UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

EQUIPMENT

for

GAGING STATIONS FOR MEASURING RIVER DISCHARGE

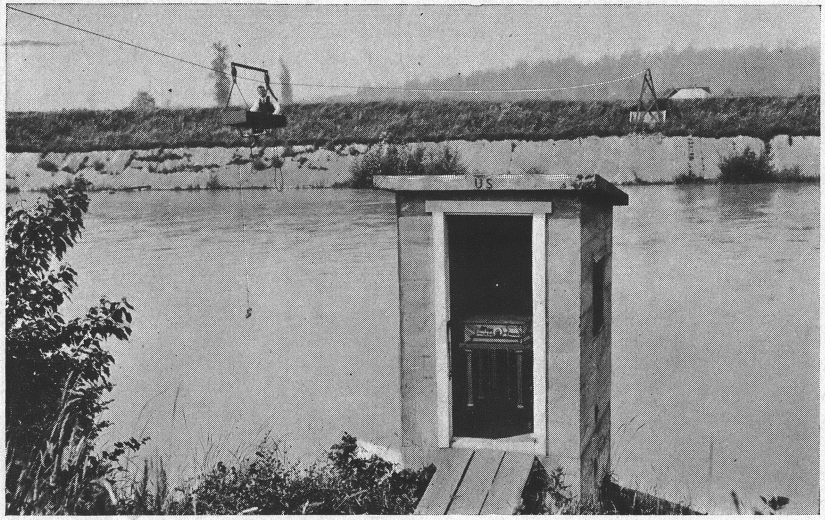
PLANS AND SPECIFICATIONS

for

REINFORCED CONCRETE WELL AND SHELTER FOR WATER-STAGE RECORDERS

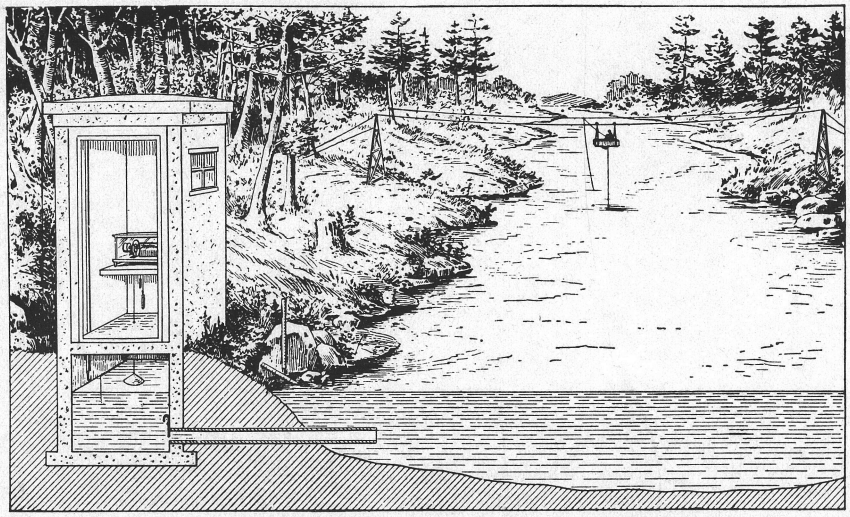
Arranged by Lasley Lee

1925



PUYALLUP RIVER, PUYALLUP, WASH.

Recorder shelter, cable tower, and standard gaging car.



TYPICAL STATION.

Recorder shelter, cable tower, and standard gaging car.

NIMISHILLEN CREEK, NORTH INDUSTRY, O.

Recorder shelter.

PLANS AND SPECIFICATIONS FOR REINFORCED CONCRETE HOUSE AND WELL FOR WATER-STAGE RECORDERS.

Introduction.

Success in operating a water-stage recorder will depend primarily on the installation which must include (1) a house or shelter to protect the recorder; (2) a well for the float, connected with the body of water whose stage is to be recorded by an intake pipe or other opening or openings to insure the maintenance of the same stage in the well as in the water outside; (3) staff or other nonrecording gages for use in setting and checking the recorder and in comparing the stage in the well with the water outside; and (4) permanent bench marks for use in maintaining the datum of the gages.

The Water Resources Branch of the Geological Survey is now operating approximately 800 river measurement stations equipped with water-stage recorders. In the installation and operation of these stations certain standard types of houses and wells have been developed that can readily be adapted to meet most requirements. Among these is a standard reinforced concrete installation which has been found especially satisfactory for general use.

In localities subject to severe winter conditions special precautions must be taken in the selection of the location of the well and in its construction to prevent, if possible, the water in the well from freezing. In such localities it is desirable to place the well back far enough in the bank that the water in the well, at the usual winter stages, will be below the frost line in the surrounding ground.

In localities not subject to severe winter conditions, the well should be so located as to eliminate, if possible, the intake pipe which is always a source of trouble due to silt which destroys the constant relation between the water in the river and the well.

A door in the side of the well below the floor and as near the ground as possible is a great convenience in cleaning out silt and in the reading of the well gage. In heavily silt-laden streams, such as the Colorado and others in the arid States, great difficulty is experienced in keeping the gage well clear of silt and for such streams it has been found advisable to install a series of doors, one above the other, so that the silt can be readily removed at any level. In cold climates it will be necessary to make a close fitting door and weather-strip it to keep out the cold air.

It is expected that modifications in the new designs may be necessary in certain instances. Before making such changes, however, the engineer in charge should be sure that the changes are made to suit the local conditions, and are an improvement over the standard plans.

Ventilation.

Proper ventilation of house and well and proper weather-stripping of floor and cupboard are necessary to prevent excessive moisture from rising from the well into the house and interfering with the operation of the recorder.

Requirements for ventilation vary widely in different localities. In humid climates the houses must be provided with large openings for ventilation. In many arid localities the houses must be practically air tight to exclude dust. Three general rules are: (1) The well should be ventilated at the top to remove vapor rising from the water; (2) the house should be ventilated at top and bottom to remove any vapor that may rise through the floor; and (3) the floor and cupboard should be as tight as possible to prevent vapor rising from the well into the house, as any plan of ventilation will prove ineffective if the floor and cupboard are not tight.

Ventilators should be placed on two opposite sides of the house and should take advantage of the prevailing wind direction. The holes in the shelf and top of cupboard for the float and weight cables or tapes should be as small as possible. They should be covered with small pieces of felt weather-strip in such a manner that the cables or tapes will operate freely but that as little vapor as possible will rise through the holes. The felt may be saturated with heavy oil to prevent it becoming watersoaked and freezing. Free air space beneath the instrument is desirable in order that any vapor that may rise into the house may be diffused and not pass directly into the instrument case and corrode, gum, or freeze upon the clock, the pencil leads, and other working parts and also soften the record paper or freeze upon it.

During very cold weather the humidity of the outside air is low. Therefore proper ventilation of the house will prevent condensation on the recorder if a tight floor and cupboard have been provided to prevent, as far as possible, the more humid air of the well from rising into the house. Ventilation of wells used in cold climates is a difficult problem. It is usually desirable to shut and seal the ventilators during the winter.

Electricity is practically the only means of successfully warming the well to prevent ice formation. Kerosene lamps do not throw enough heat downward to prevent freezing. Float cylinders are usually installed to prevent interruption of the record by freezing of the water in the well. The float rests upon kerosene in the cylinder, as described on page 10.

Foundations.

In most cases the footing shown on the plans forms a suitable foundation for the structure. The minimum thickness of footing is 8 inches. In easy excavation 2 or 3 inches more may well be added. When the structure is placed at the edge of the water or where there is danger that the soil will not bear the load, it is necessary to set the well on piles, one under each corner of the well walls. One or two additional piles should be placed under the streamward side of the well if there is danger of undercutting by the current. When piles are used, the footing need not extend beyond the well walls.

Straight-grained 6 by 6 inch pieces of durable wood free from knots will answer for such supports when only a light driving rig is available. The excavation for the well should be carried down nearly to the water surface. After the piles are driven at their proper locations, 2 by 6 inch lagging should be driven, making a rectangle a few inches larger than the outside dimensions of the well. The piles may be used for bracing and holding the guides while driving the lagging. The lagging should be pointed one side only at about a 60-degree angle with the vertical, so that when driven with the long side adjacent to the last piece driven, they will drive smugly to the last piece. The top of the lagging should be beveled to prevent splitting or brooming. A heavy wooden mall is preferred for driving the lagging. Sheet piling consisting of three 1 by 6's nailed together to form tongue and groove units may be used under adverse conditions to exclude water. Additional excavation can be carried on within the lagging and the tops of the piles should be sawed off a few inches lower than the elevation of the bottom of the well. A diaphragm pump is usually needed to keep water out of the excavation.

In selecting the location for the well use should be made of large boulders, rock ledges, bridge abutments, or other features as protection against current and debris. If the well must be excavated in solid rock it should be blasted to as near the outside size of the well as possible and the wall used for the outside form. In this case no footing is necessary. The bottom, however, should be smoothed with mortar.

When the concrete footing must be poured under water, a pipe or closed wooden chute with a hopper on the upper end should be used to place the concrete under water. In spreading the concrete the chute should not be lifted off of the concrete already poured. At the end of each batch concrete should be left in the chute above the water level and the chute forced into the soft concrete just poured.

Forms.

The forms are built of 1 by 6 inch No. 2 boards and 2 by 4's as shown on the plans. Outside forms may be made in panels, as shown on the plans, and used on several successive jobs. This method saves time and money. If the panels are used for outside forms no wiring is necessary. Blocks of 2 by 4 may be used temporarily to keep the inside and outside forms the right distance apart while the concrete is being poured.

If panel forms are not used the studding of the inside and outside forms should be crosstied every 2 or 3 feet with No. 12 annealed iron wire. The inside form boards should be nailed lightly to the studding to facilitate their removal. It is seldom desirable to build up the forms more than 4 feet in advance of the last pouring.

The location of doors and window should be carefully determined and the necessary frames set in place, plumbed, and securely fastened. The water inlet pipes, where used, may be held in place on half-inch bolts extending through the forms. They should be plugged to prevent concrete entering them. Before concrete is poured the engineer should be sure that ladder steps, gage planks, and other fixtures are in their proper position.

The house wall should be carried nearly to the top and allowed to set 24 hours before the roof is poured. The top foot of the house walls and the roof should be poured at one time. The forms should be left in place two days if possible. The side forms, however, may usually be safely removed after one day. When it is necessary to smooth up any holes or bad spots use mortar composed of one part cement and two parts sand, in order that it will set to the same color as the 1:2:4: concrete. Retempered mortar may be preferable for patching as it has taken its initial shrinkage and will hold its bond better than fresh mortar. The green concrete may be smoothed up by wetting it and rubbing with a carborundum brick.

Concrete.

The concrete should be of uniform quality, thoroughly sound, and free from voids. Great care should be used in the preparation and placing of the concrete. The best obtainable grade of Portland cement should be used. The sand should be free from lump clay and preferably of coarse grain. A fine sand requires more cement than a coarse sand for equal strength. The stone or gravel should be free from dirt. Gravel may be sufficiently uniform in quality so that the sand need not be removed, but it will usually require screening in order to insure a concrete of definite proportions.

A 1:2:4 mix should be used. One-inch stone or gravel should be specified. When gravel alone is used the mixture should be about 1:4½ provided a properly graded gravel can be obtained, otherwise screen the gravel using 3/16 or a ¼-inch mesh screen and use a 1:2:4 mix. The mixture should be just wet enough to spade well. Too much water is nearly as objectionable as too little water. An easy and accurate way to measure material, especially if a mixer is used, is by means of seven 14-quart buckets. One is filled with cement, two with sand, and four with stone. This is approximately a half-sack batch. While one batch is being mixed the buckets can be filled for the next batch.

Reinforcing.

Half-inch round deformed bars are specified throughout. Seven-sixteenths or half inch square bars may be used. The bars should be cut to the right length at the place of purchase. The bending of the bars should be done at the place of purchase, although they can be bent in the field when necessary.

The reinforcing in the footing consists of two layers of bars 2 inches from the top and bottom respectively. Each layer consists of 8 long and 9 short bars. The bars are hooked 4 inches from each end in order to develop the full strength of the bar. The vertical bars for the well walls are set in the footings. For ease in handling the first length of vertical bars are of short length. These short bars are hooked 4 inches from one end.

The reinforcing in the roof consists of one layer of 6 long and 7 short straight bars placed 2 inches from the bottom of the roof.

There are two systems of reinforcing in the walls. The first system consists of 14 vertical bars, spliced as required from the footing to the roof (except as broken by doors and window), a pair of U-shaped horizontal bars every 1½ feet from footing to floor (except as broken by well door), and straight horizontal bars every 1½ feet in the house walls. This reinforcing is placed within 2 inches of the outside of the walls, mainly to resist temperature stresses and prevent cracking. The second system consists of bars placed horizontally as close to the inside of the well walls as possible to give strength to counteract the pressure of the earth on the side walls. Four straight bars form a horizontal ring every 1½ feet from the footing to the ground level or to the floor level if desired. These bars are laid in the same horizontal plane as the U-bars. This reinforcing should be used up to the floor level where there is danger of drift striking the exposed well.

In general the centers of the bars should be placed 2 inches from the forms. They should be overlapped 2 feet for bond. The horizontal bars in the walls are usually laid on top of the fresh concrete at the proper level. Bars may be wired together with No. 18 or stove-pipe wire where convenient or necessary.

Intake.

The plans show a 4-inch intake 3 inches above the footing and one or more small inlet pipes above the ground level. In silt-laden streams the intake should be at least 6 inches above the footing to allow for more silt accumulation. If there is a probability that the intake pipe will be filled with silt, during high water, a second intake pipe should be installed at a higher level to insure a connection with the stream until the stage is low enough to permit the cleaning out of the lower intake pipe.

All intake pipes should have a threaded end extend at least an inch into the well to permit installation of valves, etc. The 4-inch pipe may be fitted with a reducer, a close nipple, and a gate valve, when it is necessary to reduce the surge or to fill the well with water to flush the intake.

Intakes of 2-inch pipe are also in general use. This size is particularly desirable when a force pump is to be installed for use in removing silt.

A strainer should be placed on the streamward end of the intake pipe. A stock footvalve with the valve flap removed makes a satisfactory strainer.

Gages.

The gage in the well is the gage which is rated. It may be a staff or a hook gage. The outside staff gage is used mainly as a check on the inside gage and to determine whether or not the intake is functioning properly. Enameled gage scales are used for practically all vertical staff gages. They may be cut to any desired length by means of a hacksaw. As slight errors have been found in the graduations of the enameled scales, it is necessary in installing them to use a steel tape stretched the full length of the gage and to set the center of each scale at the correct elevation. Round-head brass wood screws, 3/4-inch No. 9, are used.

Well gage.-If a staff gage is installed, it should be set on the side of the well on which it can be read most conveniently and checked with a level from the outside. The possible installation of a float cylinder to prevent interference from ice in the well should be considered in placing the gage. The gage plank should be of durable wood, well painted. It may be set inside the forms in order that the scale may be flush with the concrete, as shown on the plans, or it may be bolted to the wall after the forms are removed, by means of bolts set in the concrete with the threaded end projecting the exact thickness of the plank.

A simple form of hook gage consists of a movable staff, graduated to feet, from 0 downward, with a hook at the bottom, the staff being arranged to slide against a 1-foot New York level-rod scale, which is screwed to a base and is graduated to hundredths of a foot, from 0 upward. The stage is determined by drawing the point of the hook to the surface of the water and reading on the movable staff the foot mark that is opposite the fixed scale from which the tenths and hundredths are read. The material required is as follows:

One $\frac{3}{4}$ by 3 inch pine rod of proper length, tapered at bottom. (Length of rod should be equal to distance from bottom of well to zero on reading scale.)
One set (6) standard Z-lugs, with $1\frac{1}{4}$-inch No. 9 brass screws.
One window catch with screws.
One standard hook with brass screws.
One standard scale with screws and washers.
One piece cypress, chestnut or similar durable wood, 2 x 6 inches of proper length. (Length of bed piece should be 18 inches more than length of rod in Item 1.)
Machine bolts, $\frac{1}{2}$ by 6 inches, as required.

The location of the hook gage inside the well depends upon depth of well and amount of light and visibility at the water surface. For a shallow well where the water will not be more than ten feet below the recorder, it is generally desirable to place the hook gage at the front of the well where it can be read by one standing on the floor of the gage house or on the ladder steps and in this case the scale should be placed above the floor. If the well is deep, it may be better to place the hook gage on the opposite side from the door in order to obtain greater visibility, and in a deep well the scale can be placed below the floor if desired. However, it is generally more satisfactory to have the scale above the floor and to place a window catch in a convenient place against the rod below the floor so that the hook can be set and rod clamped from below the floor and the reading taken from above the floor. This arrangement removes the reading scale from the injurious effects of water vapor in the well.

In the construction of concrete gage wells, the anchor bolts for bed piece of hook gage should be set in the concrete when it is placed and consist of $\frac{1}{2}$ inch by 6 inch bolts, projecting 3 inches from face of concrete, outer ends threaded. These anchor bolts to be set in pairs 4 inches on centers horizontally and 4 feet between pairs vertically. For depths of well greater than 16 feet where two sections of bed piece are required, additional anchor bolts should be set so that a pair of bolts will be 3 inches each side of

joint. For timber gage wells, the bedpiece can be attached to the sides of the well or to horizontal crosspieces placed not farther than 4 feet apart, using ½ inch bolts or lag screws for making the connection. The bed piece should consist of a piece or pieces of 2 by 6 inch cypress, chestnut or other timber not likely to decay quickly or to warp. In setting bed piece care should be exercised to see that it is set plumb; if well sides are not truly vertical shims can be inserted between face of concrete and back of bed piece. It may be necessary to use longer anchor bolts if well sides are very irregular.

After the bed piece is set, the scale can be attached at whatever elevation is most convenient for reading, the right hand edge of scale being set 1½ inches to left of center of bed piece. Determine with the level the elevation of the zero point on the scale, referred to gage datum. The rod should be of pine or a similar straight grained non-warping timber ¾ inch by 3 inches in size, with the hook set in the middle of the face at one end, bottom of hook one inch back from end of rod. In graduating rod, square-off from point of hook to face of rod and from this point on rod measure with a steel tape a distance to zero of rod equal to the elevation of zero of reading scale. If gage datum has been so taken that elevation of bottom of well represents a positive quantity, it will, of course, be unnecessary to have top of rod extended to the zero graduation but may end at the reading corresponding to elevation of bottom of well. By holding the steel tape so that a tape reading equal to elevation of zero of scale comes at the point on rod opposite to point of hook the foot points on rod can be marked off to the necessary distance. The foot points on rod should be saw cut or scratched deep with an awl, and the proper figures inscribed.

Three pairs of Z-lugs will usually be sufficient for holding rod in place against bed piece, one lug should be set opposite the reading scale and the others below the scale but above elevations where readings are ordinarily taken. The window catch with a Z-lug opposite it, can be placed in a convenient position so that the rod may be clamped when the point of hook is brought to the water surface.

Provision should be made for obtaining readings at any stage of the water. If not desirable to have a hole in the roof with a self-closing trap through which the end of rod may be projected, an auxiliary hook may be placed on the rod for use in high-water readings.

Outside gage. - There are various ways of installing the outside or auxiliary gage. If the well extends along the ground level, as much of the outside gage as possible should be placed on the well. The same method of setting the gage plank in the forms may be used as in setting a staff gage in the well or it may be bolted to the concrete after the forms are removed. At some sites the outside gage may be fastened to suitable trees. Inclined gages with a bed piece either of a heavy timber mounted on substantial concrete piers or with a bed piece of reinforced concrete have been used with suceess. The reinforced concrete bed piece may be supported at the upper end by a concrete pier bonded to the well. At the center and at the lower end it may be supported by piers resting upon and molded around the intake pipe.

Another type of outside gage consists of a post or plank of oak, cedar, or other durable wood set directly upon the intake pipe and strapped to it by means of an iron band and lag screws. A substantial concrete pier is cast around three sides of the post and flush with the streamward side. Bolts or telephone pole steps may be placed in the post before the concrete is poured to fasten the post to the concrete. The forms for the pier are made without a bottom so that the concrete is poured around the intake and on the firm bottom of the intake trench. The pier should be large enough to prevent ice or debris knocking it out of plumb and to prevent the swelling of the post from cracking the concrete. Its height will depend upon local conditions and the number of piers to be installed. The post may extend above the top of the pier. The enameled scale on the streamward side of the first section may extend from the intake to the top of the concrete. The scale may be set on the back of the post from the top of the concrete to the top of the post.

Bench marks.

Too much care cannot be taken to insure the permanence of the relation between the zero of the gage and the supporting bench marks, as without this fixed relation it is impossible to use the record of stage for determining discharge. Two independent bench marks at each station are desirable. Wherever possible one should be placed so that the inside and outside gages may be checked with a level using equal and short sights. One, at least, should be back far enough from the stream to be undisturbed for all time. Only one datum should be used at a gaging station, namely, the datum of the gage, but the relation of this datum to mean sea level should be determined if practicable.

The use of the standard bronze Water Resources reference mark is recommended. It may be set in the abutment of a bridge, a rock ledge, or large boulder, or a hole dug with a post-hole digger well below the frost line may be filled with concrete into the top of which the reference mark tablet is set. Avoid placing bench marks on new or unstable structures. A track spike driven into a tree with front edge of the head upturned, makes a useful bench mark. At bridge stations at least one bench mark should be apart from the structure.

Special Features.

Roof. - Extra care should be taken in proportioning and mixing the concrete for the roof and also in finishing the roof, in order that it may be as impervious to water as possible. In localities where there may be snow on the roof for long periods, a coat of heavy asphalt paint may be desirable to prevent moisture from seeping through.

Doors. - A stock door should be used for the house. One with horizontal panels is stronger than one with vertical panels. If a stock door cannot be obtained, a door should be made of two ply 1 by 6's. The door in the well should be made of two ply 1 by 6's. Care should be taken in making the two ply doors that they will hold their shape. Each piece in one ply should be nailed to every cross piece in the other ply by at least two nails.

The doors should be completely covered with No. 28 galvanized iron, not only for greater protection, but to minimize swelling and sticking. The doors should be lined with felt weatherstrip if it is necessary to keep insects out of the structure.

The house door is locked by means of a padlock and safety hasp. It is held tight against the weather-stripped frame by means of a medium size refrigerator catch, as shown on the plans. A standard refrigerator catch requires a 3/8 inch shim under the handle part. Tire bolts are preferred for fastening the catch. If a tight fitting door is not necessary, a common door handle may be used instead of a refrigerator catch.

The well door is locked by means of a steel bar as shown on the plans. The bar is slightly bowed against the door to hold it tightly shut. The bar lock has been found necessary to prevent excessive surge during high water from bursting the door open.

Window. - One window usually gives sufficient light. A second window aids materially in reading a hook gage. The shutter should be made of two ply 1 by 6's, completely covered with No. 28 galvanized iron. The window may be lined with felt weather-strip if it is necessary to keep insects out of the house. A crescent sash fastener may be used to lock the sash tightly shut against the weather-strip.

Ventilators. - The ventilators should be covered with copper fly screen and also with $\frac{1}{4}$-inch galvanized netting. They are arranged in pairs, on two opposite sides of the house and well, in order to take advantage of the prevailing wind direction. In cold climates it may be necessary to shut and seal the ventilators during the winter.

Instrument shelf and cupboard. The arrangement of instrument shelf and cupboard shown on the plans reduces the total height of the structure by increasing the range in stage and permits any vapor, which may rise from the well into the house, to be diffused and not pass directly into the instrument. The holes in the shelf and cupboard top for the float and weight cables or tapes should be no larger than necessary. They should be covered with felt weather-strip as described under "Ventilation" on page 2.

The cupboard door is made the full width of the inside of the house for convenience in construction and in installing float and closing ventilators when required. It should be lined with felt weather-strip and fitted with two crescent sash fasteners to hold it tightly shut.

Trapdoor. - The trapdoor in the floor should be made of tongue and groove lumber in order to be as vapor proof as possible. The 2 by 4 inch sills upon which it rests should be covered with felt weather-strip. The trapdoor should be placed with the hinges opposite the house door so that it may be pried open easily if it swells and sticks. An allowance of half an inch for swelling of the lumber should be made on the side opposite the hinges.

Ladder steps. - The ladder steps should be galvanized regardless of cost as excessive moisture will rust painted iron. It is more convenient to have the ladder steps placed at one side of and not directly in front of the house door, in order that a man entering the well will not have to turn completely around. The use of a door in the side of the well may prevent this arrangement, as shown on the plans. The spacing of the steps depends on the convenience in setting them in the forms, and should be between 12 and 16 inches. The hooks on the steps should be well rounded to facilitate placing them in the forms. Both ends, of course, should be hooked in the same direction.

Painting. - All door and window frames and gage planks should be given one coat of paint and allowed to dry before they are placed in the forms, and a second coat later. All other woodwork should be given two coats of paint. A pure lead and oil paint should be used. The color of paint preferred for all woodwork at the gaging station is pure lead.

Float cylinders. - At stations where ice may form in the well, float cylinders should be installed for the winter months. Kerosene is placed in the cylinder. A covering of kerosene at least 3 inches more than the probable thickness of the ice around the cylinder is necessary. Five gallons of oil will make a covering of about 8 inches in a 14-inch cylinder.

The cylinders may be made of No. 22 galvanized iron, 14 inches in diameter, crimped with a tight seam and soldered. Both ends of course are open. The height of the cylinder depends upon the range in stage which must be met. Several $\frac{1}{2}$-inch inlet holes should be punched at the bottom of the cylinder. Several $\frac{1}{4}$-inch holes should be punched at the top for convenience in wiring or bracing the cylinder to the side walls. If the floor of the well is level the cylinder will stand plumb without bracing.

Construction Equipment.

When a number of concrete houses and wells for recorders are to be built, it is advisable to purchase adequate construction equipment, including truck, concrete mixer, pump, etc.

Truck. - Either a half-ton or a ton truck may be used. A ton truck with express top and side curtains is preferred for recorder construction work. A half-ton truck with similar body can be used, although its capacity is small. A half-ton truck has the advantage, however, of being adapted to miscellaneous light construction work and routine stream gaging work during the remainder of the year. The capacity of the truck for moving the construction outfit from one job to another is the main consideration, as the construction materials are usually delivered by the dealer. If a trailer concrete mixer is included in the equipment, a truck should be selected which will pull the additional load under unfavorable conditions. Puncture-proof fabric tires have been found to save time and money.

Concrete mixer. - Trailer concrete mixers, mounted on two automobile wheels with pneumatic tires, have been used with success in recorder construction work. The capacity of such a mixer is a half-sack batch. The average time of mixing and placing concrete is about 3 minutes a batch. A good mixer can be purchased for about $200. It will pay for itself in one season.

Pumps. - A 2½ or 3-inch diaphragm pump should be provided. Centrifugal pumps also are used in one district with success. The engine shafts of the mixers (Jaeger 3-E trailer mixers) are extended through the housing and fitted with 10-inch pulleys. A 2-inch Goulds centrifugal pump is connected to each mixer by a rubber belt. A few sections of 2-inch pipe of different lengths, a few couplings and elbows, and a centrifugal foot-valve are required for the suction pipe. A 2-inch rubber hose is used for the discharge. A centrifugal pump will throw the water out of an excavation in a few minutes under conditions where a diaphragm pump cannot hold its own. With this equipment, excavations have been completed and wells built without loss of time on account of the river rising to medium stages.

Forms. - Panel forms with waling-pieces and wedges for the outside forms of well and house, as shown on the plans, save time and money. Three sets or lifts are desirable, although a number of structures have been built using only two sets. With ordinary care, they will last for ten or twelve installations. The inside form lumber is not reclaimed.

Miscellaneous tools and equipment. - The following tools and equipment are usually required: Surveyor's level and rod; electric blasting machine, pocket size; pick, mattock, long-handled shovels, wheelbarrow; post-hole digger; 2 crow-bars made of 7/8 inch octagon steel 6 or 7 feet long, pointed at one end, flattened and slightly turned up at the other; 8 lb. drill hammer and rock drills; 12 lb. sledge; axe; hand-axe; wading boots; hip boots; pair of chain tongs; 5/8-inch rope and tackle; 5/8-inch rope and single block for hoisting concrete; pipe wrench; monkey wrench; pliers; gasoline can; carpenter tools; 50-foot steel tape; thermalware water jug; seven 14-quart buckets for measuring concrete materials, (especially if mixer is used), one bucket for water for mixer, and one large reinforced bucket for handling concrete; and a sidewalk ice scraper for spading concrete. A water barrel for the mixer is a convenience if it can be obtained locally for each job.

Bill of material.

Lumber.

Pieces.	Description.	Use.
As required	1 by 6 in. by 14 or 16 ft. No. 2 boards	Forms
As required	2 by 4's, 14 or 16 ft. long	Form studding and miscellaneous uses.
4	2 by 6's, 12 ft. long	Roof form
3	1 by 4's, 10 ft. long	Roof form and miscellaneous
As required	1 by 1 triangular fillet	Forms and house floor
3	2 by 6's, 12 ft. long tongue and groove	Floor, shelf, and cupboard top.
1	2 x 6, 6 ft. long, tongue and groove	Floor, shelf, and cupboard top
As required	Matched flooring	Cupboard
As required	2 by 6 cypress, cedar, redwood, etc.	Gage planks

Lumber (Cont'd)

Pieces.	Description.	Use.
As required	2 by 8 in. planks	Footwalk
1	4 by 6 in. by 1 ft. 4 in., oak preferred	Footwalk support.
7	1 by 12 No. 2 boards 16 ft. long	Mixing platform.
1	Door frame, 2 ft. 3/8 in. by 6 ft. 3/8 in. inside, made of 2 by full 6 in. plank, not beveled, with 1 by 2½ in. clincher strip all around. Built at mill if possible.	House door.
1	2 by 6 ft. door, stock or made of 2-ply 1 by 6 in. No. 2 boards, painted and completely covered with No. 28 galvanized iron. Built at mill if possible.	House door
1	Door frame 2 ft. 4 in. by 3 ft. inside, made of 2 by full 8 in. plank, not beveled, with clincher strip all around. If door is for end of well, frame should be 2 ft. by 3 ft. Built at mill, if possible.	Well door
1	Door, 2 ft. 3½ in. by 2 ft. 11 5/8 in., made of 2-ply 1 by 6 No. 2 boards, painted and completely covered with No. 28 galvanized iron. If door is for end of well, it should be 1 ft. 11 5/8 by 2 ft. 11 5/8 in. Built at mill if possible.	Well door
1	Window frame 2 ft. 1 in. by 1 ft. 8½ in. inside, made of 2 by full 6 in. plank, not beveled, with clincher strip all around. Built at mill if possible.	House window
1	Sash, 2 ft. 1 in. by 1 ft. 8½ in., four lights.	House window
1	Window shutter, 2 ft. ½ in. by 1 ft. 8 1/8 in. made of 2-ply 1 by 6 in. No. 2 boards, painted and completely covered with No. 28 galvanized iron. Built at mill if possible.	House window

Reinforcing steel.

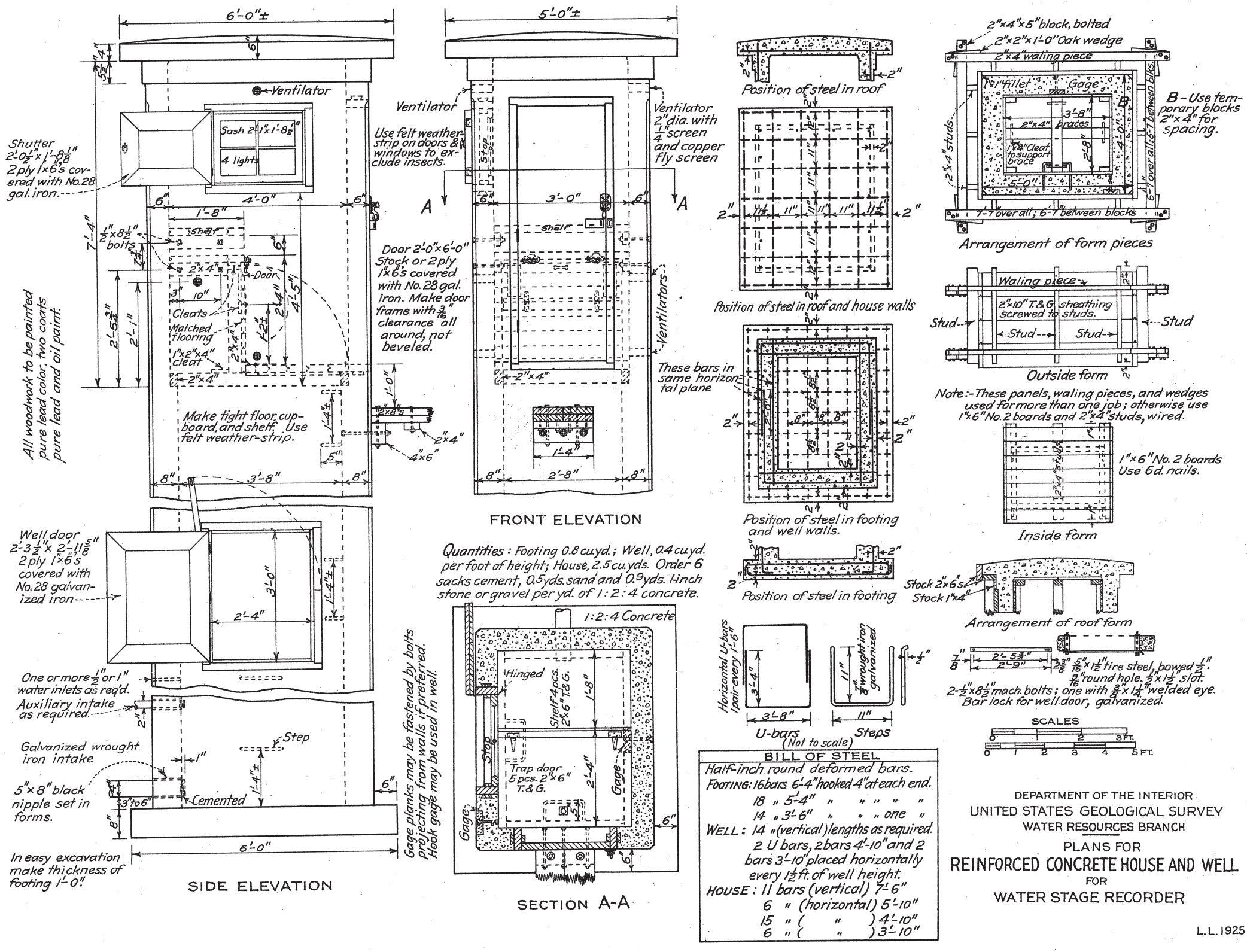
Half-inch round deformed bars throughout. Bill of steel shown on plans. Seven-sixteenths or half-inch square deformed bars optional.

Concrete.

Quantities: Footing 0.8 cu.yd; well, 0.4 cu.yd. per ft. in height; house, 2.5 cu.yds. Order 6 sacks cement, 0.5 yds. sand, and 0.9 yds. 1-inch stone or gravel per yd. of 1:2:4 concrete.

Hardware and miscellaneous.

1	6-inch safety hasp with 1¼-inch screws
1	4-inch brass, right-hand, refrigerator door catch with tire bolts
1	Iron shim, 3/8 by 1¼ by 2½ inches, with bolt holes corresponding to refrigerator catch
3 pairs	3½-inch brass butt hinges
2 "	2-inch brass butt hinges
1 "	4-inch brass tee hinges
1 "	3-inch brass strap hinges
1	Brass casement window fastener for mortise job, for shutter
3	Brass crescent sash fasteners, for sash and cupboard door
1	Flush trapdoor ring
1	Large handle for well door, with stove bolts
1	Small handle for cupboard door, with stove bolts
1	Hook and eye, for trapdoor
8	½ by 8½ inch machine bolts with washers for supports for shelf and cupboard top
3	¾ by 13 inch machine bolts with washers, for foot-plank support
2	5/8 by 11 inch machine bolts and washers for foot-plank
As required	½ by 7 inch carriage bolts and washers for foot-plank
As required	½ by 8 inch machine bolts and washers for gage planks
15 lbs.	6d common nails
2 lbs.	8d common nails
2 lbs.	10d common nails
10 lbs.	20d common nails
2 lbs.	40d common nails
As required	No. 12 annealed iron wire
1	Galvanized bar lock and bolts for well door as shown on plans
As required	Galvanized ladder steps as shown on plans
6	2-inch galvanized ventilators, 6 inches long, one end covered with copper fly-screen and ¼ inch galvanized netting
As required	Galvanized 4 in. wrought iron pipe for intake
1	Galvanized strainer for intake; footvalve without valve flap may be used
1	6 by 8 in. black nipple, for intake
As required	Water inlet pipes, ½ or 1 in. by 8 inches, screened if necessary
1 gal.	Pure lead and oil paint; color, pure lead
As required	Padlocks



DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

PLANS FOR

REINFORCED CONCRETE HOUSE AND WELL

FOR

WATER STAGE RECORDER

L.L. 1925