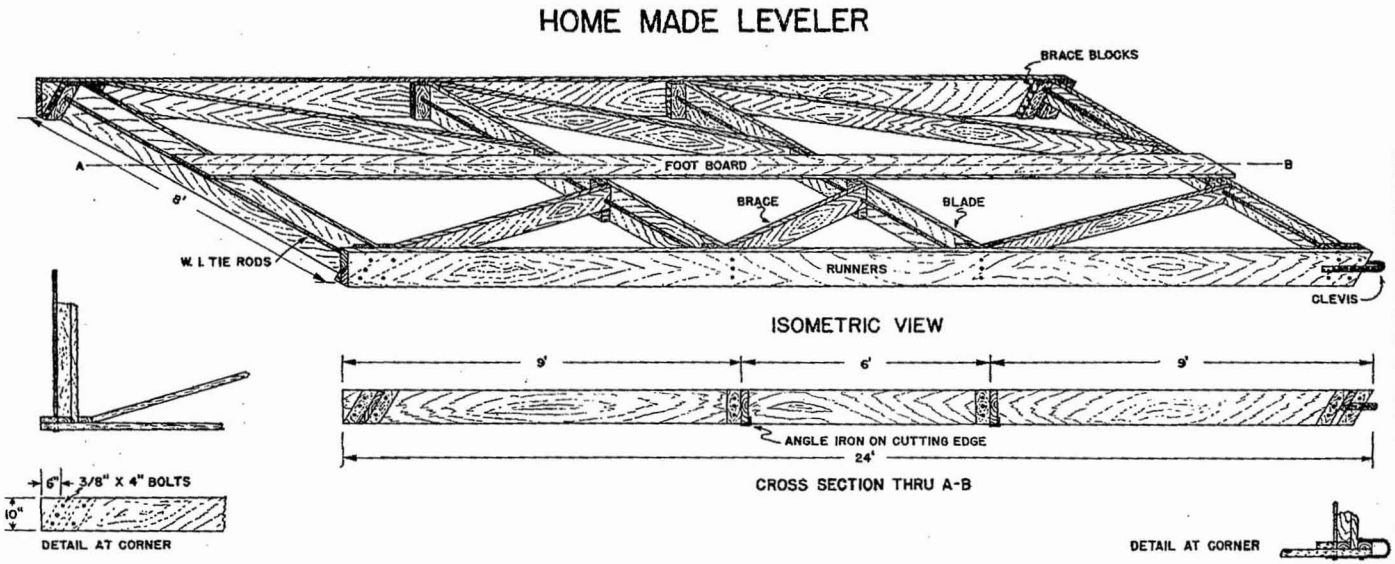
The purpose of leveling is to plane the surface and even up the small irregularities left by the plow and grader. The land must be plowed before the leveler will work to advantage. Leveling, or floating, as it is sometimes called, must be done at a time when the soil is rather dry, as it will roll up when too wet.

The leveler or float should pulverize the clods and pack the soil as well as even up the surface. Floating does not move the earth to any extent but smooths and compacts the surface. The leveler is one of the most important and useful implements in irrigation farming and should be used every time the seedbed is prepared for planting.

Home Made Leveler Or Box Float

Levelers are constructed in many forms but to do the best work they should be comparatively long—at least 3 times their width. A common size for a general purpose tractor or 8 horses is 8 feet wide by 24 feet long as shown in Fig. 20. In constructing the leveler the cross pieces are fastened at right angles to the runners. The two center cross pieces are set vertically with the lower edges flush with the bottom of the sides and shod with strap or angle iron to prevent excessive wear. The front and rear pieces slant backward at the bottom. The front crosspiece, of 2x6-inch material does not extend to the bottom of the runners and serves merely as a crossbrace. As the leveler is pulled across the field, the center crosspieces load up with dirt when crosing ridges or knolls. The dirt is carried until a low place is crossed, where it is dumped. The rear cross piece leaves the surface smooth. Adequate bracing and tie rods, as shown, are essential to hold the float rigid. Fields should be floated both ways to insure a good seedbed and a smooth surface for irrigation.

Smaller levelers are built with only 3 cross pieces, with one vertical or cutting blade located in the center. The usual size for 4 to 6 horses is 6 feet wide by 18 feet long. Larger sizes, similar to Fig. 20, are often built 30 to 36 feet in length and 10 to 12 feet in width. These larger sizes require 3x10-inch or 3x12-inch timbers.



BILL OF MATERIALS

BRACE BLOCKS	18 PCS. 2" X 4" X 10"	RUNNERS	2 PCS. 2" X 10" X 24'
FOOT BOARD	1 PC. 2" X 12" X 24'	W. I. TIE RODS	4 PCS. 1/2" X 8'6"
BLADES	3 PCS. 2" X 10" X 8'	MACHINE BOLTS	36 PCS. 3/8" X 4"
BLADE, FRONT	1 PC. 2" X 6" X 8'	CLEVIS STOCK	2 PCS. 1/4" X 2" X 30"
BRACES	4 PCS. 2" X 6" X 8'	ANGLE IRON	
BRACES	2 PCS. 2" X 6" X 7'	(FOR CUTTING EDGES)	2 PCS. 2" X 2 1/2" X 8'

COMPILED BY THE DEPT. OF AG. ECON. MONT. EXP. STA. WITH THE ASSISTANCE OF W. P. A. PROJECT NO. WP 1905-OP. 465-91-3-75.

Fig. 20—Homemade leveler or box float.

Home Made Leveler On Wheels

The draft of a home made leveler may be lightened considerably by mounting on wheels or rollers at the front, rear or both. Fig. 21 shows the use of wheels in the rear and a sled-like device in front. This leveler is built of 3x12-inch full dimension rough lumber. It is 30 feet long by 10 feet wide and well braced.

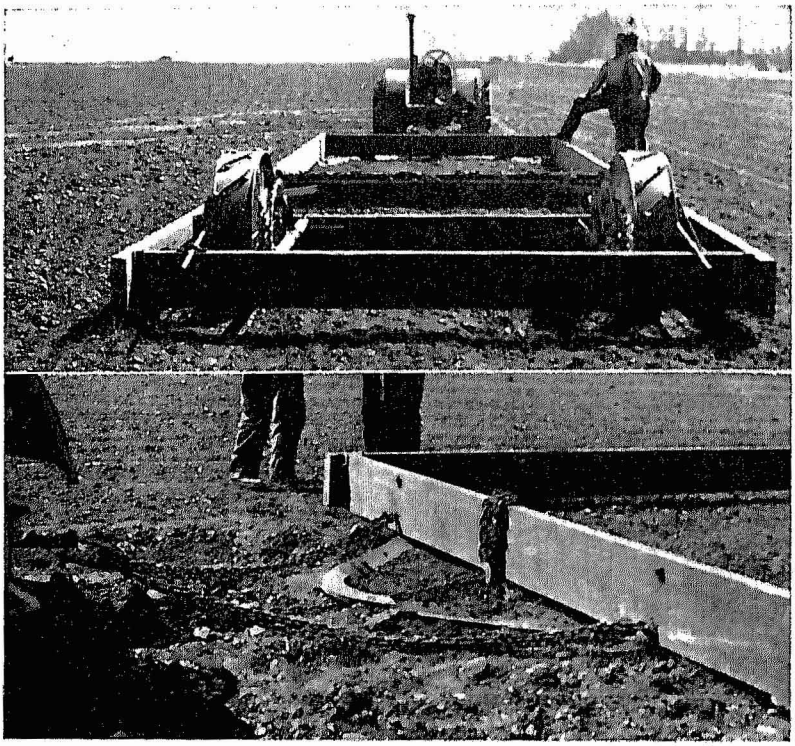


Fig. 21—Homemade leveler on wheels.
(Courtesy Hans Gaarder, Fairfield, Montana).

Right hand and left hand binder bull wheels are installed in the rear. In adition to carrying the weight of the frame they are used to raise or lower the leveler as needed in different fields or in transporting it about the farm.

A broad V-shaped steel sled or skid carries the weight of the front end. The skid is made from 2 steel bars, 8 inches wide, ½-inch thick, about 5½ feet long. These are fastened together in front (to form the blunt point of the V) by a 4-foot piece of steel of the same size, which is bent to form a quarter circle. The

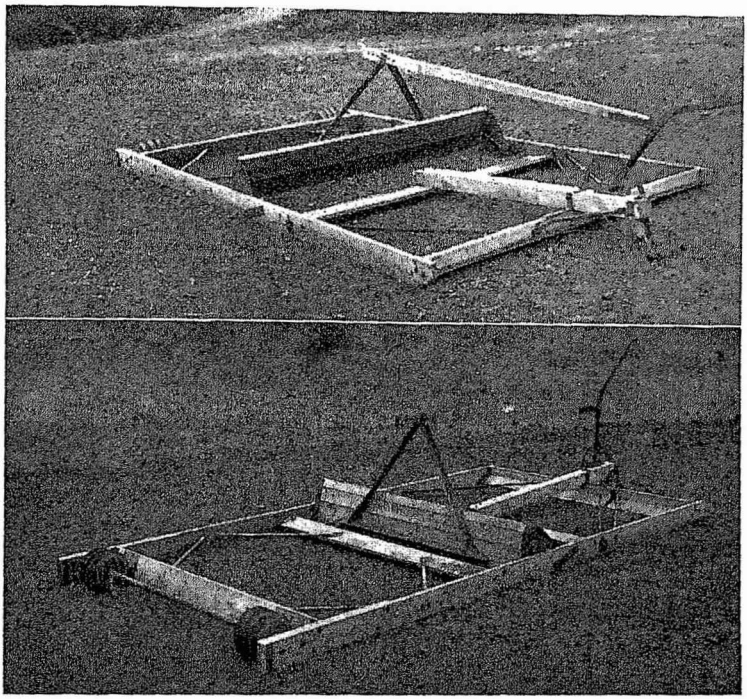


Fig. 22-a—Sidney adjustable blade leveler.
(Courtesy Holly Sugar Corp., Sidney, Montana).

2 pieces under the front corners are set at a slant of about 25 degrees from horizontal to have sled action. The nose or connecting piece, that is curved to fasten the 2 side pieces together is raised somewhat and flattened to prevent digging into the ground. The outer ends of the skid runners extend about a foot beyond the sides of the leveler.

The center crosspiece is shod with a steel edge in front and set with the lower edge about 3 inches below the side pieces. To

prevent loose dirt from being crowded out beyond the ends of the center crosspiece, pieces of sheet iron or steel extend toward the front about 18 inches, where they are bolted to the sides.

In operation the dead weight of the outfit is suspended from the front steel sled and the wheels in the rear, with only the leveling blade touching in the center. A leveler this size can be pulled easily by a 10-20 horsepower tractor.

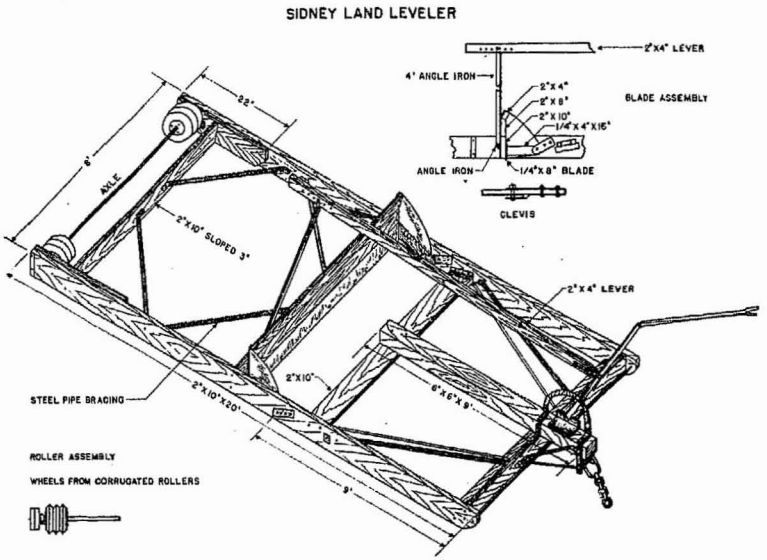


Fig. 22-b—Sidney adjustable blade leveler

Sidney Adjustable Blade Leveler

Fig. 22-a shows a home-made adjustable blade leveler that is popular around Sidney on the Lower Yellowstone project. The blade may be set to cut at any desired depth by adjusting the lever at the front. The lever assembly, taken from an old grain drill, is mounted out in front so it may be operated by the tractor driver. Light draft is assured by the rollers at the rear. The rollers are from a cultipacker. Usual dimensions are 20 feet long and 8 feet wide with side pieces of 2x10-inch timber. Fig. 22-b shows construction plans.

Columbus Adjustable Blade Leveler On Rollers

Fig. 23 shows another type of adjustable blade leveler mounted on log rollers front and rear. The adjustable blade is operated by a lever assembly taken from an old gang plow. For heavy cuts and fills the operator stands on the front platform

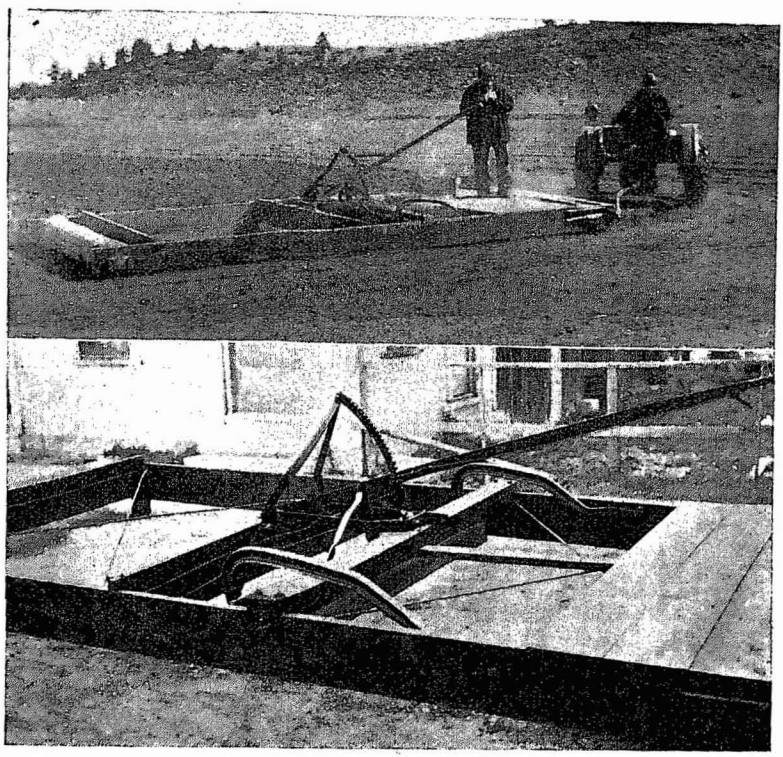


Fig. 23—Columbus adjustable blade leveler on rollers. (Courtesy C. F. Kagay, Columbus, Montana).

and operates the lever. For general leveling, the blade may be set at any desired depth. Log rollers front and rear lighten the draft. Usual dimensions are 20 feet long and 8 feet wide. Full dimension 2x12-inch rough lumber is used for the frame. Note the heavy iron reinforcing at every point of strain.

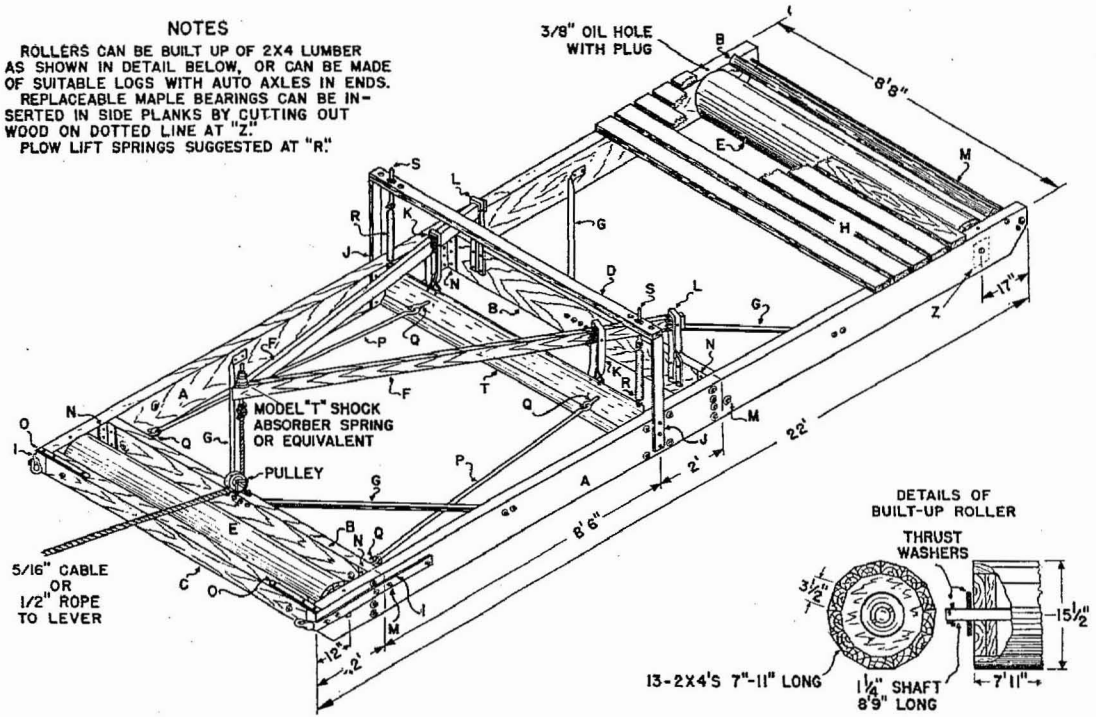


Fig. 24—Reclamation leveler float. (Courtesy Bureau of Reclamation, U. S. D. I.)

BILL OF MATERIALS

A—Side planks	2	4″x12″—22′ long
B—Cross members	3	3″x12″—8′ long
C—Cross members	1	4″x6″—8′ long
D—Cross members	1	2″x4″—8′9″ long
E—Rollers	2	14″ Diam.—7′11″ long (see note)
F—Depresser beams	2	2″x4″—11′6″ long
G—Frame braces	4	1½″ pipe—5′11″ long (bent 5″ on ends)
H—Platform boards	6	2″x6″—8′8″ long
I—Hitch irons	2	⅝″x3″—3′9″ long (bent 3″ on one end)
J—Iron for arch	2	⅝″x3″—4′ long (bent 12″ on one end)
K—Depresser irons	2	½″x2″—5′6″ long (before bending)
L—Hinge irons	2	½″x2″—4′10″ long (before bending)
M—Frame tie rods	3	¾″ Diam.—8′10″ long (ends threaded)
N—Angle irons	4	⅜″x3″x3″—12″ long
O—Strap irons	2	¼″x1½″—18″ long
P—Drag rods	2	¾″ Diam.—7′7″ between loop centers
Q—Eye bolts	4	¾″ Diam.—10″ long (6″ thread-2 nuts)
R—Blade-lift springs	2	pull type—18″ long see note)
S—Eye bolts	2	½″ Diam.—12″ long (8″ thread-2 nuts)
T—Grader blades	1	14″ high—7′11″ long

Reclamation Leveler Float

Fig 24 shows a combination grader and leveler mounted on rollers, with an adjustable steel blade. This outfit is built for a tractor. The adjustable blade may be controlled by the tractor operator or by a person standing on the rear platform.

A hoist reel, operated by hand, may be fastened on the tractor to handle the rope or cable attached to the blade lever. Catch and release devices on the reel would permit rapid adjustment of the blade.

An old wagon box type, hand operated, brake lever assembly may also be used to handle the rope to the lever. On a wheel type tractor the brake lever and ratchet is bolted to the steel wheel guards at the left of the tractor seat. The rope or cable to the leveler is fastened to the brake lever, the same as the brake rod on a wagon. To lower the leveler blade, the hand lever is thrust ahead as needed. The dirt may be dropped in one spot by releasing the lever all the way or it may be spread in a thin layer by gradually releasing the lever.

Front rollers on levelers have a tendency to bind when turning sharp corners. The use of at least 3 heavy plain steel washers on each end of the roller shaft, between the roller and the inside of the frame, will help overcome this difficulty.

Automatic Steel Leveler

Fig. 25 shows a commercial type of land leveler, that is built in several sizes depending on power available.

In operation, this leveler rides on the V-shaped buster blade in front and the curved smoother blade in the rear, leaving the wheels free to move up and down when crossing high or low places on the ground. These wheels do not carry the weight of the machine but are for automatic control of the blade.

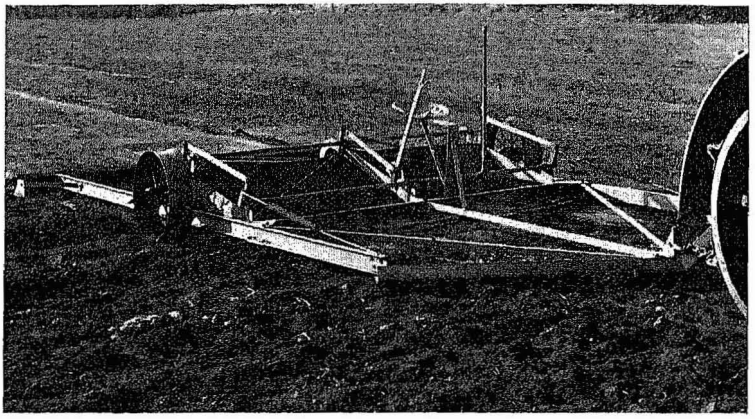


Fig. 25—Automatic steel leveler.
(Courtesy Eversman Mfg. Co., Denver, Colorado).

For ordinary leveling during seed bed preparation the Eversman is automatic and needs no operator. As the wheels rise when passing over a high place, the blade is forced downward, cutting off the excess dirt and carrying it along. When a low place is encountered, the wheels go down and the blade rises, releasing the dirt.

Heavier grading and dirt moving is possible by hand operation of the lever that controls the blade. This can be done from the tractor seat by a rope and pulley or by an operator on the machine itself.

Heavy Grading And Leveling Equipment

Wherever grading and leveling of large areas is necessary it is often more economical to hire the work done than for the farmer to purchase such equipment. Heavy power equipment used by contractors for grading and leveling includes revolving scrapers or "tumble bugs," "bull dozers," and the large "carry-alls" used in highway and reservoir construction that carry up to 30 cubic yards each load.

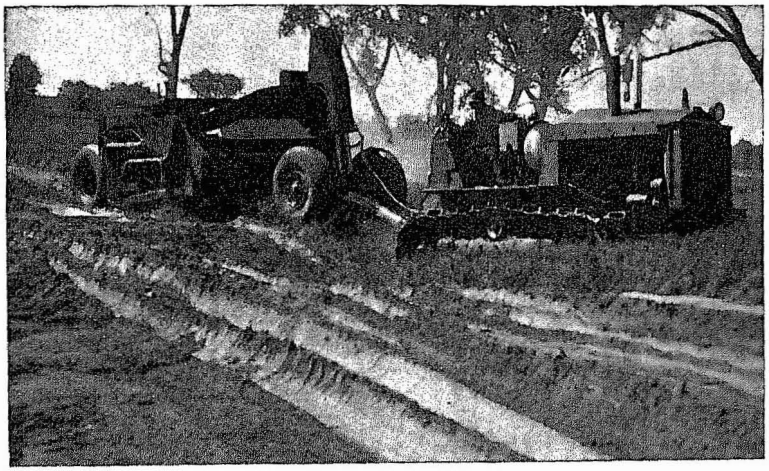


Fig. 26-a—Austin Western Scraper.
(Courtesy Empire Equipment Co., Billings, Montana).

Grading and leveling with such large outfits can be handled on a daily rental basis for the use of the equipment, with the farmer purchasing the fuel and paying the wages of the operator. Often the contractor does only the rough grading, and the farmer finishes the leveling and installs the distribution system.

Figs. 26-a—26-b—26-c show types of heavy dirt moving machinery being used in grading and leveling land for irrigation in Montana.

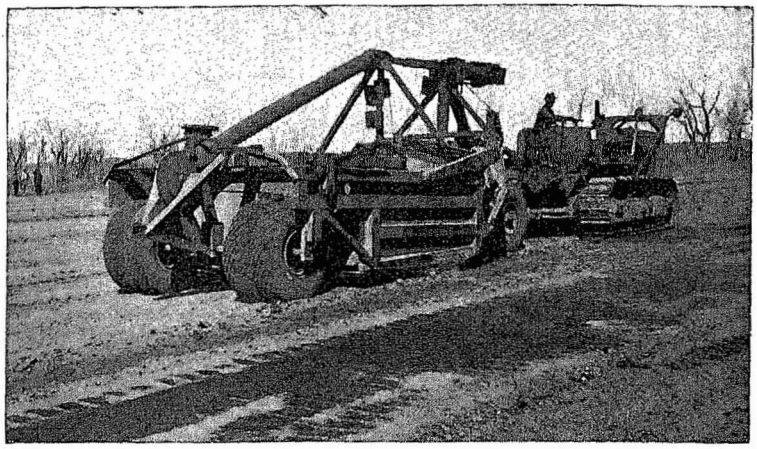


Fig. 26-b—Le Tourneau Carryall.
(Courtesy Connelly Machinery Co., Billings, Montana).

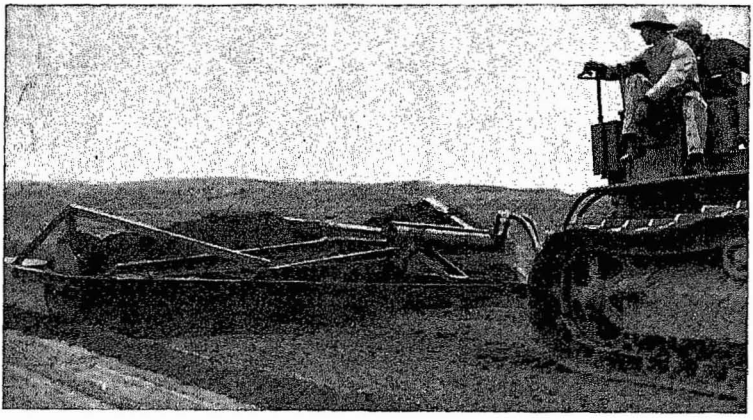


Fig. 26-c—Towner hydraulic land leveler.
(Courtsey Towner Mfg. Co., Santa Ana, California).

DITCHERS

The simplest type of small ditch consists of a single plow furrow. A better one is made by plowing a furrow with a lister plow. Such ditches may be enlarged by cleaning them out with home-made or commercial ditchers. Fig. 27 illustrates the use of single blade V-type home-made ditcher used in cleaning out a contour ditch in an alfalfa field. The frame is of 2x10-inch planks shod with iron or steel on all cutting edges. The hinged wing blade is adjustable.

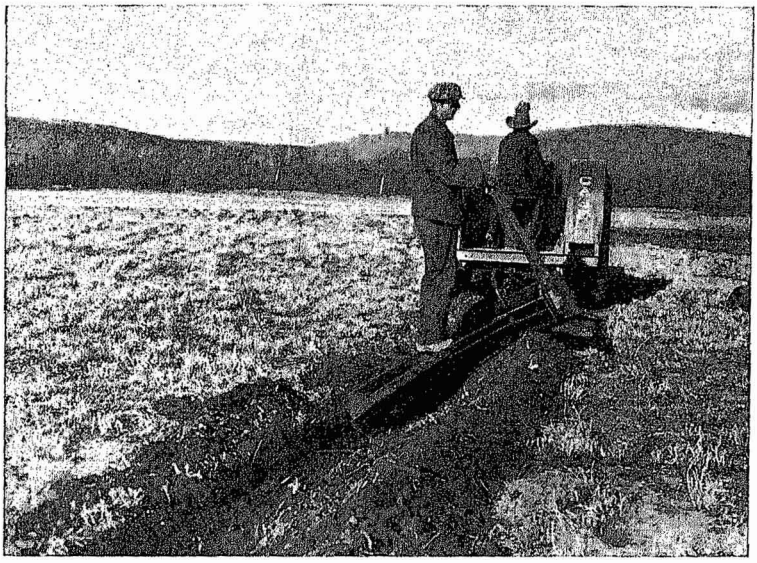


Fig. 27—Huntley homemade ditcher.

Fig. 28 shows the construction details of a home-made ditcher of the single blade, V-type with a plow wheel to support the blade. Where the wheel is not used, a handle should be attached to the wing blade as shown in Fig. 27.

Fig. 29 illustrates a double winged V-type ditcher that has found favor on larger farms in the Yellowstone valley. It consists of a heavy 2x12-inch plank V, covered with 20-ounce galvanized iron with angle iron cutting edges, attached to a heavy 6x6-inch beam on top and riding on a 4x4-inch beam on the

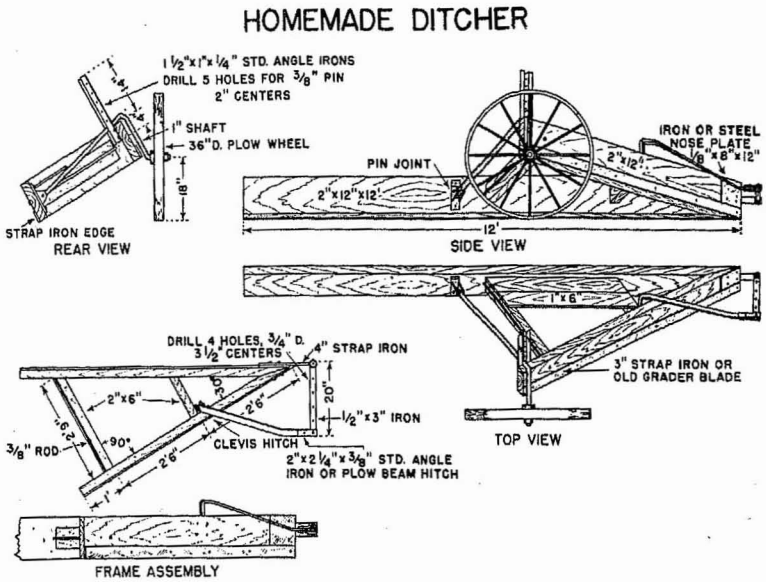


Fig. 28—Homemade ditcher with wheel.

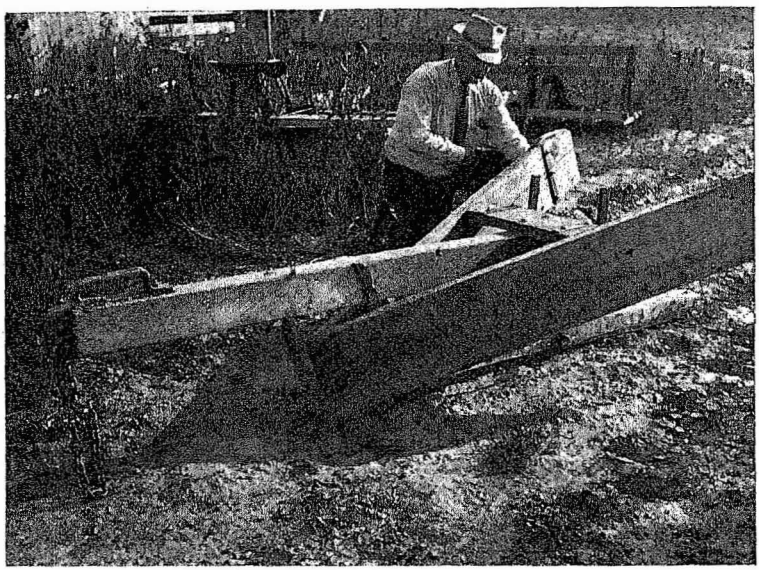


Fig. 29—Double-wing ditcher.

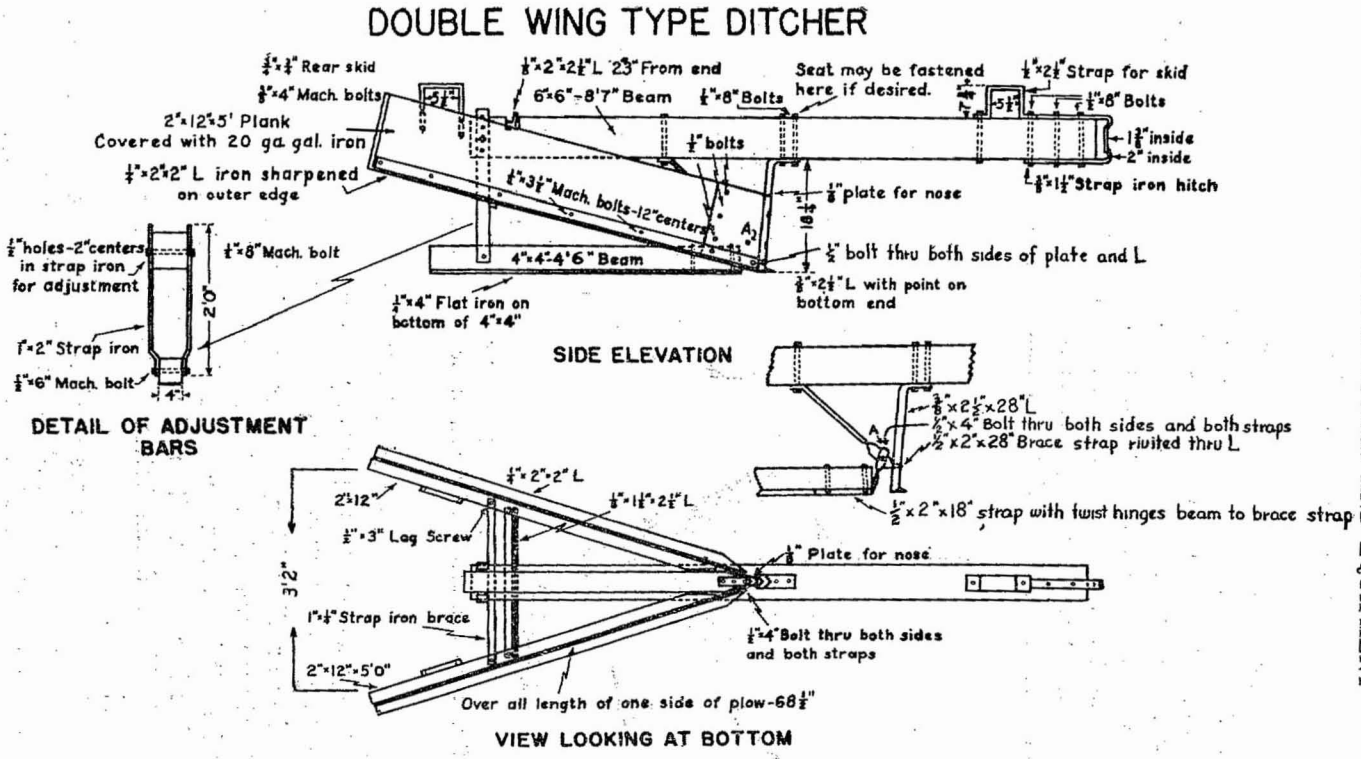


Fig. 30—Double wing ditcher.

bottom. The V-shaped wings are stationary but the depth is adjusted by changing the position of the lower beam, at the rear. On grain, corn or beet fields, this ditcher completes a ditch with one trip, no previous plowing being needed. On hay fields, a chisel or plow is sometimes pulled in front of the ditcher to loosen the soil to the desired depth. This ditcher makes a good load for a 20 to 30 horsepower crawler type tractor. Fig. 30 shows plans for constructing a double-wing ditcher.

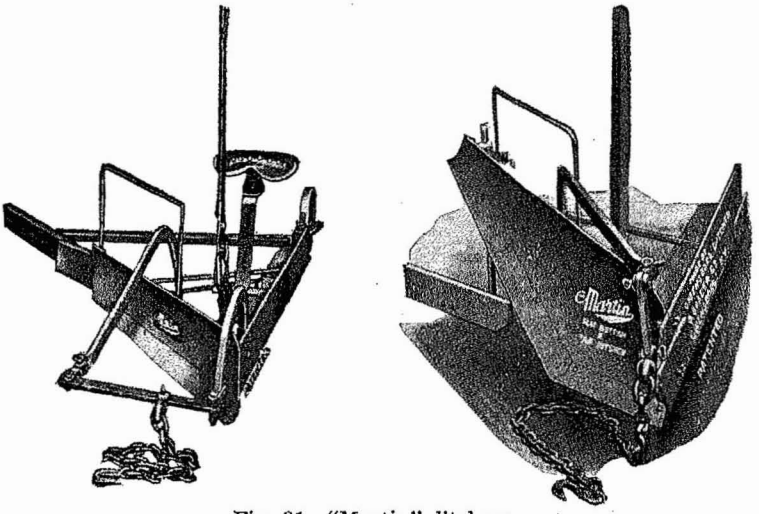


Fig. 31—"Martin" ditchers.
(Courtesy Owensboro Ditcher and Grader Co., Owensboro, Kentucky).

Commercial Ditchers

The ditcher at the left side of Fig. 31 is an improved model of the V-type steel ditcher. It makes a V-shaped ditch. It may be used in building dikes, terraces, grading roads as well as for constructing new ditches and cleaning out old ones.

The ditcher shown on the right side of Fig. 31 is shaped somewhat like a plow. It is adjustable for cutting ditches with V-shaped sides and flat bottoms. These ditchers are available in several sizes.

Fig. 32 shows two more steel ditchers. The one at the left is of the V-type and is fully adjustable as to depth, slope of bank, width and shape of ditch. As shown, the ditcher is set

to make a flat bottom ditch. However, the blade may be adjusted to build a V-shaped ditch.

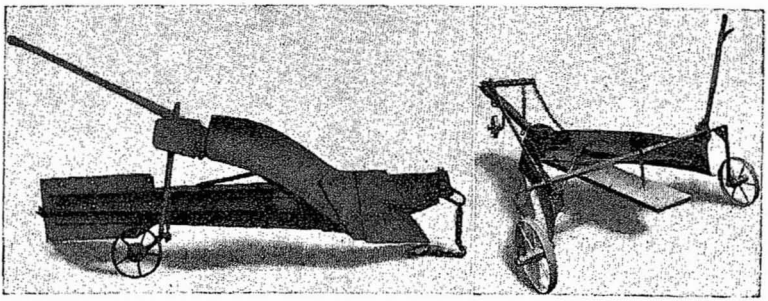


Fig. 32—"Chattin" ditchers.
(Courtesy Olson Mfg. Co., Boise, Idaho).

The ditcher on the right is a double wing type, fully adjustable. The broad half round point makes a flat bottom ditch. The double wings complete both banks of the ditch at the same time. Both ditchers shown in Fig. 32 are available in several sizes.

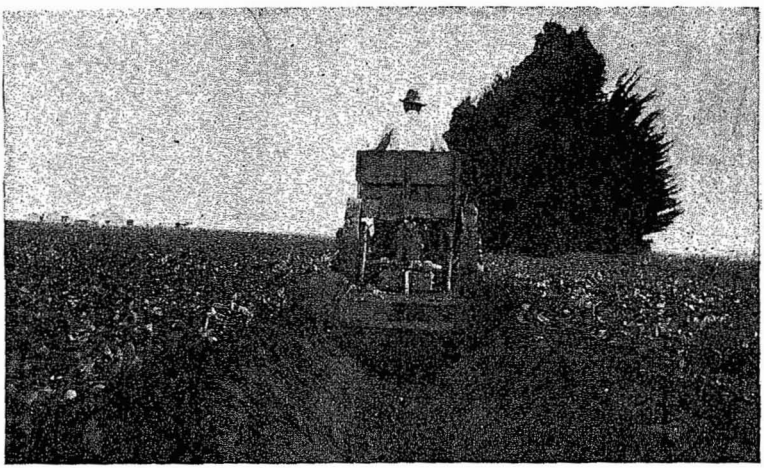


Fig. 33—Round bottom lateral made by ditcher.
(Courtesy Killifer Mfg. Co.)

Fig. 33 shows a large round bottom lateral being constructed complete with both banks after only one trip through. This ditcher resembles a large lister shovel with wing extensions.

DIKES AND DIKERS

Dikes for the border method of irrigation or for flood irrigation may be made in a variety of ways depending on the equipment available.

Constructing Border Dikes With Plow And Ditcher

For the border dike method, the field is first graded and leveled as uniformly as possible. The dikes are then located by marking with stakes so they may be made straight and at the proper distance apart.



Fig. 34—Plowing backfurrow for border dike.

Construction of the dikes begins with plowing a back furrow as shown in Fig. 34. Note that a space nearly 3 feet wide is left unplowed between the furrows. This space is the foundation of the dike.

One or two round trips are then made with a V-type ditcher, shoving the dirt over the unplowed foundation to form the dike as shown in Fig. 35. This makes a broad, firm dike 8 to 10 inches high and about 8 feet wide. Larger or smaller dikes may be made by increasing or decreasing the number of plow furrows in the back furrow.

Shoving the dirt up with a ditcher leaves a depression or borrow pit on each side of the dike as shown in Fig. 35. If these are not completely filled so that the field is level laterally between dikes, the water will collect near the dikes and run down the borrow pits instead of spreading uniformly across the strip between the dikes.

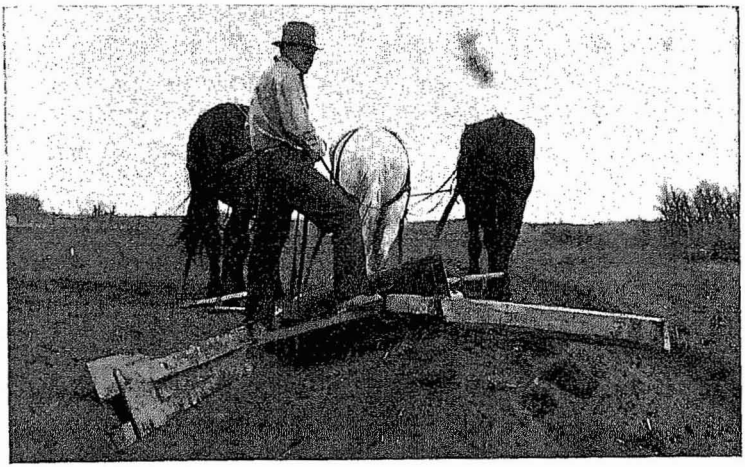


Fig. 35—Constructing border dike with ditcher.

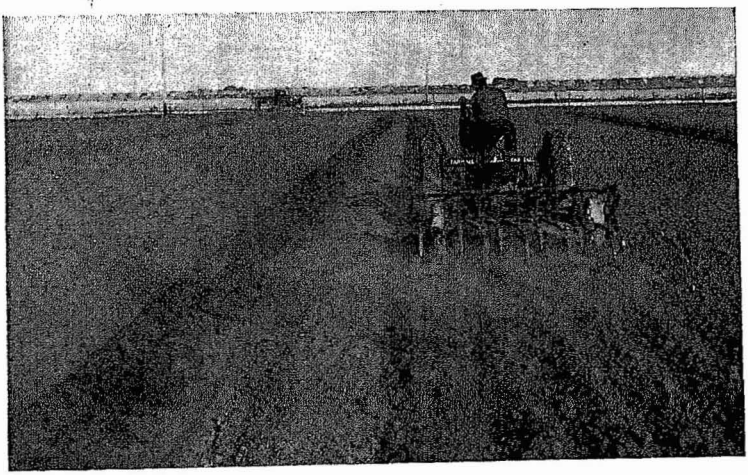


Fig. 36—Leveling borrow pit along border dike.

Fig. 36 shows a method of filling the borrow pits. After the dike was completed 2 plow furrows were turned against the dike, followed by the springtooth harrow.

Sometimes the dikes are constructed before the field is plowed. Then the entire strip between each pair of dikes may be plowed as a land. The resulting dead furrow in the center of the land may be filled by plowing it in with 2 or 3 furrows. Regular seed bed preparation will complete the leveling of the entire strip.

Building Dikes With Disk Ridger

Another way to make the foundation of the dike is with a disk ridger, or short 4-foot disk, like the one shown in Fig. 37. A round trip is made along the line of each dike. This piles up moist earth sufficient for the V-ridger to make a dike of good proportions.

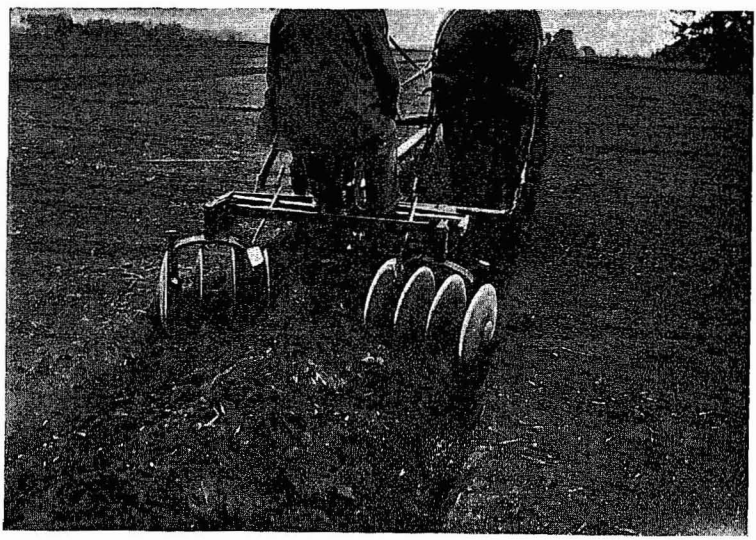


Fig. 37—Four-foot disk ridger for making border dikes.

RIDGER FOR BORDER DIKES

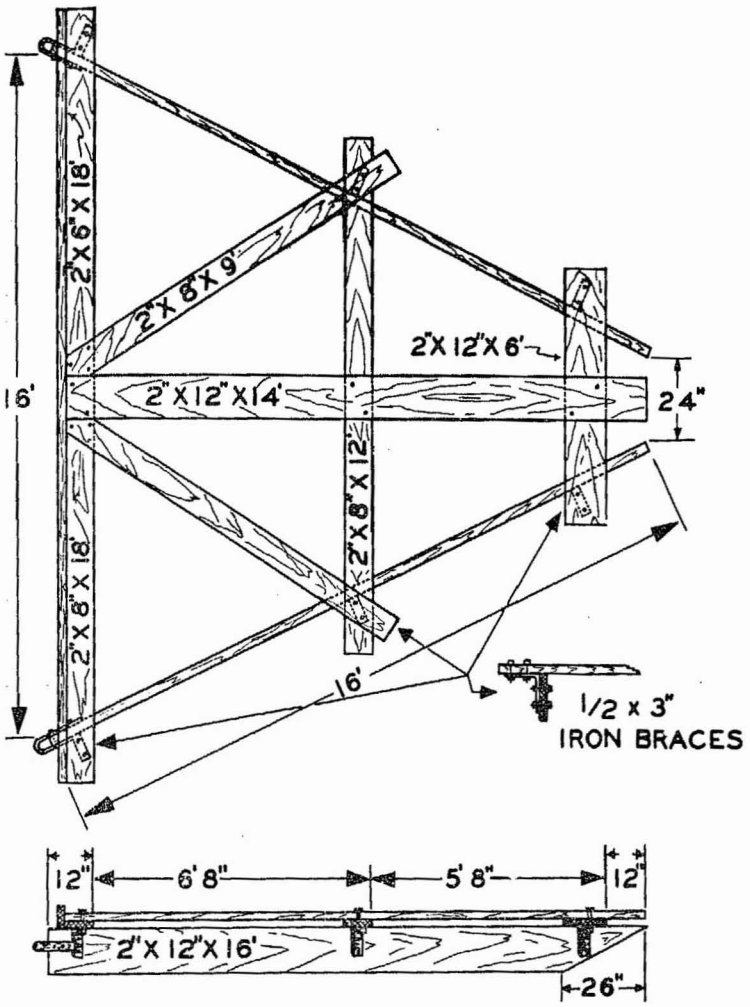


Fig. 38—Ridger for finishing border dikes.

Ridger For Border Dikes

Another way to finish border dikes after the foundation has been prepared with a plow or disk ridger, is to draw a home made implement called a ridger along the dike to smooth it up, and fill the furrows on each side. This home-made implement is shown in Fig. 38. The extreme width in front is to gather a shallow layer of earth from a wide area to fill up the furrows or borrow pits.



Fig. 39—Building border dikes with buck scraper.

Building Border Dikes With Scrapers

Another practical method is to build the foundation of the dike with a scraper, then shape it up with a ridger and pack it down well with a packer. Fig. 39 shows how a buck scraper may be used in dike building.

After the dikes have been staked out, a furrow is plowed to mark the location of the dikes. The scraper is then driven across the field at right angles to the dikes, skimming the dirt between dikes and dumping a load at each dike crossed, as shown in Fig. 39.

If the field is rough, the earth to build the dikes may be taken from the high places within the border strip, instead of from the entire area.

This method leaves no borrow pits along the dike to fill up later, and the ridger (see Fig. 38) can be cut down to one-half the size shown since its only function becomes the smoothing and finishing of the dike.

A Diker-Ridger

An attempt to complete the dikes in one operation has resulted in the design of a home-made diker-ridger shown in Fig. 40. It is well adapted to the construction of larger erosion control dikes or terraces.

It consists of a right-hand and left-hand unit connected with chain hitches which are flexible and adjustable. By connecting the two units in this way the side thrust on one overcomes that on the other, and the energy is all employed in the useful work of cutting and moving soil up the side slopes of the dike.

Number 11, Fig. 40, shows the cutting edges. They were made of 4x4-inch angle iron 10 feet long, but lighter metal could be used. The parts numbered 12 are the blades to which the cutting edges are attached. These push the soil up the sides of the dike. They were made of 2x12-inch lumber, 20 feet long. Parts numbered 13 are the outside members of the framework, made of 2x12-inch lumber 18 feet long. Underneath the rear ends of these members iron shoes may be attached to prevent excessive wear. Parts numbered 14 are cross braces designed to take compression loads and are made of 2x6, 2x8, or 2x10-inch material. The shorter members may be of 2x6-inch lumber, but the longest ones which are 8 feet long should be made of 2x10-inch lumber. The tops of the members numbered 14 should be set flush with the tops of the main members (12 and 13) to avoid their cutting the soil uselessly and preventing their being split or broken by loose rocks which might roll under them. Parts numbered 15 are ½-inch iron rods designed to take tensile stresses and to hold the framework together.

The adjustable hitch chains are indicated by 16, 17, and 18. It is upon the manner in which these chains are adjusted that the successful and economical operation of the diker largely depends. If a tractor-implement hitch is available, the chains 16 and 17 do not need to converge at a common point as indicated in the figure. Parts 19 are the shoes attached underneath the

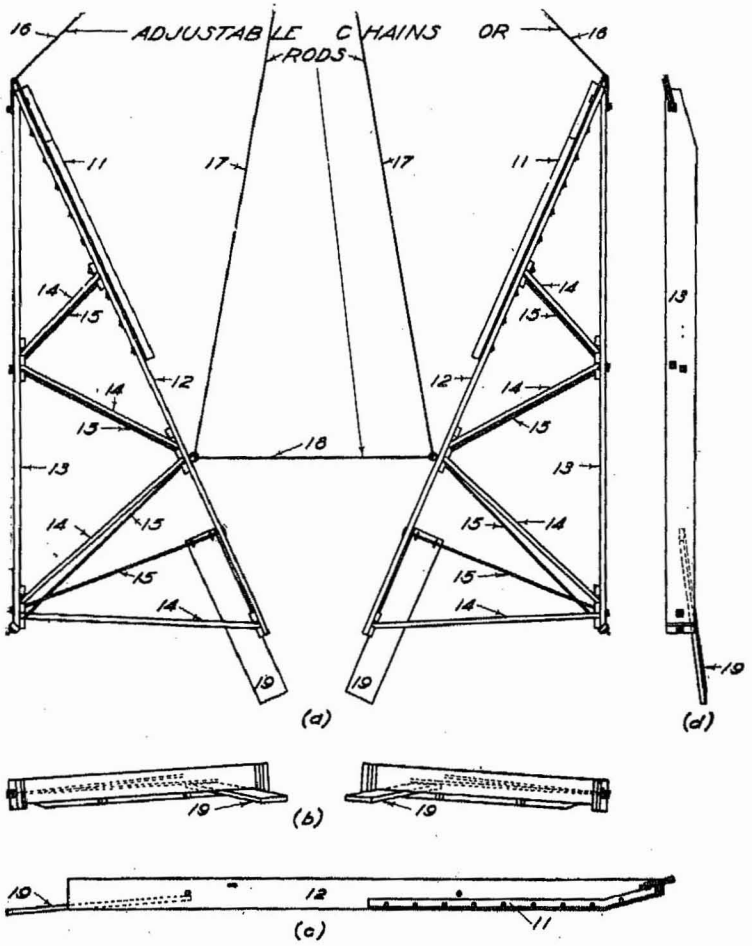


Fig. 40—Design of double A. or M. diker-ridger.

inside rear corner for holding up that corner to permit the soil that has been cut by the forward cutting edge and moved toward the middle of the dike to escape along the slope.

In using the diker on the first trip, chain 18 is made long enough so the parts, 13, will run at the extreme width of the proposed cut for the dike and the cutting edges will move the soil from this width, as shown in Fig. 41. The chains, 16 and 17, must be lengthened to give the proper width to the front end and to give penetration to the cutting edges. On each succeeding trip, hitch 18 is shortened to bring the members closer together.

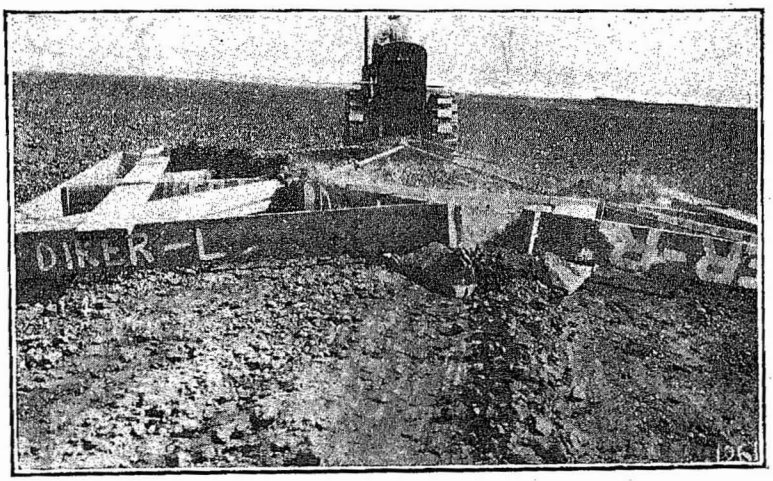


Fig. 41—Rear view of diker-ridger on first trip through.

The amount of this shortening depends upon the width and height desired for the finished dike and upon the number of trips necessary to finish the dike. At the same time that 18 is shortened, hitch members 16 and 17 must also be shortened a proportionate amount.

Shortening hitches 16 will lift the front end of the diker and cause shallower cutting. Lengthening 17 also will reduce the depth of cut. When it is necessary to make a sharp turn or when it is desired to transfer the diker without moving soil, 16 may be hooked up very short or 17 may be dropped. For ease

in adjusting the hitches it is well to have a supply of chain hooks that can be hooked into any portion of the chains to shorten them.

By starting the first cut at the extreme width of the dike and narrowing the diker after each trip, the soil is gradually worked toward the middle of the dike and no energy is lost in moving the soil in the wrong direction and bringing it back again. Also, by starting on the outside of the dike it is not necessary to move soil into holes from which the other soil has been moved toward the center, as would be the case if the work were started near the middle of the dike. In this arrangement the load is balanced and no side draft comes on the tractor, thus permitting it to travel near the middle of the dike and pack the soil. When

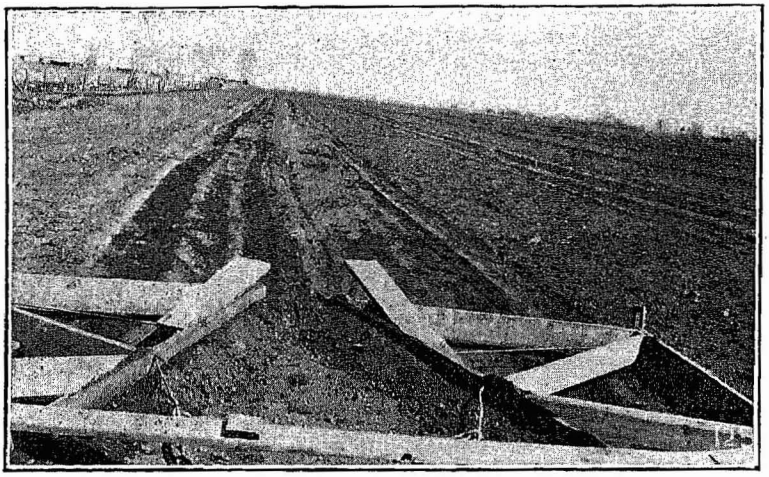


Fig. 42—Diker-ridger constructing border dike. Shoes have been removed from the bottom of diker.

the dike is finished, it will have been packed by the tractor so that there will be very little later settling.

The implement also can be used to build border dikes for irrigation as shown in Fig. 42. By removing the shoes, (see 19 in Fig. 40) the soil is pushed up in a ridge instead of being distributed along the sides and making a gently sloping dike.

FURROWERS AND CORRUGATORS

The furrow or corrugation method of irrigation is used for irrigating alfalfa, grain and other field crops, as well as for gardens and orchards. It consists essentially of irrigating in small furrows which generally run down the steepest slopes.

For orchards, berries, potatoes, cabbage and corn, large lister type furrows or small ditches 6 to 8 inches deep and 30 to 48 inches apart are used to spread the water. Somewhat smaller furrows are used for beans, sugar beets and other root and vegetable crops. Regular irrigating shovels of various sizes are available for cultivators.

HOME MADE CORRUGATOR

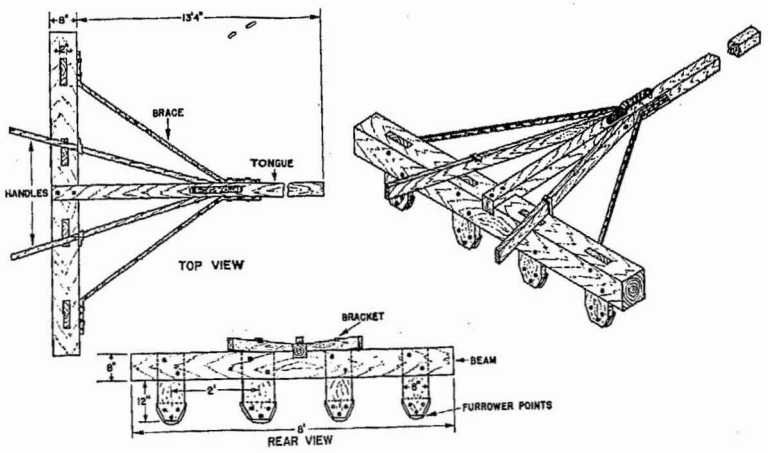


Fig. 43—Marker type corrugator.

BILL OF MATERIALS

Beam	1 Pc. 4″x4″x14′	Handles 2 Pcs. 1½″x4″x5′	
Tongue	1 Pc. 8″x8″x8′	Braces 2 Pcs. ¼″x1¼″x6′ (iron)	
Furrowers	4 Pcs. 2″x8″x20″	Bolts and lag screws as needed	

Furrower points—4 old steel discs cut to shape

For alfalfa, pasture, grain and peas, the furrows are about 4 inches deep and spaced 2 feet apart. A beet cultivator with irrigation shovels attached is widely used.

Fig. 43 shows a marker type of corrugator. It is built like an old-fashioned marker, except that flat pieces of disk steel are

bolted to each marker to aid in penetrating hard ground. This type is used in renewing the corrugations each season on alfalfa fields in areas where it is necessary to keep them open year after year.

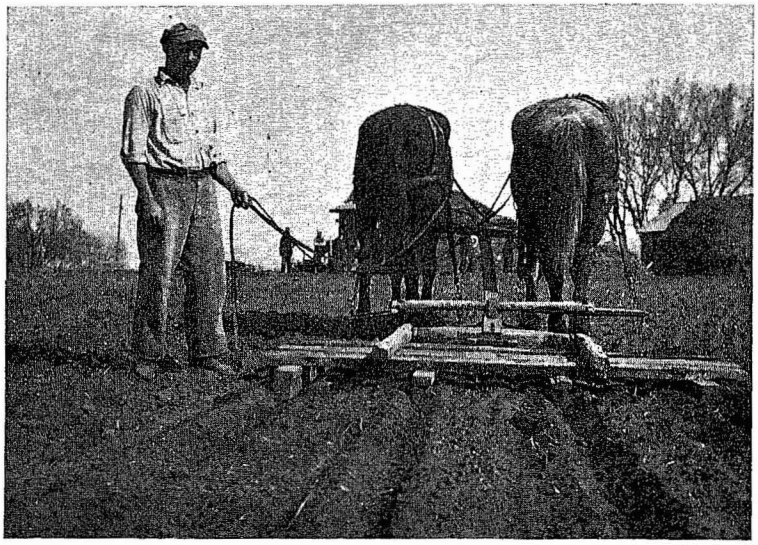


Fig. 44—Sled type corrugator.

As an aid to irrigating up alfalfa, pastures, small grains and field peas, the sled type shown in Fig. 44 is often used. It consists of 4x4-inch or 4x6-inch runners 4 to 6 feet long, to which a plank platform is nailed. Six-inch poles are also used for runners. Corrugations should be installed immediately after the crops are seeded.

LATH TURN OUT BOXES

Wherever corrugations are maintained year after year, on steep lands subject to erosion, and especially when ditches are new and fields have been planted for the first time, small pipes or lath turnout boxes are used to distribute the water from the

ditches into the corrugations. These spouts may be made by nailing four laths together or cutting short sections of iron pipe. The spouts are made in lengths of 2 to 3½ feet. Fig. 45 shows a field being irrigated with the corrugation method in which the water is regulated through lath spouts placed at intervals in the ditch bank. On flat land one spout is needed for each furrow. On steeper lands a single lath box spout will supply enough water for 2 or 3 furrows.

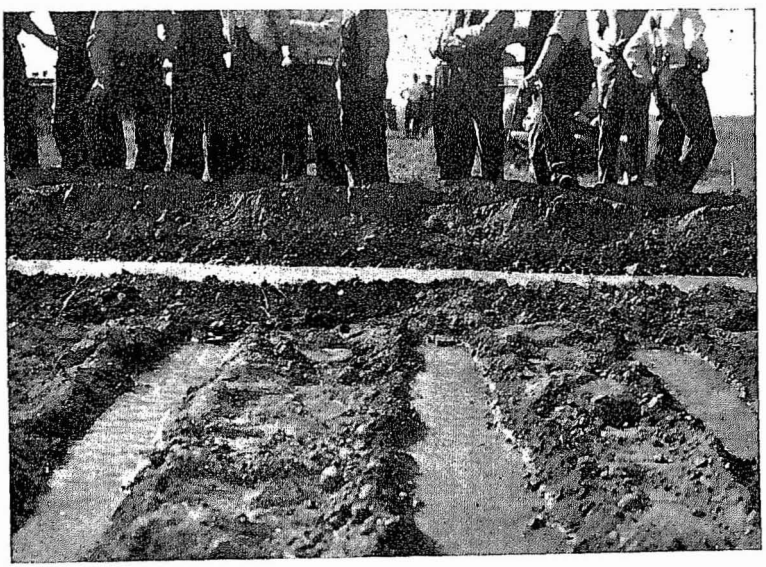


Fig. 45—Lath turn out boxes distribute water to furrows.

LEVELS AND SURVEYING EQUIPMENT

To apply the irrigation water with the least trouble and expenditure of time, the ditches should be run to the proper grade; and weirs, headgates, checks, turnouts, and other devices should be properly installed before the water is ready for the ditches. To accomplish this requires the use of levels.

Home-Made "Cricket' Level

A practical home-made device used for surveying ditches with a uniform grade is the "cricket" level shown in Fig. 46. It consists of a straight edge 16½ feet long, equipped with well-braced legs 3 feet long. A carpenter's level rests in a small frame in the middle of the straight edge and is adjusted so that the level bubble is in the center when the device stands on level ground. When used to locate a ditch, a small block of wood is fastened to the bottom of one of the legs to allow for fall in the ditch.

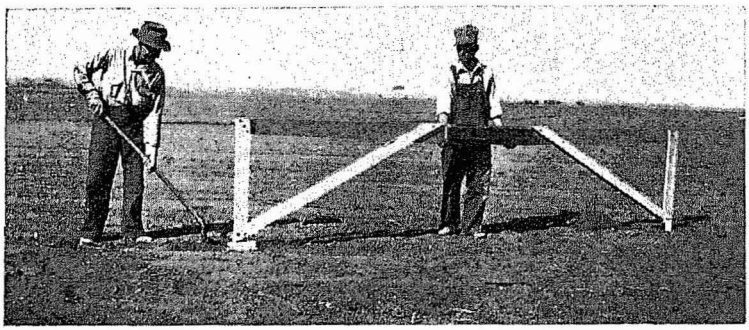


Fig. 46—Surveying contour ditches with "cricket level."

The top board or straight edge of the cricket shown in Fig. 46 was cut from a pine board 1½ inches thick and 8 inches wide. Pine is both light and rigid. The ends were tapered to about 4 inches and the center to about 7 inches in width to reduce the weight. The legs are 1x4-inches x 3 feet long. Four braces, 1x3-inches x 7 feet pieces were used, a pair on each side to prevent warping. The grade block was bolted edgeways to the side of the bottom of the leg to provide the proper grade and also to prevent the leg sinking into soft soil. A tomato can was nailed on the bottom of the other leg to prevent it sinking into the soft soil.

A 5/8-inch block will give about 0.3-foot fall per 100 feet and a 3/8-inch block, which is the thickness of a lath, will give 3/8-inch fall per rod or nearly 0.2 foot per 100 feet. Table I, gives the size of block to use for different grades.

TABLE I. THICKNESS OF BLOCK FOR DIFFERENT GRADES FOR 16½-FT. "CRICKET" LEVEL

Thickness of block and grade in inches per rod	Approximate Grade		
	inches per 100 feet	feet per 100 feet	feet per mile
3/8	2¼	.19	10.0
½	3	.25	13.3
5/8	3¾	.32	16.7
¾	4½	.38	20.0
1	6	.50	26.6

When locating a contour ditch, the operator places the device with the short leg 2 or 3 inches below the water surface in the head ditch and swings the other end around until the bubble in the level comes to the center, with both legs resting on the ground. A helper marks the point by driving a small stake beside the longer leg or else turns up a shovelful of dirt. The "cricket" is then carried forward placing the short leg beside the stake or shovelful of dirt, swinging the other end around until the bubble returns to the center, and so on, repeating the process across the field.

A ditch so located conforms to the warped surface of a field in a series of easy bends, and water will flow in it with uniform velocity. Contour ditches are made with a grade of 0.2 to 0.4 foot per 100 feet or from 3/8 to 3/4 inches per rod. The most common grade is 0.25 foot per 100 feet or ½ inch per rod. A flatter grade is desired for ditches designed to carry more than 2 cubic feet per second. Small ditches carrying smaller streams require steeper grades.

A grade of 3/8 inch per rod or 0.2 foot per 100 feet is the minimum for which the "cricket" is reasonably accurate. This limits the use of the "cricket" to the steeper lands where all ditches may be given a grade of 0.2 foot per 100 feet or more.

The "U" Tube Level

Faster work can be done with the "U" tube level shown in Fig. 47 than with the "cricket" level, but grades with less than ½-inch fall per rod or 3 inches per 100 feet should not be attempted with such an instrument. The level shown in the cut is a patented instrument and was designed by a Montana man. It consists of two ¼-inch pipes connected with water gages and mounted on a convenient form or tripod. The legs of the tripod are attached to a sleeve or collar that moves freely up or down the vertical rod. The vertical rod has a ball and socket connection with the flat circular base. When the "U" frame is screwed onto the vertical rod, the instrument rotates freely. The pipe is filled with liquid until it rises about half way in the glasses When the instrument is set up, the surface of the liquid in both glasses will be at the same elevation regardless of whether the instrument is exactly vertical or not. Prestone was the fluid used in the instrument shown in Fig. 47.

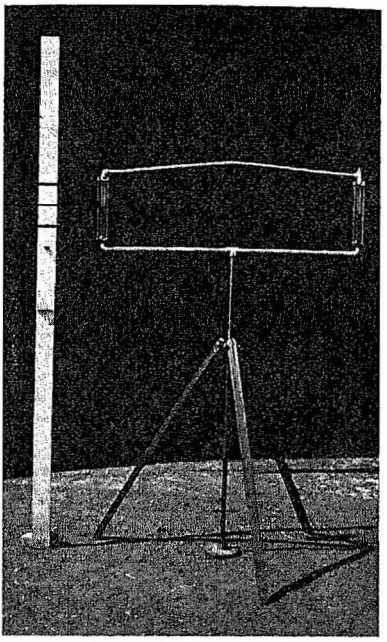


Fig. 47—The "U" tube level and rod. (Courtesy O. A. Hammer, Valier, Montana).

The "U" tube level is used in connection with the rod as shown in Fig. 47. Set up the instrument and the rod on a level floor, filling up with liquid until the liquid level shows exactly at the height of the center mark on the sighting staff. Be sure the gaskets are tight, allowing no liquid to escape from the water gages.

To run a contour ditch on grade, set up the instrument where the ditch is to start, with the round base resting on the ground 2 or 3 inches below the water level in the supply ditch. Have the

rod man pace off 100 feet in the direction which the water is expected to run. The level man points the "U" frame at the rod, steps back about 18 inches and sights along the side of a level line connecting the top of the liquid in both glasses. He directs the rod man to move the rod up or down hill until the liquid level line of sight is level with the heavy black line above the center line of the rod. The rod man then sets a stake at this point or turns up a shovelful of dirt. The levelman then moves forward to this point and sets up the level while the rodman paces off the distance along the proposed ditch to another point which is located in the same manner.

The heavy black target lines on the rod in Fig. 47 are spaced 3 inches from the center line or line of sight. If readings 100 feet apart are taken as outlined above, it will give a downhill grade of 3 inches each 100 feet. On rough fields, additional readings may be taken, 33 or 50 feet apart without moving the instrument, by reading a point ⅓ or ½ the distance up from the center to the top mark. The back of the rod is graduated in inches. A regular surveyor's rod and target may also be used.

In running a grade **down hill,** remember that the line of sight is directed to the line **above** the center. Where it is desired to run the ditch line up hill read the proper grade interval **below** the center line on the rod.

Use Of The Surveyor's Level

Running a contour ditch grade with a surveyor's level requires two persons, the instrument man and the rod man. The level is set up about 300 feet out from the head ditch down the side of the field and a little above the elevation where the first contour ditch is to be taken out, so that when leveled, the telescope or line of sight is 4 or 5 feet above the proposed turn out. When using a small farm level the length of sight should be limited to 200 or 300 feet each way from the instrument. Fig. 48 shows a farm level and a surveyor's rod often used in laying out farm ditches.

The rodman places lower end of the rod 2 or 3 inches below the water surface in the head ditch or turnout box, care being taken to have the rod plumb. The levelman sights through the

telescope and reads the figure on the level rod intercepted by the horizontal cross-hair. For example, assume that the cross-hair intercepts the figure 4.8 feet. Then the target is set at that figure which is the initial reading. (Surveyors' level rods are usually marked off in feet and tenths of a foot, being easier to read and calculate than one marked in feet and inches.)

If the grade of the ditch is to be 0.2 feet per 100 feet, a stake is placed or a shovelful of dirt turned up to mark the spot. The rodman then paces approximately 100 feet from the starting point in the direction the ditch is expected to go and sets the target at 5.0 feet which allows 0.2 foot fall. The rod is then held up by the rodman for a reading. If the target center is **above** the horizontal line of sight of the cross hair in the telescope the rod is too high and should be moved down hill slightly until the cross hair of the telescope intercepts the center of the target. Conversely, if a reading shows the target **below** the line of sight it should be moved uphill until the center of the target and the cross hairs intercept each other. The proper rod readings may be made by the instrument man without the aid of the target, but faster progress is made if the rod man sets the target for the proper reading at each point.

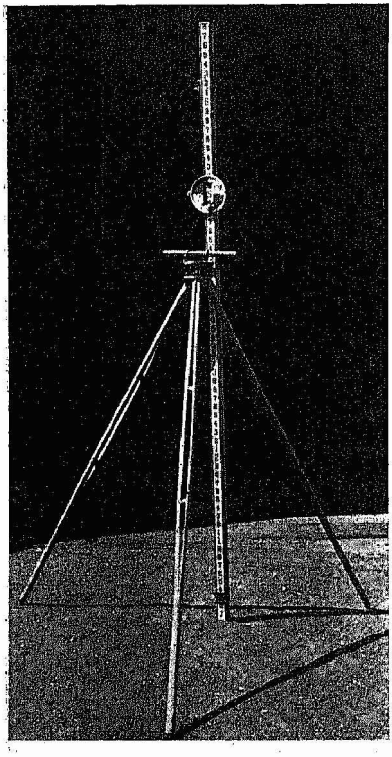


Fig. 48—Farm level and rod.

For station two, 100 feet farther ahead, the target is moved up 0.2 feet to 5.2, indicating a fall of 0.2 feet from the last station. This operation is repeated for each 100 ft. station until a point about 300 feet beyond the level is reached, when the instrument

must be moved ahead. Then set up and level the instrument and take a back sight on the rod which has remained at the last point established. The target is now set on a new reading corresponding to the height of instrument again. If for example, the new reading is 3.4, the station 100 feet ahead must read 3.6 ft., the next 3.8 ft. and so on.

When running a grade line down hill, the target is moved **up** for succesive stations. Where a grade line is run up hill the target is moved **down.** In locating a level grade line, the target remains constant.

Proper Grades For Farm Laterals

The typical farm lateral as made with a plow and ditcher is usually run on a grade of about 0.2 foot per 100 feet. Where it is necesary to keep the ditch "up" to reach some certain point, or on heavy clay soils, flat grades as low as 0.1 foot per 100 feet may be used. On the other hand, ditches with grades of more than 0.3 foot per 100 feet are subject to serious erosion where the soil is light. The flat grade is desirable for ditches designed to carry more than 2 cubic feet per second. Small ditches require steeper grades. Table II on this page gives the carrying capacity of farm ditches at varying depths at grades of 0.1 and 0.2 foot per 100 feet. Ordinary V-type ditches carry considerably less water than these sizes.

TABLE II—CARRYING CAPACITY OF FARM DITCHES

Depth in inches	Cross section —sq. ft.	Velocity—feet per second		Discharge in cubic feet per second	
		Grade .001 or .1 ft/100	Grade .002 or .2 ft/100	Grade .001	Grade .002
		Bottom width of ditch 2 feet			
9	2.06	.80	1.15	1.65	2.36
12	3.00	.96	1.38	2.88	4.14
15	4.06	1.10	1.57	4.46	6.38
18	5.25	1.24	1.75	6.50	9.20
21	6.56	1.35	1.92	8.85	12.60
24	8.00	1.46	2.03	11.70	16.20
		Bottom width of ditch 3 feet			
9	2.81	.88	1.24	2.47	3.48
12	4.00	1.06	1.47	4.25	5.88
15	5.31	1.20	1.70	6.36	9.02
18	6.75	1.34	1.90	9.05	12.82
21	8.31	1.44	2.04	11.98	16.92
24	10.00	1.58	2.26	15.80	22.60

TEMPORARY DAMS FOR FIELD DITCHES

Temporary dams of dirt, straw, manure, canvas and metal are used to divert the water from field laterals onto the land.

For small ditches that are plowed out with a lister or cleaned out with a wooden crowder, a series of dirt dams are often constructed from 25 to 50 feet apart with a "dammer" as shown in Fig. 49. It consists of a 24-inch disk bolted onto a walking lister

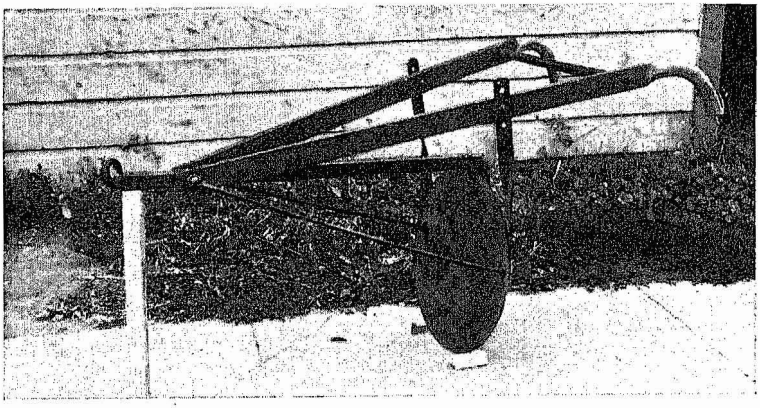


Fig. 49—The "disk dammer."

frame. It is pulled by one horse in the ditch channel and wherever a dam is needed the operator lifts up on the handles which leaves a dirt dam in the ditch. Old straw, or manure is often hauled out and placed in such ditches to check and spread the water. Such systems, however, are a waste of both time and water and should be replaced by contour ditches or border dikes as far as possible, which will permit the use of larger heads of water.

The Use Of Canvas Dams

The canvas dam is indispensable. Each irrigator should have several. They are made from 12 to 20-ounce canvas, and should be about 4 feet wide and 6 feet long, but may be larger for larger ditches. The 6-foot side is fastened to a 10-foot 2x2, a 2x4, or a pole, either by nails through a lath, or by sewing a large hem through which the stick or pole may be inserted. This makes it possible to withdraw the pole and fold the canvas when not in use. Heavy burlap will also make a satisfactory dam.

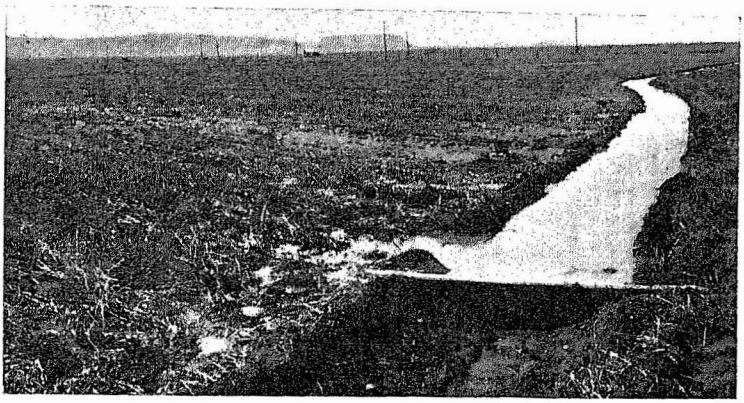


Fig. 50—Diverting water from contour ditch with canvas dam.

Fig. 50 shows a canvas dam used to divert water from a contour ditch to the land. The dam is usually put in place before the water reaches the point of diversion and is laid in the ditch with the canvas extending up stream and the pole spanning the ditch and resting on each bank. Some earth should be thrown on the edges of the canvas to hold it in place. With two dams on each lateral, one may be placed while the water is spreading from the one above. Canvas dams will last much longer if cleaned, dried and placed under cover after each irrigation.

Fig. 51 shows a sleeve type of canvas dam. The sleeve is 3 to 4 feet long and about 10 inches in diameter. The quantity of water flowing through the sleeve is regulated by the draw cord at the outlet end. This type of dam makes it possible to check water onto the land and at the same time permits some to flow through the sleeve to lower sets. It is particularly suited to the irrigation of row crops.

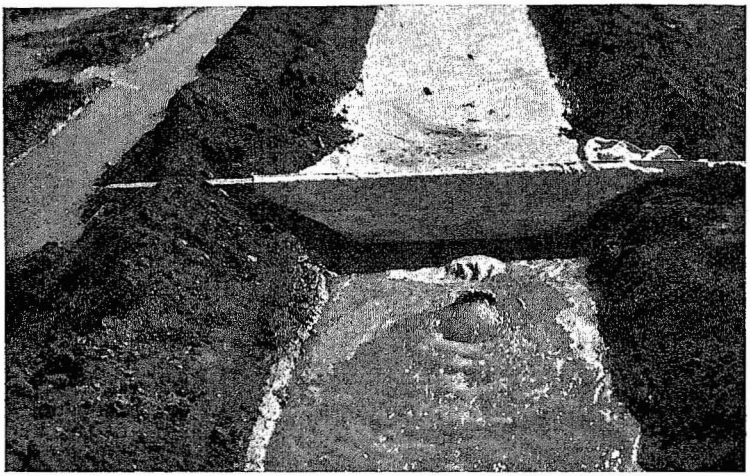
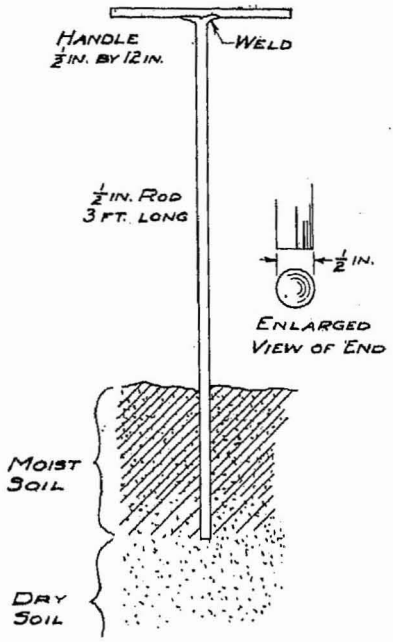


Fig. 51—Sleeve type canvas dam.

Portable metal dams are used successfully for small ditches in soils that do not erode readily. They consist of a half circle or triangle-shaped piece of heavy gage galvanized iron or steel, reenforced across the top and usually with a single metal peg through the center that sticks into the bottom of the ditch.

SOIL MOISTURE PROBER

The depth to which the soil should be filled with water during irrigation depends upon the kind of crop, whether deep or shallow rooted, as well as whether annual or perennial, and the stage of growth. Moisture requirements for annual crops are relatively light early in the season and tend to increase as the plant grows. Perennial crops such as alfalfa and pastures require rather uniform amounts of water throughout the growing season according to the depth of the root system.



MOISTURE PROBER
(COURTESY BUREAU OF RECLAMATION)

Fig. 52—Soil moisture prober.

The soil moisture prober shown in Fig. 52 is helpful to determine the depth in the soil to which moisture has penetrated during or just after irrigation. With a little pressure the probe can be pushed through moist soil, but cannot be pushed through dry soil.