UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

EQUIPMENT
FOR RIVER MEASUREMENTS

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

ARRANGED BY LASLEY LEE
DISTRICT ENGINEER, COLUMBUS, OHIO
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UNITED STATES GEOLOGICAL SURVEY
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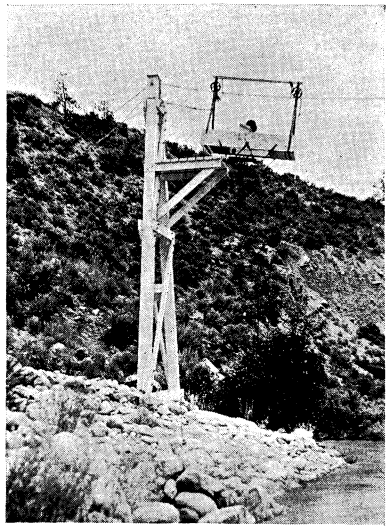
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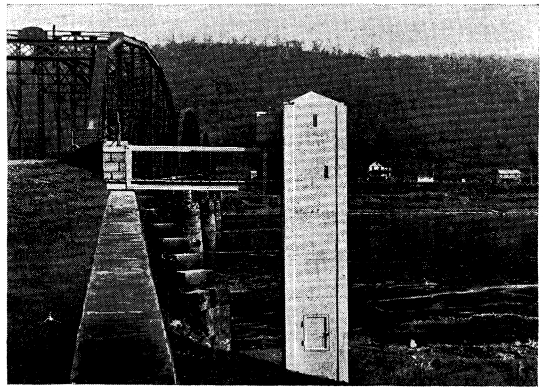
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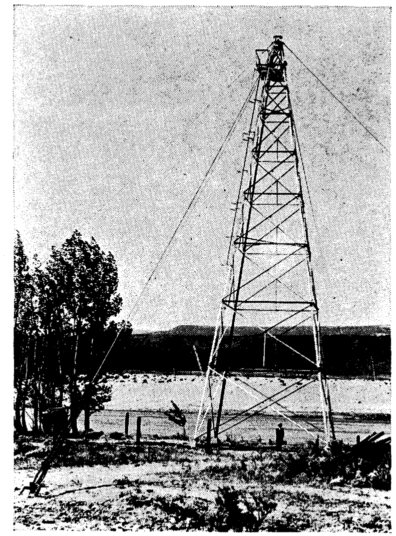
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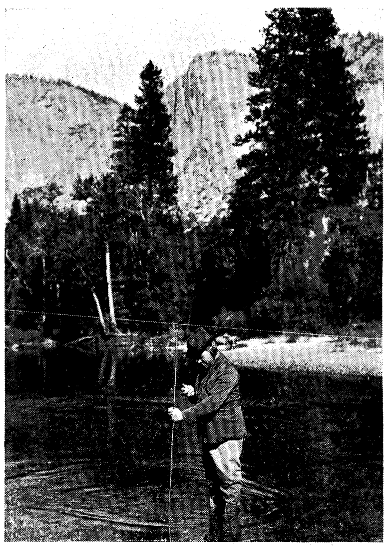
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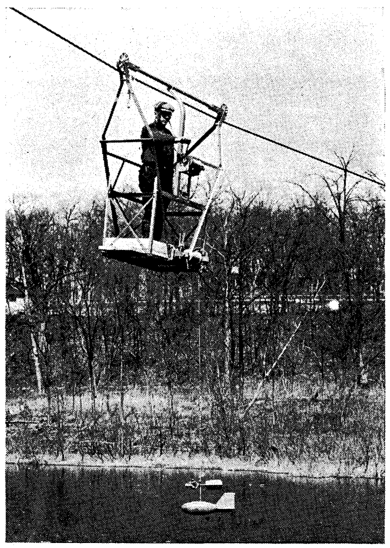
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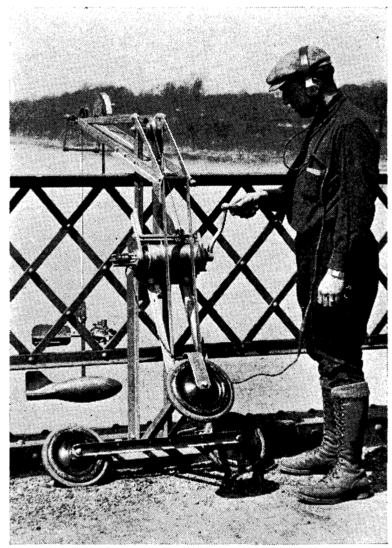
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FOREWORD

By

John C. Hoyt

The systematic collection of continuous records of river discharge was first undertaken by the United States Geological Survey in 1888. In 1895 definite Federal authority was given for the work and it was placed on a nation-wide basis. Since that time it has been continued and enlarged to meet growing needs. This activity has been an important factor in crystallizing the science of river hydraulics in its relation to the economic development of the water resources of the nation.

When the work was started, the need for information in regard to surface streams in connection with economic and social development had not become definitely established; methods, instruments, and equipment for conducting the work had not been developed; little if any scientific information in regard to the problem was available, and in the earlier years the approach to it was empirical. With the growth of the country, the demand for water increased, and with this increase came the demand for more accurate information in regard to available supplies. As a result, more refined methods, instruments, and equipment became necessary, and the scientific basis of approach superseded the empirical methods of earlier days.

Prior to 1910, few water-stage recorders had been used in the collection of continuous records of flow of streams. At that time it became apparent that on account of diurnal fluctuations of stage, due to regulation of streams for power and other uses, staff-gage readings were not adequate for computing accurate records of flow. In the summer of 1910 C. C. Covert, then district engineer of the Geological Survey for New York, equipped the river-measurement station on the Sacandaga River (a power-regulated stream) at Hadley, New York, with a water-stage recorder protected by a concrete house and well. In addition to the recorder, a cable and car were installed, and the channel of the stream was improved to create more satisfactory conditions for measuring discharge.

After the improvement of the Sacandaga station, there gradually arose from various parts of the country a general demand for better equipment and facilities at river-measurement stations, and as a result of many requests standard plans and specifications for the essential structures were prepared. The first set of standard plans was prepared by C. C. Covert, G. J. Lyon, and C. H. Pierce, and was published in pamphlet form in 1913 under the title, "Plans and specifications for current meter gaging stations." These were revised and expanded by G. J. Lyon in 1915 and published under the title, "Equipment for current meter gaging stations" as U. S. Geological Survey Water-Supply Paper 371.

Since that date numerous pamphlets have been issued by the Geological Survey, each descriptive of particular instruments, equipment, or methods used in measurements of river discharge or of the interpretation of the records. The present pamphlet relating to concrete house and well for water-stage recorders is a revision of an earlier pamphlet prepared by Mr. Lee in 1927.

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

Introduction

Continuous and accurate records of the fluctuations of water surfaces are important in connection with practically all problems having to do with water. Experience has shown that water-stage recorders are essential in the collection of such records, their use being required for the following reasons:

1. To eliminate errors due to inaccurate gage readings by observers.

2. To eliminate errors caused by lack of complete record of fluctuations which may be too great to be defined by two or three gage readings a day.

3. To give the records a high standing in connection with their use for legal purposes.

4. To make it possible to obtain a record at a site too inaccessible for sufficiently frequent reading of a non-recording gage.

Water-stage recorders have been used most extensively in connection with the measurement of river discharge. A discussion of the conditions relative to such use as given by Charles H. Pierce at the conference of district engineers, December 8, 1914, is published in Water-supply paper 375-F.

The general location of a water-stage recorder installation is determined by the availability of the conditions that are necessary in order to obtain accurate records of flow by the stage-discharge method. The exact location of the well and house and other structures is governed by three main considerations:

1. Conditions affecting accuracy of the record to be obtained by the recorder.

2. Conditions affecting construction and operation with special reference to cost and stability.

3. Property rights.

The essential features of a water-stage recorder installation are listed below. The care with which the installations are designed and constructed to meet local conditions will, in a large measure, determine the successful operation of the recorder.

1. A stilling well connected by an intake pipe or other openings with the body of water whose stage is to be recorded.

2. A house over the stilling well to protect the recorder.

3. Staff or other nonrecording gages outside and inside the house and well for comparing the stage in the well with that outside and for use in setting and checking the recorder.

4. Permanent bench marks for use in maintaining the datum of the gage.

Unless the water flowing past the gage is clear and free from silt at all times, a flushing device for cleaning intake pipes is also essential and for streams with an unusually high silt content a silt trap may be desirable.

Out of about 2,900 gaging stations now operated by the Water Resources Branch of the U. S. Geological Survey, more than 2,000 are equipped with water-stage recorders. Among the various types of houses and walls that have been used to shelter these recorders, the reinforced concrete installation described herein has been found to be especially satisfactory for general use. The plans for this structure represent the composite experience of the engineers of the Branch over a period of years, and acknowledgment is due to this group for bringing water-stage recorder installations to their present high standard, both in efficiency and in appearance.

It is expected that modifications in the details may be necessary in certain localities. Before making such changes, however, the engineer in charge should be sure that the changes are necessary to meet the local conditions and are for that particular locality an improvement over the standard plans.

The plans herein presented have to do only with the structures themselves. If necessary, additional plans drawn to scale may be prepared for each installation to show the details of the station and the relation of the structure to the specific location. These should include

1. A ground plan of the site, covering the area around the structures, on which the location of the house and well, auxiliary gages, bench marks, and other station equipment may be indicated.

2. Elevations and vertical sections perpendicular to the river showing the location and height of house and well, intakes, auxiliary gages, cross section of stream (partial at least), elevation of well door, and foot-walk or concrete steps.

3. Supplementary plans showing any structures in detail for which plans are not given in the standard plans, also the proposed arrangement of house and well with

respect to position of intakes, riser pipes, flush tank or silt trap, pump, recorder, ladder, inside gage, and well door.

In addition to the detail plans above listed any other changes that should be made to meet local conditions may be indicated on the standard plans.

The object of these plans is twofold--(1) to guide the engineer in the construction of the installation; (2) to give a permanent record for use in connection with work that may be required in the maintenance or modification of the installation

Special plans prepared in advance may not be necessary for many installations, however, if an experienced engineer is in charge of the construction.

Every effort should be made to carry on the work of construction economically and efficiently.

As water-stage recorder installations are usually in a conspicuous place, frequently near bridges or other structures, special care should be taken to insure that they will compare favorably in appearance and design with the best standards for structures in highway, railroad, and other classes of construction. The work necessary to accomplish this result does not add substantially to the cost of a job and should be regarded as essential and necessary. There is little excuse for anything other than the best quality of design and finish in Geological Survey construction. The site should be cleared of refuse and made to conform to the general surroundings.

When the installation is completed, a report should be prepared and filed in the district office covering the essential details in connection with the work. This report will furnish for future reference exact and complete information concerning the structure. A statement should be furnished covering the cost, the length of time required to do the work or a brief log of the actual operations, any unusual conditions that were encountered during construction, and other information pertaining to the operation and maintenance of the structure.

Photographs taken before, during, and after construction are very desirable. If time and money are available for it a special illustrated report on a construction job, typed and bound with cardboard cover, may be made by the engineer who supervises the construction. Such a report offers about the only available means of dissemination of construction experience among the many districts and the Washington office. Several districts now follow this procedure.

Construction Equipment

When several reinforced-concrete houses and wells for recorders are to be built, it is advisable to purchase or rent adequate construction equipment, including truck, concrete mixer, pump, etc.

A half-ton truck with canopy express top and side curtains is very satisfactory for recorder construction and is also adapted to miscellaneous work of construction and routine stream gaging. A 1½-ton truck may be preferred, however, wherever adequate transportation facilities are not available. As a rule the capacity of the truck for moving the construction outfit from one job to another or to and from the railroad is the main consideration, as the construction materials are usually delivered by the dealer. The concrete mixer, forms, and other heavy equipment are usually shipped by freight.

Trailer concrete mixers, mounted on two rubber-tired wheels, have been used with success in recorder construction. A 2-inch self-priming centrifugal pump or a 3-inch diaphragm pump is desirable for use in excavating for the well and intake.

The following miscellaneous tools and equipment are usually required: Surveyor's level and rod; pick; mattock; long-handled round-pointed shovels; short-handled square shovel; one or two crowbars made of 7/8-inch octagon steel 6 or 7 feet long, pointed at one end, flattened and slightly turned up at the other; 6-foot digging bar with 3-inch blade; 8-pound drill hammer and rock drills; 12-pound sledge; heavy wooden maul for driving shoring; ax; extension ladder; wading boots; hip boots; ½-inch rope and blocks; pipe wrenches; monkey wrench; pliers; gasoline can; carpenter tools; 50-foot steel tape; thermalware water jug; seven 14-quart buckets for measuring concrete material (if mixer is used); one bucket for water for mixer; one large reinforced bucket for handling concrete; sidewalk scraper or straightened garden hoe for spading concrete; carborundum bricks; and trowels. A water barrel for the mixer is a convenience and can usually be obtained locally for each job.

Excavation.

The excavation may be very expensive unless it is well planned and every measure taken to expedite it.

It is desirable to use a suitable posthole digger whenever possible to make borings to determine the nature of the soil, particularly to determine the presence of quicksand. A good posthole digger can be used to bore a 4-inch hole to a depth of about 35 feet. It cannot, of course, be used in gravel. The borings will influence the selection of the gage site and may effect a considerable saving.

Special consideration should be given to the nature of the soil encountered; the depth of excavation, and the height of the river to determine whether or not the sides of the excavation will stand without shoring during construction. Substantial shoring is a small part of the installation cost. In addition to insuring against injuries and fatalities it pays for itself in preventing lost time and duplication of work due to cave-ins.

The position of the structure should be staked out carefully with offset batter boards from which strings can be stretched to mark the neat lines of excavation and to suspend a plumb line to insure vertical sides. This will save time and trouble later.

Where shoring is not used a hole 8 by 8 feet is usually ample as this allows a 6-inch clearance at each end of the forms. Depths as great as 9 or 10 feet can usually be excavated without any hoisting arrangement, but for much greater depths it is necessary to erect a gin pole or tripod over the hole and hoist the material in a bucket or a wheelbarrow in a sling.

In deep excavations where shoring is used a platform may be rested on the rangers and the dirt shoveled onto the platform and then shoveled out.

Shoring or sheet piling is sometimes used as the outside form for the well for the first 8 or 10 feet above the footing. This is accomplished by allowing enough space between shoring and inside forms to make the walls about 1 foot thick. This thickness leaves about 8 inches of wall where the shoring rangers protrude into the wall. The resulting extra cost of concrete may be more than offset by the convenience and time saved in the elimination of regular outside forms for this portion of the well. The intake pipe may be placed in the same manner under these conditions as when ordinary outside forms are used.

Experience has shown that the shoring indicated in these plans will take care of practically all conditions. In certain places, however, it has not been wholly adequate to hold back considerable depths of mud or quicksand. Under such conditions special shoring must be designed or the caisson method of construction used. (See discussion of sheet piling under "Foundations," pages .)

Excavation in water is best handled by using a 2-inch self-priming centrifugal pump. A sump should be dug in one corner of the excavation for the pump strainer. Ordinarily the pump can remove the water faster than it seeps in.

Blasting.--If the site chosen is in rock it is necessary to resort to blasting. On account of the danger incident to blasting, men who have had experience in handling explosives should be employed if possible. If the work must be done by inexperienced men a blaster's handbook should be consulted for details.

The excavation should be made slightly larger than the dimensions of the house, and the rough rock wall should be used as the outside form. In excavating by blasting it is advantageous to place the holes so that free vertical faces will be developed for the easy shattering of the rock by the explosive.

Blasting by means of electric detonators is the safest and most economical method, as dangers and delays incident to misfires are avoided. It is not necessary to obtain a blasting machine, as an ordinary "hot-shot" 6-volt dry-cell battery does the work. Two strands of ordinary bell wire or rubber-covered wire may be used to make the electric circuit. Dynamite of 40 per cent strength is sufficient to shatter almost any rock.

For drilling holes use a $1\frac{1}{4}$-inch star drill or a single-bit drill at least 24 inches long. The dynamite must be at least 18 inches down, or it cannot be tamped sufficiently. The holes may be cleaned with a stick or spoon or by pouring in water and pushing a sledge handle forcibly into them. This squirts the water out and carries with it most of the stone dust.

Keep battery or blasting machine disconnected entirely and away from wires except when ready to shoot. The man who tamps the hole and strings the wire should be the one to get the battery or blasting machine and connect it up. The charge is ignited by touching the two wires simultaneously to the terminals of the battery.

In case of misfire it is safe to investigate immediately, if electric detonators are used. It is not safe to dig out the charge of dynamite; in some States there are laws against it. Try to get the tamping out and fire a stick on top of the other. This generates enough heat and concussion to explode the misfire.

Caution should be used in handling dynamite, to prevent severe headaches or more serious nitroglycerine poisoning. Avoid handling the dynamite with bare hands if possible, and do not touch the face with hands or gloves after handling dynamite.

Concrete

Regardless of who does the work, there are certain fundamental requirements for the selection of materials and the mixing and placing of concrete that should be observed in order to produce the most durable job. Too much emphasis cannot be placed on the importance of durability in concrete construction. The following specifications are based upon the recommendations of the Portland Cement Association:

Cement.--The cement used should be portland cement and should conform to the requirements of the standard specifications of the American Society for Testing Materials. It should be stored in a dry building or under waterproof coverings to protect it from hardening due to dampness.

Fine aggregate.--Sand should be clean and free from lumps or particles of shale, fire clay, or loamy matter. It should not contain clay, silt, or dust amounting to more than 5 percent by volume. It should be well graded in size. Not more than 4 percent should pass the 100-mesh sieve, and not more than 10 percent should be retained on a sieve of $\frac{1}{4}$-inch square opening. Organic matter, sugar, or tannic acid (which may occur, especially in sand deposits taken from the vicinity of oak, hemlock, tamarack or larch trees) is very objectionable if present in material quantities. To detect the presence of these substances place $6\frac{1}{2}$ ounces of sand in a 12-ounce flask, fill the flask to the 8-ounce mark with a 3 percent solution of sodium hydroxide, shake well, and let stand for 24 hours. If the liquid above the sand at the end of that period is darker than a yellowish straw-color, the sand should be tested in a laboratory before it is permitted to go into concrete.

Coarse aggregate.--For the coarse aggregate in concrete it is desirable to use only clean, tough crushed natural stone or gravel, preferably material which is all retained on a $\frac{1}{4}$-inch screen and none on a $1\frac{1}{2}$-inch screen. Bank-run materials should be separated on the $\frac{1}{4}$-inch screen and reassembled at the time of mixing.

Proportions.--Probably the best method of proportioning the materials for the strength and weather resistance required in this work is to use equal parts of water and cement and sufficient sand and stone to produce a workable concrete under the specific conditions of placement. In using this method it is necessary to know the amount of water, if any, in the sand and gravel at the time of measuring for the mix.

$\frac{W}{C} = 0.665$ or 0.865 if moisture content is 5%

Under ordinary conditions met in the field in this work it may be preferable to use a straight 1:2:4 or 1:2:5 mix. For concrete to be poured under water a richer mix, $1\frac{1}{2}$:2:4, is desirable. An easy and accurate method of measuring the material for a 1:2:4 mix, 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.

Quality of water.--Water for mixing concrete should be reasonably clear and entirely free from oil, acid, alkali, sugar, organic matter, or other deleterious substances.

Mixing.--Mechanical mixing should be used whenever possible. For ordinary purposes one full minute of mixing will suffice, but for work that must be water-tight, a minimum of $1\frac{1}{2}$ minutes should be required. If hydrated lime is used the mixing time should be longer. Mixing time is figured from the moment that all materials are in the drum of the mixer until dumping starts.

In using a 1:2:4 mix the sand required for the batch should be placed in the drum first, then the stone, the cement, and the water.

Hand mixing is often necessary. It should be done on a tight platform. The most uniform mixing will be obtained if the fine aggregate is first spread out on the platform, followed by the cement and coarse aggregate and the whole mass turned over three or four times before water is added, a little at a time, in a crater in the center of the mix. Hand mixing should continue until the mass is of uniform color throughout and all stones are well coated with mortar.

Quantity of water.--There is never any excuse for making a sloppy concrete. Not only does too much water weaken the concrete and make it porous and of low resistance to weathering, but it results in a mix that cannot be placed without segregation. An essential requirement of good concrete is that it be homogeneous and uniform in all sections. This will not be accomplished where the heavier aggregate particles can settle to the bottom of the layer. The best general-purpose mix is one that is just workable and that does not show standing water in the form. A mix that will heap up on a shovel and still look plastic is about right for most purposes.

Removal of laitance.--When concrete is placed to any considerable depth, spading combined with excess of water will usually cause fine materials, dirt, and scum to rise to the surface. This solidifies in a soapy layer and is called laitance. It has very little if any strength and should be scraped off as soon as the concrete has stiffened. If left in place it will disintegrate and leave a weak spot in the structure. Water goes through laitance planes readily.

A thick layer of laitance is evidence of gross excess of water, and the accumulation of water at the top results in a porous concrete in the portions just below the laitance. The practice that results in this condition should be avoided.

During.--Proper curing during the first seven to ten days is necessary to obtain good concrete. Care in this important detail will often double the strength and wearing qualities of the finished product. In midsummer a hot sun and drying wind may remove some of the moisture necessary to proper hardening unless the concrete is sprinkled frequently. When possible the new concrete if exposed to an extremely hot sun or drying wind should be wet frequently or covered with wet sacks. In cold weather it is necessary to protect new concrete from frost. To provide this protection and also to hasten curing a small kerosene oil stove may be placed inside the structure and a heavy tarpaulin over the top and around the outside.

Concrete Forms.

Wooden panel forms for outside and inside of house and well, as shown on plans, save time and money. Three sets or lifts are desirable. With ordinary care they will last for several jobs. If 2-inch is preferred to 1-inch lumber for panel forms the middle walers may be omitted. Construction engineers who have used both the inside panel forms and rigid inside box forms built up as the job progresses prefer the inside panel forms, on account of easy access to the bottom of the well to remove the lowest forms while the job is progressing, ease of removal, saving in time even with an inexperienced crew, and saving in cost of lumber.

If panel forms are not used, the studding of the inside and outside forms should be cross-tied 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 forms should be oiled before using and cleaned immediately after using.

The forms for the roof should be made of steel, as shown on the plans. The corner-block forms should be made of wood.

Construction of house and well.

Concrete should be placed in the forms before it has stiffened. If there is considerable delay in placing the concrete, it should be well stirred at 15-minute intervals. Under ordinary conditions this will be necessary within one hour after mixing.

In placing concrete, the surface should be kept as nearly horizontal as possible, because if it is heaped up in one place honeycombing or sand streaks are likely to occur. It should be carefully spaded to insure a complete filling of the form and the elimination of impounded air and excess water. A good tool for this purpose is a sidewalk ice scraper. A hoe bent out straight with the handle may be used, providedit is filed off dull enough not to cut the forms easily. A piece of 1 by 2-inch scantling is also fairly effective. Hammering on the form studding at the point of placement helps to compact the fresh concrete. A wooden hammer is to be preferred.

Pouring the footing under water is recommended where a gravel formation permits much water to enter the excavation. Water can be kept from the excavation by pumping until the reinforcing steel is in position. There should be as little agitation or current in the water as possible when the concrete is poured, in order to prevent washing the cement from the aggregate. Concrete should not be dropped unprotected through water. The best method of placing concrete under water is with a tremie pipe, usually called a tremie. Another method of placing concrete is to use buckets to take it from the surface to its position under water. Some washing out of the cement takes place as the concrete is dumped from the bucket.

The tremie may be from 6 to 14 inches in diameter at the bottom and must be long enough to reach from the water surface down to the concrete. A tremie suitable for most jobs may be made of No. 20 gage galvanized iron about 3-1/2 feet in height, about 8 inches in diameter at the bottom, and 18 inches in diameter at the top, with rolled edges at top and bottom. Two horizontal handles made of strap iron should be riveted at the top, the handles extending 2 inches above the top edge. When a sheet iron tremie cannot be obtained a wooden one may be constructed from 1 by 8-inch lumber as follows: Four pieces 3-1/2 feet long are nailed together to form a hollow chute. A funnel piece wide enough to accommodate a shovel blade is attached to the top of this chute. The funnel consists of two pieces about 16 inches long spread outward at the top, nailed to the top of the chute at their bottom ends, and boxed by nailing cross pieces of 1-inch lumber to their edges. The cross pieces are sawed off flush with the outside edges of the slanting pieces. Small wooden handle grips are placed at the sides of the funnel near its top and permit easy handling of this by one man. The sheet-iron tremie is much lighter and easier to operate than the wooden one.

The tremie is first filled with concrete and lowered into the water until it reaches the bottom. Then as more concrete is added at the top, some is permitted to flow out at the bottom. Once the operation is started the bottom of the pipe is kept below the surface of the soft concrete. With this method there is practically no washing out of the cement. The pouring should be continuous until the job is done or until the concrete is above the surface of the water. The concrete may be leveled off by the feet of the man handling the tremie, but he should do as little walking as possible. The tremie may be gradually moved around to deposit an even thickness of concrete. At the end of each batch concrete should be left in the tremie above the water level and the tremie forced deeper into the soft concrete just poured. After removing the tremie it is easy to level the concrete if reasonable care is used, without destroying the strength of the mixture. The floor may be sloped toward the middle with a small shallow sump there, so that the well may be bailed practically dry. If a float cylinder is to be installed it may be preferred to leave the floor as level as possible.

After pouring the footing and before placing forms for the well, the number of lifts of outside panel forms required to reach the roof line should be computed. Any fractional part of an outside left should be taken care of at the start by rings of 2-inch plank starting on the footing, so that the outside panel forms will stop at the roof line. The adjustment of the inside panel forms to come at the right height for the roof is made at the level of the house floor. The 2 by 4-inch ring at the floor of the house is nailed to the inside panel forms at the proper height, regardless of the height of that panel form. After the concrete has been poured nearly to the top of the 2 by 4-inch ring at the floor level and after it has set, the inside forms are removed and a lift for the house wall set upon the 2 by 4-inch ring.

The outer form planks, if used, need not be removed except as required for the intake. In order to remove easily any plank rings on the inside of the well it is desirable to saw each plank in two in the middle and nail cleats behind the butt joint before setting them. Opposite planks should then be braced with 2 by 4's. For convenience in construction the inside panel forms should be started about 6 inches lower than the outside panel forms.

The inside dimensions of the house are greater than the inside dimensions of the well. The same inside panel forms and inside loose braces may be used in the house, however, by using wider corner boards on the panels and extra wedges or spacing blocks on the loose braces.

The forms should be left in place two days if possible. The outside forms, however, may usually be safely removed after one day. The inside forms should be removed as soon as it is safe to do so. Any holes or bad spots should be smoothed up with mortar composed of 1 part of cement and 1-1/2 parts of sand, in order that it will set to the same color as the 1:2:4 concrete. The mortar for patching should preferably be retempered mortar about 1 hour old that has been stirred at 15-minute intervals. Such mortar has taken its initial shrinkage and will adhere better. The green concrete may be smoothed up by wetting it and rubbing with a carborundum brick. This should be done immediately after removing the forms.

Special care must be taken to prevent unevenness in the outside wall at the joints between successive lifts of panel forms, due either to bulging or to pitting. Some of the unevenness can be prevented by the use of paper between the forms and the concrete; the paper should be well oiled. Uneven joints should be rubbed down as soon as possible after the forms are removed.

Reinforcing.--Half-inch round deformed bars are specified for the reinforcing, except for the roof, for which 3/8-inch bars are recommended. Square bars may be used for the roof or in place of the round. 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 steel should be kept free from loose scale, rust, or oil.

The reinforcing in the footing consists of a layer of bars 2 inches from the top and another layer 2 inches from the bottom. Each layer consists of nine bars in each direction. 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 footing as soon as the footing is poured.

The reinforcing in the walls is both vertical and horizontal. The vertical reinforcing consists of twelve bars, spliced as required, from footing to roof, bent to pass doors and window. There are two sets of horizontal bars. The principal set consists of four hooked bars and four L-shaped bars every 1-1/2 feet in height from footing to floor of house (except as omitted for well door) and straight horizontal bars every 1-1/2 feet in height in the house. Four of the L-shaped bars are also placed in the house walls just below the roof. The second set consists of four straight bars placed 2 inches from the inside face of the walls every

1-1/2 feet in height from the footing to the ground level to give strength to counteract the pressure of wet earth. These layers of bars should be extended higher than the ground level if there is danger of drift striking the structure.

The reinforcing in the roof consists of twelve straight bars placed 2 inches from the bottom of the roof.

In general the centers of the bars should be placed 2 inches from the forms. They should be overlapped 1 foot for bond. When overlapped, the bars should be parallel and at least 1-1/2 inches apart. The horizontal bars are usually laid on top of the fresh concrete at the proper elevation instead of wiring them to the vertical bars.

Foundations.--In most localities the footing shown on the plans forms a suitable foundation for the structure. The minimum thickness of footing is 9 inches, except that where the foundation is bedrock the thickness of walls should be increased at the bottom in order to safeguard against defects that may be caused by difficulty in fitting forms to the bedrock. The bottom of the well should then be leveled off with mortar. Where excavation is easy 2 or 3 inches more may well be added to the thickness of footing shown in the plans. If the structure is placed where there is danger that the soil will not bear the load, or where tremors from nearby railroad or highway bridges might tend to cause settling, where the structure may be battered by waves or drift, or at the edge of the water, it is necessary either to increase the width and thickness of footing or 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. If 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 piles if 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 the proper location, the sheeting 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 sheeting. The sheeting should be pointed on one side only at about a 60° angle with the vertical, so that when a piece is driven with the long side adjacent to the last piece driven, it will drive snugly to the last piece. The top of the sheeting should be beveled to prevent splitting or brooming.

A heavy wooden maul is preferred for driving. A piece of a green log 6 or 8 inches in diameter with a 2 by 4-inch handle to use as a vertical ram is also good for driving sheeting. Sheet piling consisting of three 1 by 8's or 2 by 8's nailed together to form tongue and groove units (sometimes called Wakefield piling) may be used under adverse conditions to exclude water. Additional excavation can be carried on within the sheeting, and the tops of the piles should be sawed off a few inches lower than the bottom of the well. A centrifugal or diaphragm pump is usually needed to keep water out of the excavation.

Gage planks.--It is convenient and economical to set the planks for inside and outside staff gages in the forms before the concrete is poured, instead of drilling holes in the concrete after the forms are removed and bolting them to the wall with malleable lead anchors. The sides should be beveled 1/8 inch so that the concrete will hold them securely. If the outside gage plank is placed near the corner of the well, some extra short pieces of reinforcing steel should be placed around the plank in such a way as to prevent the splitting of the concrete next to the corner.

Ladder.--Two types of ladder are in general use. If galvanized manhole steps are used they must be placed in the forms before the concrete is poured. This adds to the expense of form work and delays the concrete work to some extent. Continuous galvanized-steel ladders bolted to the wall by means of malleable lead anchors soon after the forms are removed are recommended for economy and ease of replacement in future years. There is less danger of a man's foot slipping off the continuous ladder. A man can keep his hands cleaner on a continuous ladder than on manhole steps, and this is desirable when changing record sheets.

A convenient temporary support when working in the well after the forms are removed is obtained by use of a plank about an inch longer than the inside dimension of the well. One end of the plank may be set on top of a ladder rung and the other end against the opposite wall a little higher than the rung.

Placing doors and window.--The frames for the doors and window should be placed in the forms as soon as the concrete has been poured to the proper level. Care should be taken to brace the door frames by means of a strut across the middle to prevent the pressure of the wet concrete bowing them.

Placing ventilators.--Good judgment must be used in deciding upon the amount of ventilation and the type of ventilator required, as conditions vary widely in different localities. 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 the top and bottom to remove any vapor that may arise through the floor; (3) the floor, shelf, and partition 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 they are not tight. Ventilation of wells in localities having cold climates is a difficult problem. It is usually desirable to shut and seal the ventilators during the winter. Ventilators should be placed on two opposite sides of the house and well, as far as possible. To insure a smooth beveled concrete edge around the ventilator the outer face may be covered when placed in the forms, by a thin piece of board or plywood, the inner face of the board to be the exact size of the ventilator and the edges to be beveled to make the opening larger.

Roof.--When the concrete in the house walls has been poured to the level of the roof line on the inside of the house (or an inch or two below that level), it should be allowed to set for at least 24 hours before the roof is poured. The wooden corner form blocks may be secured in position by nailing through the outside panel forms from the outside. If the makers of the inside or lower steel roof forms clipped the top corners (as is usually done), the small hole should be capped before placing concrete. When starting to place the concrete for the roof, it may be poured to the level of the outside roof line and some concrete piled up on the lower roof form. The roof reinforcing may then be laid in place and the top roof form set on the wet concrete and on the corner blocks. It should be well braced as shown on the plans, to resist the upward thrust due to tamping the concrete poured through the hole in the top of the form. The mix should be rather wet and well tamped. When the forms are filled, the small cap form made from the steel pieces sheared from the outside roof form is filled with mortar and pressed down on the peak. A hole about half an inch in diameter should be left in the cap form through which the last bit of mortar can be placed to give a sharp peak.

Shelf and instrument support.--The arrangement of shelf and vertical partitions (called the cupboard) permits the float to rise to the shelf, thereby increasing the range in stage over 2 feet and reducing the height of the structure by that amount. The instrument support shown on the plans holds the recorder several inches above the shelf to permit any vapor that may rise from the well into the house to be diffused and not pass directly into it. This support consists of two 2 by 4's on edge at the ends of the shelf, two flat 2 by 4's at the front and back edges of the shelf, and two flat 2 by 4's placed parallel to the first pair to support the instrument. It may be preferred, however, to install a second solid shelf, using two 2 by 6's on edge at the ends of the lower shelf to support it. The holes in the shelf for the float and weight cables or tapes should be no larger than necessary. They may need to be covered with felt weatherstrip.

At some stations extra precautions must be taken to prevent mice from destroying the record paper. This damage may be prevented by attaching a strip of tin underneath the instrument shelf. It may also be necessary to place a strip of tin around the base of the recorder.

Submergence cover.--At a few stations it may be impracticable to build the structure high enough to take care of extremely high floods. In such floods the submergence cover for the recorder shown on the plans will prevent water touching the instrument, even though the gage house is submerged. The peak of the flood will not be shown on the gage-height chart and must be determined from high-water marks. The instrument should function properly, however, as soon as the stage has receded to the level at which the float was held by the instrument shelf.

Trap door.--The trap door 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 may need to be covered with felt weatherstrip. An allowance of three quarters of an inch for swelling of the lumber should be made on the sides parallel to the grain. A strip should be placed on the solid floor and underneath to close the crack.

Doors.--A stock door may be used for the house. One with five cross panels is stronger than one with vertical panels and is more suitable for covering with galvanized iron. If a stock door can not be obtained, a door should be made of two-ply 1 by 6's, though this will be heavier than is necessary. 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 door should be covered on the outer side with No. 16 galvanized iron for greater protection from shooting. The door should be lined with felt weatherstrip if it is necessary to keep insects out of the structure. The door may be locked by means of a safety hasp and padlock, dead lock with cylinder taking standard key. A bar lock and padlock for the house door as shown on the plans for the well door may be preferred. Either D handles or refrigerator-door handles may be used on the house and well doors. The later permit closing the doors tightly against the frames.

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 reading and checking the inside gage. This door may be made of two-ply 1-inch boards nailed together, well painted or coated with other preservative, and covered with No. 26 gage galvanized iron. The seams should be tightly soldered. The door is locked by means of a steel bar, as shown on the plans. In some districts a bar for a padlock is fastened directly to the door instead of as shown on the plans. The bar lock has been found necessary to prevent excessive surge during high water from bursting the door open and to keep the well door pushed so tightly shut against its stop as to prevent silt from passing around the door into the well. A substantial stop should be placed entirely around the well-door frame, including the bottom, in order to prevent entrance of silt. Rubber or felt stripping of some kind may also be placed on the face of the stop to render the door more water-tight. If the well door is made with enough clearance so that it will not swell tight against the door frame, and if it is equipped with a strong handle fastened to the door by bolts instead of screws, there should seldom be difficulty in opening it, even though some ice and snow may be frozen along the bottom of the door.

In making the door frames ample allowance should be made for swelling. In heavily silt-laden streams 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 another, so that silt can be readily removed at any level. In cold climates it may be necessary to make a close-fitting door and weatherstrip it to keep out the cold air. At some stations a door in the well may not be necessary or desirable.

Steel door frames and doors for house and well and steel window frames have been manufactured by commercial firms for recording-gage installations. They add greatly to the appearance of the structure and are recommended as more durable and economical in the long run. Plans for the several types of steel doors and windows have not been included in this publication. The Columbus office will refer anyone desiring information regarding them to the manufacturers and to the district engineers who have their own designs.

Window.--One window usually gives sufficient light. For pleasing appearance its height should be greater than its width. The plans show a two-light sash sliding with shutter. A stock 10-inch hook and eye may be used to hold the shutter open when inspecting the recorder. An optional and more economical design is to omit the shutter and use instead a protecting screen of woven wire cloth of No. 9 wire 3 by 3 mesh (to the inch). In this design a sliding sash is unnecessary. Glass reinforced with wire mesh may be used.

Window and door frames should have no casing, as it is desirable to make the window and doors inconspicuous. The appearance of the structure will be improved thereby.

The window is usually placed on the same side as the recorder shelf. In placing the window it is advisable to consider the possibility of damage to the recorder by rifle shooting, especially if there is a bridge or high bank on which the marksman can stand. If necessary the shelf may be placed lower than shown on the plans, to keep the recorder out of danger. The 3 by 3 No. 9 screen will stop small rifle bullets.

Subfloor.--In cold climates a subfloor or frost barrier should be installed to prevent the formation of ice in the well, if the well is not so exposed that there is little range in stage below the frost line of the surrounding ground. A subfloor also prevents vapor rising from the water surface into the house and forming frost on the recorder. The position of the subfloor, to be most effective, depends on three factors: (1) It must be below frost line, (2) it must be high enough to allow for normal winter fluctuations if possible, and (3) it must be below auxiliary intake pipes unless the ends of the pipes are under water, are connected to riser pipes, or are capped during the winter to exclude cold air.

The plans show a subfloor of tongue and groove flooring. Celotex and tempered Presdwood have also been used with success and may be obtained at lumber yards. If boards are used, some are left loose so that they will rise with the water. If Celotex or Presdwood is used, a round hole may be cut for the float and a "lid" of the same light-weight material or of light galvanized iron placed over the float to rise with the float above the stage of the subfloor. The float cable may be threaded through a small hole in the lid. The four sills and the cross piece should be installed substantially so that they will safely bear a man's weight. At the end of the winter season the subfloor may be removed and stored in the gage house if desired. The sills, of course, are not removed. That part of the subfloor which is away from the ladder may be permanently placed in the well with the proper holes through it for the recorder float and weights to operate. Usually it will not be necessary to provide a place for the clock weight to go through. A small hole should be left for the float counter weight; it can be felted in such a way as to exclude considerable moisture and yet permit the passage of the weight. It may be desirable to fasten the end of the float cable to the under side of the shelf and suspend a grooved sheave and double counterweight unit on the float cable, to reduce the fall of the counterweight in order that it can not reach the subfloor. On the side of the well that is next to the ladder loose boards (not necessarily tongue and groove boards) may be laid, each with a handle of some sort on top that will permit its easy removal each time a man goes below the subfloor to read the inside gage. This plan has proved to be definitely satisfactory and does not exclude the use of the lower part of the well when a subfloor is in place.

Where subfloors are installed it is advisable to use an electric-tape gage or a float gage in the well instead of a staff or hook gage, as it is desirable not to disturb the subfloor during the winter.

To further diminish the effect of frost, if necessary, a barrier may be placed anywhere under the table, the most convenient place being in the cupboard at the floor level. A strip of heavy tar paper can be used for this. Small holes are cut in the paper just large enough to allow easy passage of the instrument cables and tapes. A small amount of vapor will pass through these holes but not enough to affect the recorder.

Float cylinder.--If a subfloor does not prevent the formation of all ice in the well and if electric current is not available to warm the air in the well, it may be necessary to install a float cylinder. In deep wells where the clock weight may not be stopped by ice, a cylinder 14 inches in diameter may be used. Otherwise the diameter should be 20 inches. A covering of oil 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 7-1/2 inches in a 14-inch cylinder. The height of the cylinder depends upon the range in stage during the winter and upon the height of the well door. It is desirable to have the top of the cylinder higher than the sill of the well door, so that when a rising stage allows the oil to escape from the cylinder it may also escape over the sill of the well door, and not coat the ladder and lower well walls. On account of some danger of fire if oil in the well should be lighted by a match and also to prevent loss of oil by overflow, it may be preferred to erect the float cylinder to a height within a few feet of the house floor.

The cylinders should be made of No. 22 galvanized ingot iron, crimped with a tight seam and soldered. Both ends, of course, are open. Three sharpened pieces of 1/4 by 1-inch steel should be bolted or riveted to the bottom of the cylinder to hold it at the desired height above the footing--probably a few inches below the flow line of the intake. This support permits the easy removal of silt from under the cylinder. The float cylinder may be built up in the well in 10-foot lengths and soldered in place. All the lengths should be made with exactly the same diameter. The bottom of the intermediate and top sections should be crimped but not swedged. A blow torch, string solder, and noncorrosive soldering paste should be used to seal the joints after erecting the cylinder in the well. It is usually more practicable in soldering the joints to go around the cylinder twice, as it is difficult to solder all crevices completely the first time around. A 14-inch cylinder will require about 10 feet of string solder and a 2-ounce can of paste for each joint.

Inside gage.--The gage inside the well is the gage that is rated. It may be a staff, float, electric-tape, or 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.

For an inside staff gage the plank should be of cypress or other durable wood, well painted or treated with other wood preservative. It may be set inside the forms during construction, in order that the gage scale may be flush with the concrete, or it may be bolted to the wall after the forms are removed. If the latter method is preferred, holes may be drilled in the concrete immediately after the forms are removed for 1/2-inch bolts with two-unit malleable lead anchors, or bolts may be placed through the forms before the concrete is poured. Enameled gage scales should be used. They may be cut to any desired length by means of a hacksaw. As slight errors may be found in the graduation of the enameled scales, it is necessary in installing them to use a steel tape stretched the full length of the gage, make a pencil mark clear across the gage plank at every foot of gage height, using a square, and then adjust each scale so that its foot marks fall as nearly as possible at the horizontal pencil marks. Measurements should be made to the center and not the top of the graduations on the enameled scale. Round-head brass screws, 3/4-inch, No. 8 are used to attach the scale to the plank. The screws should not be too tight or the enamel will chip off. If a staff gage is installed, it should be set on the side of the well on which it can be most conveniently read and checked with a level from the outside. The possible installation of a float cylinder should be considered in placing the gage.

The float gage is a convenient form of inside gage. It can be read instantly by reading the position of the pointer against a stainless-steel tape passing over a pulley on the instrument shelf or on a bracket securely fastened to the wall of the house. It can be used under all conditions where sufficient space is available for the pulley and for the float directly beneath the pulley on the water surface, and where temperatures do not go sufficiently low to form ice on the water surface or where ice is prevented by use of a subfloor. The gage is checked for datum by measuring to the water surface from a permanent reference point located in the frame of the trap door in the house, using a steel tape, either hooked over the reference point and read at the water surface or weighted with a chain-gage weight and read at the reference point. The height of the reference point minus this measured distance to the water surface must equal the height of the water surface and also the tape-gage reading. The reference point should be so located that it can be conveniently checked by levels from the outside.

The standard U. S. G. S. float gage (obtainable through the Boston office) consists of a 10-inch float similar to a standard water-stage recorder float, a stainless-steel tape graduated to hundredths of a foot, a counterweight, and a 6-inch flanged cast-aluminum bronze-bushed pulley mounted on a standard that may be rigidly fastened to the instrument shelf or a bracket. A knife-edge pointer in front of the tape enables the observer to read the tape directly. The pointer is adjustable to facilitate the original setting of the gage and the making of any small corrections that may be occasionally necessary. The tape may be adjusted at the clamp that fastens it to the float. The use of one float for both the recorder and the float gage is not recommended. For the maximum degree of accuracy or for an installation in an extremely high well requiring a long tape, a float with a diameter of 15 or 20 inches is recommended.

The U. S. Geological Survey electric-tape gage contains a stainless-steel tape graduated to hundredths of a foot with a cylindrical brass weight fastened to the lower end. Adjustment is provided where the tape enters the weight. The tape is fastened to a sheave fitted with a crank. A pocket compass is mounted inside of a galvanometer coil, which is adjusted to a north and south position on the gage bracket. A small dry cell is used, or the engineer's current-meter headset may be plugged in to the gage to furnish the electric current. When the weight touches the water the circuit is closed and the compass needle is deflected from the north and south position. The tape is wound up when the gage is not being used. An insulated bracket is provided so that the gage may be rigidly and permanently fastened to the side wall of the house at any convenient location and absolutely independent of any wooden gage shelf. The permanent installation of the bracket on the wall of the house is strongly recommended. A 1-inch hole through the shelf, floor, and subfloor is necessary. The gage is easily checked for datum by sighting into the gage house with a level, lowering the weight to the height of the instrument, and reading the tape at the index line.

A hook gage may be preferred if the well is not deep and if unusual accuracy is required. Although this type is not considered a standard gage in many districts, it seems desirable to include a detailed description in this publication for use when needed. A hook gage is not recommended for deep wells where the rod would need to be spliced or for wells where a scale above the floor would not be practicable. A simple form of hook gage consists of a movable rod graduated in feet from 0 downward, with a hook at the bottom, the rod being arranged to slide against a 1-foot New York level-rod scale, which is screwed to a back piece and is graduated to hundredths of a foot from 0 upward. The stage is determined by raising the rod until the point of the hook just pricks the water surface, reading on the rod the foot mark that is opposite the fixed scale, and reading the tenths and hundredths on the scale. The location of the hook gage in the well depends upon the amount of light and visibility at the water surface. It should be placed where it can be read by one standing on the floor of the house or on the ladder. The material required includes one 3/4 by 3-inch rod of white pine tapered at the bottom, its length equal to the distance from the bottom of the well to zero on the scale, six or more Z-lugs, 1-1/4-inch No. 9 brass screws, one small wooden wedge, one hook with brass screws, one scale with screws and washers, one 2 by 6-inch bedpiece of durable wood 18 inches longer than the rod, and 1/2 by 6-inch machine bolts.

In concrete gage wells the anchor bolts for the hook-gage bedpiece should be set in pairs 4-1/2 inches on centers horizontally and about 4 feet apart vertically. In wells where the bedpiece must be spliced additional bolts are required at the joint. The threaded ends of the bolts should project 3 inches from the concrete. In wooden gage wells the bedpiece may be attached to the side of the well or to horizontal crosspieces about 4 feet apart, with 1/2-inch bolts or lag screws. The bedpiece should be well painted or treated with wood preservative before installing. Care should be taken to see that it is set plumb. Three pairs of Z-lugs will usually be sufficient for holding the rod in place against the bedpiece. One lug should be set opposite the level-rod scale. The Z-lugs should be sufficient in number to secure the rod properly down to a level near the bottom of the well. A wedge is used in a convenient place between a Z-lug and the rod below the floor, so that the hook can be set and the rod clamped from below the floor and the reading taken on the scale. The scale can be fastened at a convenient height above the floor, with its right-hand edge 1-1/2 inches to the left of the center line of the bedpiece. It is a convenience to have the zero of the scale set by levels at some even foot above the gage datum, thereby fixing the point of the hook exactly 1 foot from the nearest graduation on the rod. The hook should be set in the middle of the face of the rod, with the bottom of the hook at least 1 inch up from the end of the rod for protection. In graduating the rod, square off from the point of the hook to the face of the rod and from this point on the rod measure with the steel tape to set the zero graduation on the rod a distance equal to the height of the zero of the scale above the gage datum. If the bottom of the well is above the gage datum it is unnecessary to have the top of the rod extended to the zero graduation. The foot points on the rod should be narrowly saw-cut or scratched deep with an awl, and the proper figures inscribed. 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, auxiliary hooks may be placed on the rod at 5-foot intervals for use in making high-water readings.

Painting.--Door and window frames and gage planks and posts should be given three well-brushed coats of paint and allowed to dry before they are placed in the forms. The third coat for the exposed surfaces, however, may be applied after forms are removed. The doors and other woodwork should be given three well-brushed coats. If possible the tongue and groove planks for the floor and cupboards should be painted before assembling, as decay starts where the surfaces are in contact.

A pure lead and oil outside house paint should be used. The color should match that of the concrete closely, in order to make the doors, etc., less conspicuous.

The paint for the first or priming coat only should be mixed in the proportions of 1 quart ready-mixed outside house paint, 1 pint raw linseed oil, and one fourth pint of turpentine. Turpentine should not be used for any but the priming coat, as it tends to remove the gloss.

INTAKE

An adequate connection by an intake pipe must be made between the gage well and the stream or other body of water for which the fluctuations are to be recorded, to insure maintaining the water within the well at the same level as that on the outside. Although the size of the intake pipe needed will vary somewhat with local conditions, the governing factor in its selection and installation is to insure that it has adequate carrying capacity to admit water into and out of the well at a sufficient rate to maintain this relation without appreciable lag. Some lag is allowable during rapidly rising stages, because equilibrium will be reached as the flow reaches a peak and the rate of rise decreases.

At stations where high velocities may occur there may be a

Pitot tube effect. Frequently differences of as much as 0.2 foot between the outside and inside gages are found, which can be accounted for by the high velocity of the water passing the outer end of the intake pipe.

The following tables will assist in selecting the size of pipe to be used under various conditions. The following tables show the computed or theoretical loss of head, or lag, due to entrance and friction losses in intake pipes of various sizes and lengths for different water-surface areas of wells. The area of the well shown on the standard plans is 13.7 square feet.

A.--Lag in feet due to loss of head in intake pipes of various sizes for well having 9 square feet of water surface.

For 2-inch pipe.

Rate of rise (ft. per hour)	L = 0	L = 10	L = 20	L = 30	L = 40	L = 60	L = 80	L = 100
1	0.000	0.001	0.001	0.002	0.002	0.003	0.004	0.006
2	.000	.003	.005	.007	.009	0.014	.018	.023
5	.003	.017	.031	.046	.060	.089	.118	.146
10	.010	.067	.125	.183	.240	.355	.470	.585

For $2\frac{1}{2}$-inch pipe.

1	.000	.000	.000	.001	0.001	.001	.001	.002
2	.000	.001	.001	.002	.003	.004	.006	.007
5	.001	.005	.010	.015	.019	.028	.037	.046
10	.004	.022	.040	.058	.076	.111	.147	.183

For 3-inch pipe.

1	.000	.000	.000	.000	.000	.000	.000	.001
2	.000	.000	.001	.001	.001	.002	.002	.003
5	.001	.002	.004	.006	.008	.011	.014	.018
10	.002	.009	.016	.022	.029	.043	.056	.070

For 4-inch pipe

1	.000	.000	.000	.000	.000	.000	.000	.000
2	.000	.000	.000	.000	.000	.000	.000	.001
5	.000	.001	.001	.001	.002	.002	.003	.004
10	.001	.002	.004	.005	.006	.010	.013	.016

L = Length of pipe in feet

B.--Lag in feet due to loss of head in intake pipes of various sizes for well having 13.7 square feet of water surface.

For 2-inch pipe

Rate of rise (ft. per hour)	L = 0	L = 10	L = 20	L = 30	L = 40	L = 60	L = 80	L = 100
1	0.000	0.001	0.002	0.004	0.005	0.007	0.009	0.012
2	.001	.006	.012	.017	.022	.033	.044	.054
5	.006	.038	.070	.102	.135	.199	.264	.328
10	.024	.130	.236	.342	.449	.661	.872	1.08

For 2½-inch pipe

1	.000	.001	.001	.001	.002	.003	.004	.004
2	.000	.002	.004	.006	.007	.011	.014	.018
5	.002	.013	.023	.034	.044	.065	.086	.107
10	.010	.049	.087	.126	.165	.243	.320	.398

For 3-inch pipe

1	.000	.000	.000	.001	.001	.001	.002	.002
2	.000	.001	.002	.002	.003	.004	.006	.007
5	.001	.005	.010	.014	.018	.026	.035	.043
10	.005	.021	.037	.053	.069	.101	.134	.166

For 4-inch pipe

1	.000	.000	.000	.000	.000	.000	.000	.000
2	.000	.000	.000	.000	.000	.001	.001	.001
5	.000	.001	.002	.003	.004	.006	.008	.010
10	.002	.005	.009	.012	.016	.023	.030	.038

L = Length of pipe in feet.

C.--Lag in feet due to loss of head in intake pipes of various sizes for well having 20 square feet of water surface.

For 2-inch pipe

Rate of rise (ft. per hour)	L = 0	L = 10	L = 20	L = 30	L = 40	L = 60	L = 80	L = 100
1	0.001	0.004	0.007	0.010	0.012	0.018	0.024	0.030
2	.002	.013	.025	.036	.047	.070	.092	.115
5	.013	.081	.148	.216	.284	.420	.556	.692
10	.050	.316	.582	.848	1.12	1.65	2.18	2.71

For 2-1/2-inch pipe

1	.000	.001	.002	.003	.004	.005	.007	.008
2	.001	.004	.008	.011	.015	.022	.030	.037
5	.005	.026	.047	.068	.089	.131	.173	.215
10	.021	.103	.185	.267	.349	.514	.678	.842

For 3-inch pipe

1	.000	.000	.001	.001	.001	.002	.003	.004
2	.000	.002	.003	.005	.006	.009	.012	.014
5	.003	.011	.020	.028	.036	.053	.070	.087
10	.010	.044	.077	.110	.145	.212	.279	.346

For 4-inch pipe

1	.000	.000	.000	.000	.000	.001	.001	.001
2	.000	.001	.001	.001	.002	.002	.003	.004
5	.001	.003	.005	.007	.008	.012	.016	.020
10	.003	.010	.018	.025	.033	.048	.063	.078

L = Length of pipe in feet.

After choosing one of the above-listed sizes of pipe to fit the conditions at a proposed gaging station, the arbitrary increasing or decreasing of this theoretical size for actual use will depend upon various other factors that affect the rate of passage of water through an intake pipe, among which are (1) clogging of the intake by silt, ice, or other material; (2) velocity of the water in the stream; (3) need for dampening extreme surge and wave action in the stream or other body of water.

For most installations, particularly those that are equipped with flushing apparatus, either 2-1/2-inch or 3-inch intake pipes are adequate. If larger intakes are used, there may be danger of wave action being transmitted to the well which may require reducing, and if smaller intakes are used there is danger that water may not be taken in and out of the well fast enough to eliminate lag or that they may become clogged. At certain gaging stations 2-inch pipes were not strong enough to prevent being bent downstream during severe floods. Four-inch pipes can not always be flushed satisfactorily. The following table may be used as a guide in determining the size of pipe.

Size of intake pipe for various local conditions.

Local conditions	Lower pipe (inches)	Secondary pipe (inches)
A. Clear water, small surge or wave action (rivers just below power plant or lake outlets, or small lakes protected from wind). Flushing system not needed.	3 or 4	None
B. Clear water, slow rises, but heavy wave action (lakes and large reservoirs). Flushing system not needed.	2 or 2-1/2	2 or 2-1/2, if any
C. Clear water most of year with silt for short periods, slow rises, not much surge, average condition. Use flushing system.	2-1/2 or 3	2-1/2 or 3
D. Silty water most of the time. Use flushing system or a silt trap.	2-1/2 or 3	2-1/2 or 3

The intake should be perpendicular to the current at high water and should be low enough to be well covered in the lowest stage of water. The bottom of the well should be far enough below the intake to provide for the collection of silt and to enable the intake to be readily accessible from the inside of the well. In cold climates the intake should be below the frost line.

It is often desirable to provide one or more secondary intakes at different levels, especially on streams having a wide variation of stage. These will insure against loss of records on silt-laden streams if the lower intake clogs. In cold climates the lower intake may become clogged with ice, and the secondary intake will come into action and eliminate loss of record during freshets. The secondary intake also provides increased intake capacity, which will tend to eliminate lag for rapidly rising streams. If the secondary intake is out of the water it may admit enough cold air to cause freezing in the well, and in that event it will be necessary to provide protection.

Extra openings through the well should be provided and plugged so that additional intakes may be placed if needed or the position of the intake pipes may be changed. Where ice forms to a considerable depth, it is difficult to ascertain the best possible location of intakes until some experience has been gained.

The well end of the intake pipe should be threaded and protected by a union to permit the connection of the valve, etc. Graphite or other heavy grease should be used in attaching the union so that it can be readily removed, and during construction, a metal plug should be inserted in the union. It should be borne in mind that the threads that have been cut on galvanized pipe are not galvanized and are subject to rust if not protected. If the connections are not to be installed in the near future, the threaded ends may be coated as described above and wrapped with burlap. If there is a possibility that the intake may need to be extended farther outstream, the threads on the outer end may be similarly protected. Pipe caps may be screwed on the ends to protect the threads for future use.

A length of the intake pipe may be set in the walls of the well when they are built, or a piece of pipe 1 inch larger in diameter than the intake pipe may be set in the forms as shown on the plans. This prevents cutting holes in panel forms and permits easy adjustment of the intake pipe for vertical and horizontal direction. It requires care, however, to make a tight seal to prevent leakage of water into or out of the well. When making the seal with mortar, rags should be wrapped around the intake and plugged into the crevice either on the outside or inside of the well, to prevent any current washing the cement out of the mortar which is placed from the other side. After the mortar has set the rags may be removed and mortar placed on that side. If a tight seal cannot be made in this manner, two or three buckets of concrete may be placed on the outside of the well where the intake enters.

Another method is to place between the forms an assembly consisting of two couplings joined by a close nipple and adjusted to be as long as the exact thickness of the wall. This should be filled with sand and either cloth or paper tied over each end to hold the sand, after the threads have been protected by grease, lead, or a paste made by mixing linseed oil and cement.

If plank forms are used, a short section of pipe of the same size as the intake pipe can be placed through the forms and set in the walls of the well when they are built. The outside of the pipe should be roughened with a chisel in order to make a strong bond with the concrete and prevent the pipe from turning in the wall. Further bond can be obtained by screwing two 1/2-inch bolts about 2 inches long into the pipe, with their ends flush with the inside walls of the pipe.

In the installation of intakes, ground-joint railroad unions should be used. It is much easier to connect the pipes in the trench with unions than with couplings. The unions permit correction of slight errors in direction and also permit making changes and adjustments with the minimum amount of trouble.

All pipe and pipe fittings should be galvanized. Although galvanized wrought-iron pipe costs about twice as much as galvanized steel pipe it should be specified, as it has a much longer life. Brass gate valves are recommended up to the 2-1/2-inch size. For larger sizes iron-body valves with brass fittings are satisfactory and much more economical. In close quarters where it is necessary to take the valve apart to install it on the intake, an iron-body brass-mounted clip or clamp-type gate valve is more convenient, because of ease of dissembling, than the all-brass gate valve, which is not made in the clip type but which can be taken apart by removing the bonnet.

If the well is in a dam, bridge pier, etc., with a short intake, the pipe should have a downward slant of about 30° from the vertical, in order that silt will not be deposited in it.

In wells receiving considerable silt it may be necessary to install a 2-inch vertical pipe for the float counterweight. This pipe should be closed at the lower end.

Occasionally it is necessary to install the intake by jacking the pipe either from the inside of the well out to the stream or to an intake trench, from an intake trench out to the stream, or from the stream to the excavation for the well. This method may be required when a recording gage is to be installed on the bank of a canal or on a levee. It can be used in clay or other soils, quicksand, and gravel. It can be used in gravel intermixed with boulders if the material has first been blasted to shatter and loosen the boulders.

To jack the pipe from the well toward the stream or intake trench it is necessary to have the pipe cut into about 28-inch lengths, and both ends carefully threaded with two or three more threads than are usually cut. It has been found that 3-inch pipe is the best for this purpose, as it possesses greater strength and rigidity than the smaller sizes. Extra heavy recess or casing couplings should be used for connecting the pipe sections. The jack used should be of as compact a design as can be procured. A hydraulic jack with a rated capacity of 25 tons is about 9 inches in length and is operated by a hand lever 1 foot long. Another type of jack, which may be operated more rapidly, is the track jack with a capacity of 20 tons. It has the disadvantage of being awkward to handle in cramped quarters.

In jacking the pipe the outer end of the first section of pipe must be closed, either with a cap or with a pointed hardwood plug. An eyebolt should be placed in the wooden plug for convenience in removing it. It is essential that the first section of pipe be started at the desired slope and direction. In clay and sandy soils the outer end of the pipe will tend to drop as it is jacked toward the stream. Through gravel it will tend to move upward. This tendency should be considered when lining up the first section of pipe.

If the pipe is not to be jacked from the inside of the well but from the excavation to the stream or vice versa, longer sections may be used, from 8 feet up to full lengths. Unions should be used for any connections to be made after the pipe is in position, as they are easier to install than couplings and they permit some change in direction.

If the pipe is jacked from the stream to the well, this must be done before the well is constructed.

Flushing Equipment.

The flushing equipment shown on the attached plans is recommended as a standard for all stations where a moderate amount of silt is encountered. The use of one of the silt traps shown on the plans instead of a flushing system is optional where a considerable amount of silt is encountered and where the stream is flashy enough to permit the trap to be cleaned frequently. The characteristics of the stream must be taken into consideration before deciding whether to use flushing equipment or a silt trap. In the Southwest silt traps are in general use. In the Northwest, where the glacial streams are high for months at a time, three or more intake pipes with risers to each one are necessary. Three or more are needed because of the building up and washing out of bars over the lower pipes. For a flushing system where considerable quantities of silt may cause valve trouble with a lift pump, specially constructed buckets with valves in the bottom, as used in the Tacoma district, work very well. Details of this plan can be obtained from the Tacoma office. Whichever plan is used, it is important that the well door be made as watertight as possible; otherwise great quantities of silt may enter the well and hinder the cleaning of the intakes either by the flushing equipment or by the silt trap.

The flushing equipment consists of a riser pipe connecting the intake to a flushing tank, a lift pump to fill the tank, and a gate valve, with key, to prevent the flushing water from discharging into the well. (More than one intake may, of course, be connected to the flushing tank by using separate risers, valves, and connections to the tank. They should be flushed separately, however.) When the flushing system is being installed it does not double the cost to connect it to two intakes, as the same tank, pump, and pump pipe are used for both. The work of keeping the second intake open is thereby made much easier. (Where silting is likely to be serious the riser pipe and the connection to the flush tank should preferably be of the same diameter as the intake pipe. Riser pipes and flush-tank plugs half an inch less in diameter than the intake but not less than 2 inches may otherwise be used) however. The plans show a lift pump with a 1-1/4-inch pipe and a 3 by 10-inch brass-lined cylinder, which is the size of pipe and cylinder usually carried in stock by dealers. A pump fitted for 1-1/2-inch pipe and with a 3-1/2-inch brass-lined cylinder is recommended if readily obtainable, except for very deep wells, as the capacity is much greater. The pump-rod couplings should not be placed so close to the pipe couplings that they will catch on them. Pitcher spout pumps are not recommended. The weight of the pump should be supported by the pump base resting on the floor of the house. The pump pipe should be prevented from swinging by means of a stock pipe hanger and an adjustable metal strap bolted to the side of the well. The cylinder should always be submerged if possible. A small drain hole should be drilled in the pipe just above the cylinder. (At least one ground-joint railroad union is required for each riser pipe.)

In a small well the placing of the gate valve behind the riser pipe and in line with the intake may interfere with the float or with working in the well. In such a case a side-outlet elbow or a four-way tee may be placed on the intake. If the side-outlet elbow is used the side outlet should be used for the close nipple and valve and one of the end openings turned up for the riser pipe. If the four-way tee is used one side outlet should be used for the nipple and valve, the other side outlet turned up for the riser, and the back end opening closed with a plug. The elbow causes less disturbance in the water when flushing. The cross permits cleaning the intake from the inside with cable or sewer rods.

Silt trap.

The following description of silt traps and the attached plans were arranged by C. E. Ellsworth.

A silt trap may be used to advantage at some recording-gage installations where an intake pipe is necessary. Its primary purpose is to catch silt that would otherwise be deposited in the stilling well or intake pipe; its secondary purpose is to furnish an efficient means for cleaning the intake.

The accompanying drawings show three types of silt traps-- a circular concrete trap, a rectangular concrete trap and a metal trap of corrugated pipe. The use of the circular concrete trap would probably be restricted to districts having circular metal forms and also probably to jobs where the forms were already on the ground for the construction of a circular stilling well. The rectangular concrete trap may be used at any location where stability is a needed feature and where water trouble is not too serious and cofferdam expense too great, and even then, of course, if stability is necessary regardless of expense. The metal trap is popular because of its economy and ease of installation and is suitable to any location not subjected to excessive velocities. It can be installed at places where a concrete trap would not be feasible because of difficulty in providing a suitable foundation.

The essential features of all types of traps are the same. The trap should be located at or very near the edge of " low water in order to be sure of free entrance of water to the trap at all times. A short intake, not more than 3 or 4 feet in length and not less than 3 inches in diameter, may be used between the trap and the stream if necessary, and there will be small probability of its clogging unless the ends become covered.

The required depth of trap below the intake pipe depends on the silt burden of the stream, the duration of flood periods, and the frequency with which the trap can be cleaned. A 2-foot sump is sufficient under ordinary conditions. However, the deeper the sump the greater the margin of safety.

The top of the trap should be at a height somewhat above ordinary stage, as the trap cannot be cleaned when the water is above the cover. On streams subject to such long continuous floods that the trap is likely to fill with silt above the intake level before the flood recedes sufficiently to permit cleaning, it may be advisable to install an intake slightly below the top of the trap and not connected with it. However, in that event the trap would lose a large part of its effectiveness.

The number of intake pipes used likewise depends on the characteristics of the stream. In some localities it will be advisable to use three intakes--the upper one just below the top of the trap, the intermediate one at ordinary low-stage level, and the lowest one at the lowest stage that may be expected. The lowest intake may be kept closed except when a stage below the intermediate intake is expected. At many stations two intakes will be desirable, and on some small streams and on larger ones with well-known habits one intake may be sufficient.

Screw gate valves with stems extended are used on intakes within the trap, in order that whenever the trap is accessible the water may be shut off and the trap cleaned. After cleaning the trap the valves on the intakes to the well may be opened and permit the water to flow from the well to the trap; the well may then be cleaned if necessary; then the valves from the trap to the well may be closed and the valves from the trap to the river opened, allowing the trap to fill with water; then the valves from the trap to the well may be reopened, allowing water to flow back into the well. This process may be repeated until the intakes are positively clean.

The baffle is advisable as an aid to the settlement of silt. It should extend from a level below the lowest intake to one above the highest intake.

Staff gages should be attached to both the inside and the outside of the trap.

An iron ladder, a little shorter than the depth of trap, left standing in the trap is convenient.

A silt trap will not ordinarily catch all of the silt, but some will be deposited in the well and the intake. It is therefore also necessary to provide a generous sump in the well.

A silt trap is probably not adaptable to some streams of heavy silt burden and subject to long-continued floods.

The silt trap does away with the necessity of a low-water gage pier, which is expensive and difficult to install with sufficient security to prevent overturning during flood time. The effective cost of the trap is therefore reduced by the amount that it would cost to install a substantial pier.

Outside Gage

There are several satisfactory types of outside or auxiliary gages. If the well extends above the ground level, as much of the outside gage as possible should be placed on the well. If the well is situated on a steeply sloping bank, it is convenient to place a short section of the outside gage on the center of the streamward side and the upper sections on either the upstream or the downstream side, the choice depending mainly on the location of the well door. If the above-mentioned short section can be read without too much difficulty it may save constructing one gage pier. The same method of setting the gage plank in the forms may be used as in setting a staff gage in the well, as shown on the plans, or the plank may be bolted to the concrete after the forms are removed, using malleable lead anchors. At some sites the outside gage may be fastened to a suitable tree. If a silt trap is installed the lowest section of the outside gage should be placed on it. Gage sections should not overlap in the range covered.

A very satisfactory type of outside gage consists of a post of oak or other durable wood set vertically in a substantial concrete pier, which is cast around three sides of the post and flush with the side of the post toward midstream. Lag bolts should be placed in the post before the concrete is poured, to fasten it securely to the concrete. 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 gage scales on the side of the post toward midstream should extend slightly above the level of the top of the concrete. Above that point they should be placed on the back of the post. The top of the post should be beveled and capped with galvanized iron. The post should be well painted or treated with preservative to prevent rapid swelling before the concrete has set. In cold climates the bottom of the gage piers should be below the frost line. The low-water pier may be set in the downstream side of the intake trench but should not be cast around the intake, as it may be necessary to replace the intake at a later date. Where floating drift, ice, or logs are apt to hit the gage pier, it should be made shorter in height and larger in both horizontal dimensions than is usually necessary. Under such conditions the forms should be sloped in such a way as to streamline the gage pier effectively and permit ice or debris to be warded off from it without damage, and the post should not extend above the concrete. As a general rule, a 6 by 6 inch post should be used. The pier should be at least 2 by 4 feet in plan at the base, with the longer dimension parallel to the stream. It is better to err in making a pier too large in plan than too small.

In some districts it is preferred to anchor a piece of galvanized-steel channel into the concrete pier instead of the post. The channel is allowed to extend above the concrete. The bedpiece is then fastened by means of bolts to the channel. This provides a stronger cantilever arm for the gage and eliminates any possible cracking of the concrete pier due to swelling of the wood.

Another satisfactory type of vertical staff gage consists of a section of 7-inch steel channel set in a concrete footing in the intake trench. The channel is bolted just below the natural ground level to an 8 by 8-inch reinforced-concrete beam, which is made to span the intake trench and is about 4 feet longer than the width of the trench. The channel is placed with the legs away from the stream, so that a 2 by 6-inch plank may be bolted in the channel as a bedpiece for the gage scales. If more than one section is required, they may all be placed in the intake trench or, if more practicable, the higher sections may be set in holes at least 5 feet deep. Each hole should be filled with concrete after the channel has been plumbed.

Inclined gages with a bedpiece of heavy timber or with an inclined bedpiece of reinforced concrete have been used. The timber bedpiece may be mounted on substantial concrete piers or on 7-inch galvanized-steel channels driven into the ground, or, if frost occurs, it may be set in concrete below the frost line. The reinforced-concrete bedpiece 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. This type of gage is more expensive to install and probably more likely to become inaccurate than the vertical staff set in substantial concrete piers.

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 difficult to use the record of stage for determining discharge. The first essential at a gaging station is that the bench mark be more permanent and stable in position than the gage itself. The reverse of this has too often been true. Two or three independent bench marks at each station are desirable. Wherever possible one should be so placed that the inside and outside gages may be checked with a level using equal and short sights. At least one should be far enough back 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. Bench marks should not be placed on new or unstable structures. At bridge stations at least one bench mark should be apart from the bridge. Great care should be used in determining the altitude of the bench marks and in setting the gages. Levels should not be run to bench marks or gages set on new concrete piers before the concrete has thoroughly set. The level rod should be read to thousandths of a foot. A separate run or circuit of check levels should be made.

The use of the standard gaging station reference-mark tablet is recommended. It may be set on the abutment of a bridge, on a rock ledge, or on a concrete pier made for this purpose. If it is to be placed on a concrete pier a hole should be dug deep enough to get well below the frost line, if in a cold climate, and at least 4 feet deep. The deeper it is the better. The bottom part of the hole should be at least 1 foot in diameter. It should be filled for about 1 foot with concrete. Four vertical reinforcing bars hooked at the bottom should be pushed into the concrete in the bottom of the hole, and a piece of 6-inch stovepipe long enough to extend 6 inches above the ground lowered into position over and around them and pushed about 2 inches into the concrete. The bars should reach within an inch of the top of the pipe. The pipe should then be plumbed, held in position by earth backfill, and filled with concrete. The tablet should be set in the top. Instead of using stovepipe some engineers prefer to dig a larger hole, place concrete in the bottom of it, and then place on the wet concrete a pyramidal wooden form 2 feet square at the base and 6 inches square at the top. Four reinforcing bars are used, one near each corner of the form. The forms are removed before backfilling.

COST-KEEPING.

The field engineer should keep the time of the crew and turn it in to the district office for the pay roll, using a method which will minimize the possibility of duplication or other error. See sample form A.

The following method of cost-keeping on recorder construction work is recommended for the district offices of the U. S. Geological Survey. The same general method may be used on other construction work.

1. In the district office: List on cost sheets, form 9-216, all pay rolls and vouchers that pay any items in connection with recorder construction work. The charges should be segregated under services, transportation, subsistence, materials, etc. Separate forms are made for each recorder installation and for "Moving plant" and "Top cost and depreciation" for the season. This list should be brought up to date when pay roll and vouchers are made out. At the end of the season the totals of "Moving plant" and "Top cost and depreciation" should be divided between and charged to the several installations. Equipment is usually depreciated at 25 percent a year.

2. In the field: Keep daily record of time spent and materials used in the following subdivisions of the work:

1. Excavation for well, backfill, clean-up.
2. Well and house.
3. Intake, excavation, and materials.
4. Auxiliary gages, bench marks, etc.
5. Recorder, installed.
6. Moving plant.
7. Top cost and depreciation.

The field engineer's entries under item 7 will be mainly for tools purchased in the field and for lost time on account of bad weather, etc. (if considerable). The field engineer should keep a daily memorandum of the number of hours spent by the crew and himself and the cost or estimated cost of the materials used in all the subdivisions of the work except materials for item 2, "Well and house," which need not be listed by the field engineer. After entering the cost of materials charged to the lesser subdivisions, the balance of materials from the cost sheets in the district office is charged to "Well and house," which is the large item. See sample form E.

3. In the district office: At the end of the season compute and list on charge sheets, form 9-272 (one for each recorder installation),

the total costs for the seven subdivisions of the work. The costs for each of these seven subdivisions need not be segregated under services, transportation, etc., on the charge sheet. The prorated costs of "Moving plant" and "Top cost and depreciation" are shown in the totals column opposite items 6 and 7 on the charge sheet for each installation. On each charge sheet indicate the over-all height, depth of excavation, length of intake, and time, including Sundays and holidays, but excluding lost time (if considerable) and moving plant. The lost time (if considerable) should be charged to top cost for the season and prorated. See sample form F.

A summary of costs for the season may then be shown on a separate charge-sheet form. A similar summary charge sheet for a construction program covering several years may also be prepared. Sample form G shows the summary of costs of 65 concrete installations in the Ohio district in 1923-31. These summary sheets show the total and the mean costs as divided among the seven construction items obtained from the individual charge sheets, and also the total and mean costs as segregated among the cost-keeping items of services, transportation, subsistence, materials, etc., obtained from the cost sheets. The summary charge sheets should also show the five items over-all height, depth of excavation, length of intake, time, and cost of labor and should indicate the total cost per foot of height, excluding price of recorder.

Form A. UNITED STATES GEOLOGICAL SURVEY

WATER RESOURCES BRANCH

Field engineer's weekly record of time for payroll and report of progress.

Construction work on Cuyahoga River near Hiram, Ohio

Name	Pay	Sun. 8/7 (date) Hrs.	Mon. 8 Hrs.	Tue. 9 Hrs.	Wed. 10 Hrs.	Thur. 11 Hrs.	Fri. 12 Hrs.	Sat. 13 Hrs.	Total Hrs.	Lost time, over-time Hrs.
J.H.Bass	$4 per day	0	8	8	9	9	8	4	46	+2
L.D.Cummings	"	0	8	8	9	9	8	4	46	+2
O.N.Essex	"	0	5	8	9	9	8	4	43	-1
M.C.Grogan	"	0	8	6	9	9	8	4	44	0

Report of Progress:

(Signed) E. P. Coady

(Date) Aug. 14, 1927

9-216—December, 1927

Form "B"

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

COST SHEET

EXPENSES ON ACCOUNT OF TOP COST AND DEPRECIATION DURING THE FISCAL YEAR 1927.

GOVERNMENT PRINTING OFFICE 6—6894

Voucher No.	Date	Name	Investigations, Surveys, Operation, and Maintenance				Construction				Office Work	Top Cost	Nonexpendable Property	Total Charges
			Services	Transportation	Subsistence	Materials	Services	Transportation	Subsistence	Materials				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
494	6/15	Panel forms								62.51				62.51
498	6/30	Pay Roll					28.50							28.50
503	6/30	Cornice forms								22.00				22.00
512	6/30	New tools, etc.								14.82				14.82
42	8/15	Pump hose								18.00				18.00
		Deprec.on truck											142.00	142.00
		" " tools								17.50				17.50
		etc.												
		Totals					389.81			167.84			142.00	699.65
		Per installation					64.97			27.97			23.67	116.61

9-216—December, 1927

Form "C"

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

COST SHEET

EXPENSES ON ACCOUNT OF MOVING PLANT DURING THE FISCAL YEAR 1927.

GOVERNMENT PRINTING OFFICE 6—6894

Voucher No.	Date	Name	Investigations, Surveys, Operation, and Maintenance				Construction				Office Work	Top Cost	Nonexpendable Property	Total Charges
			Services	Transportation	Subsistence	Materials	Services	Transportation	Subsistence	Materials				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6	7/15	Pay Roll					20.10							20.10
11	7/15	L.L.expenses						10.50	13.50					24.00
15	7/31	Pay Roll					20.10							20.10
18	7/31	Gasoline						14.50						14.50
33	8/15	Pay Roll					40.00							40.00
		B/L 14004								3.42				3.42
		B/L 14007								5.55				5.55
		B/L 14008								1.94				1.94
		etc.												
		Totals					157.37	39.31	33.37	10.91				240.96
		Per installation					26.23	6.55	5.56	1.82				40.16

9-216—December, 1927

Form "D"

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

COST SHEET

EXPENSES ON ACCOUNT OF CUYAHOGA RIVER NEAR HIRAM, OHIO DURING THE FISCAL YEAR 1927.

Voucher No.	Date	Name	Investigations, Surveys, Operation, and Maintenance: Services	Transportation	Subsistence	Materials	Construction: Services	Transportation	Subsistence	Materials	Office Work	Top Cost	Nonexpendable Property	Total Charges
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
492	6/30	Hardware								2.19				2.19
503	6/30	Doors & frames								19.97				19.97
516	6/30	Enamel gages								5.04				5.04
1	7/1	Ladder steps								4.20				4.20
F 96	7/5	Padlock								2.20				2.20
11	7/5	L.L.expenses						1.18	4.25					5.43
14	7/5	Recorder											207.50	207.50
33	8/15	Pay Roll					141.50							141.50
59	8/31	E.P.C.expenses						4.15	15.06	8.50				27.71
70	9/19	Sand & gravel								23.75				23.75
85	9/19	Lumber & cement								54.46				54.46
		Etc.												
		Totals					314.50	9.25	27.10	235.66			207.50	794.01

Form "E"

UNITED STATES GEOLOGICAL SURVEY and OHIO COOPERATIVE TOPOGRAPHIC SURVEY

Recorder installation on CUYAHOGA RIVER NEAR HIRAM, OHIO

Field engineer's record of distribution of time and materials.

Date	1 Excav. Backfill Clean up: Men	Hrs.	2 Well and house: Men	Hrs.	3 Intake incl. excav.: Men	Hrs.	4 Aux. ga. B.M.'s Etc.: Men	Hrs.	5 Recorder: Men	Hrs.	6 Moving plant: Men	Hrs.	7 Top cost and lost time: Men	Hrs.	Materials for items 1 and 3-7 only. Note item number, kind of material, and approx. cost.
1927. Aug. 10	3	8									2	9			
11	3	8									2	9			#1, Lumber for shoring, $10.
12	3	8			1	8					2	5			
	2	3													
13			5	4											
15			5	8											
16			1	8	2	8	4	4							#4, Gage pier $12.50.
17			3	8	2	3									#3, 26' of 4" pipe $29.70.
			2	5											
etc.															
Total hrs		123		333		30		18		4		46			

9-872 December, 1927

Form "F"

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

CHARGE SHEET

CUYAHOGA RIVER NEAR HIRAM, OHIO

Office at Columbus, Ohio, ____, 19 27.

Distribution of voucher { Field No. ____ Washington No. ____ } dated ____, 19__, in favor of ____, for $____

chargeable to the appropriation for ____ This voucher is to be charged against the allotment for ____

ITEMS FOR WHICH COSTS ARE DESIRED	INVESTIGATIONS, SURVEYS, OPERATION AND MAINTENANCE				CONSTRUCTION				OFFICE WORK	TOP COST	NONEXPENDABLE PROPERTY	TOTAL CHARGES
	Services 4	Transportation 5	Subsistence 6	Materials 7	Services 8	Transportation 9	Subsistence 10	Materials 11	12	13	14	15
1. Excavation for well, backfill, clean-up												$ 80.00
2. Well and house												433.31
3. Intake, excavation and materials												41.70
4. Auxiliary gages, bench marks, etc.												28.00
5. Au recorder, installed												211.00
Subtotal												794.01
6. Moving plant												40.16
7. Top cost and depreciation												116.61
Total												950.78

Total time, 15 days.

Over-all height, 19 ft.

Depth of excavation, 9 ft.

Note.- A picture of this installation is shown in "Plans and Specifications, 1927."

9-872 December, 1927 Form "G"

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

CHARGE SHEET

SUMMARY OF COSTS OF 65
CONCRETE RECORDER INSTALLATIONS.

Office at Columbus, Ohio, 1923-1931, ~~19~~

Distribution of voucher { Field No. ____ Washington No. ____ } dated ____, 19__, in favor of ____, for $____

chargeable to the appropriation for ____ This voucher is to be charged against the allotment for ____

ITEMS FOR WHICH COSTS ARE DESIRED	INVESTIGATIONS, SURVEYS, OPERATION AND MAINTENANCE				CONSTRUCTION				~~OFFICE WORK~~ (Mean)	TOP COST	NONEXPENDABLE PROPERTY	TOTAL CHARGES
	Services 4	Transportation 5	Subsistence 6	Materials 7	Services 8	Transportation 9	Subsistence 10	Materials 11	12	13	14	15
1. Excavation for well, backfill, clean-up									$ 153			$ 9965
2. Well and house									640			41599
3. Intake, excavation and materials									75			4848
4. Auxiliary gages, bench marks, etc.									41			2649
5. Au recorder, installed									211			13730
Subtotal									1120			72791
6. Moving plant									38			2450
7. Top cost and depreciation									104			6761
Total									1262			82002
Segregation: Totals					$35668	4358	2456	24899			14616	82002
Segregation: Mean					549	67	38	383			225	1262

Over-all height....total 1795 ft.; mean 28 ft.

Depth of excavation " 652 " " 10 "

Length of intake... " 1861 " " 29 "

Time............... " 1772 da.; " 27 da.

Total cost per foot of height, excluding price of recorder, $38.

Average cost of labor, $4.50 per day.

Bill of materials

Lumber.--

Pieces.	Description.	Use.
As req.	No. 2 yellow pine lumber and oak wedges for panel forms not itemized, as forms are usually made by planing mill....................................	Forms.
4	Corner blocks for foof forms, as shown on plans.....................................	Forms.
As req.	1" x 4" x 14' or 16' No. 2 Y. P...........	Miscellaneous
As req.	1" x 12" x 16' No. 2 Y. P................. (unless mixer is used)	Mixing platform.
As req.	2" x 4" x 14' or 16' No. 2 Y. P...........	Miscellaneous
As req.	2" x 6" x 14' or 16' No. 2 Y. P...........	Miscellaneous
As req.	2" x 10" x 10' or 14' No. 2 Y. P..........	Shoring.
As req.	4" x 4" x 10' No. 2 Y. P..................	Shoring.
2	2" x 12" x 12' No. 2 Y. P.................	Outside well forms (first foot)
1	2" x 12" x 14' No. 2 Y. P.................	Inside well forms (first foot)
2	2" x 4" x 3'8-3/8" cypress................	Floor ring.
2	2" x 4" x 3'11-5/8" cypress...............	Floor ring.
2	2" x 4" x 3'10¾" cypress..................	Floor ring.
3	2" x 6" T. & G. x 3'11-1/8" cypress.......	Floor.
1	2" x 6" T. & G. x 2'0" cypress (with groove only).........................	Floor
5	2" x 6" T. & G. x 2'0" cypress (1 with groove planed off)......................	Trap door.
2	2" x 4" x 2'0" cypress....................	Trap door.
4	2" x 4" x 1'10-5/8" cypress...............	Shelf support.
2	2" x 4" x 1'8-3/8" cypress................	Shelf support.

Pieces.	Description.	Use.
5	2" x 6" T. & G. x 1'8-3/8" cypress (1 with groove planed off)....................	Cupboard end.
10	2" x 6" T. & G. x 2'7" cypress (2 with groove planed off)....................	Cupboard front and top.
4	2" x 4" x 1'5" cypress....................	Instrument support.
2	2" x 4" x 2'7" cypress....................	Instrument support.
As req.	2" x 5" cypress..........................	Gage planks.
As req.	6" x 6" oak..............................	Gage posts.
2	Door frames, as shown on plans.	
2	Doors, as shown on plans.	
1	Window frame, as shown on plans.	
1	Window, as shown on plans.	
1	Window shutter, as shown on plans.	

Note.--In localities where cypress is not readily obtainable, substitute the most durable wood available.

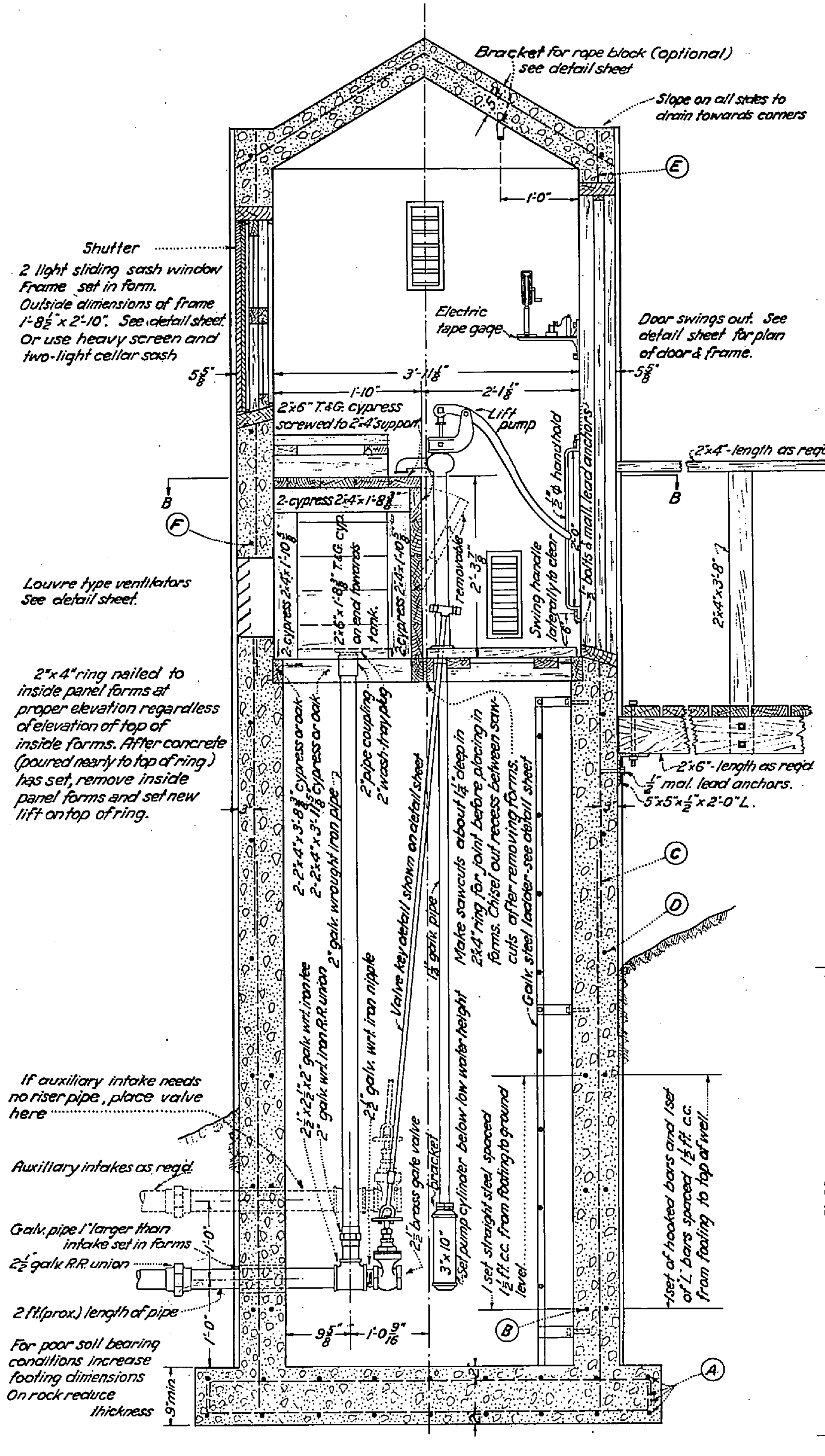
Reinforcing steel.--Half-inch round or square deformed bars throughout. Specify intermediate grade, new billet steel. Schedule of steel shown on plans.

Concrete materials.--Quantities: Footing 1.0 cu. yd.; well, 0.4 cu. yd. per foot in height; house, 2.6 cu. yds. Quantities for gage piers, etc., as required. Order 6 sacks cement, 0.5 yd. sand, and 0.9 yd. 1-inch stone or gravel per yard of 1:2:4 concrete.

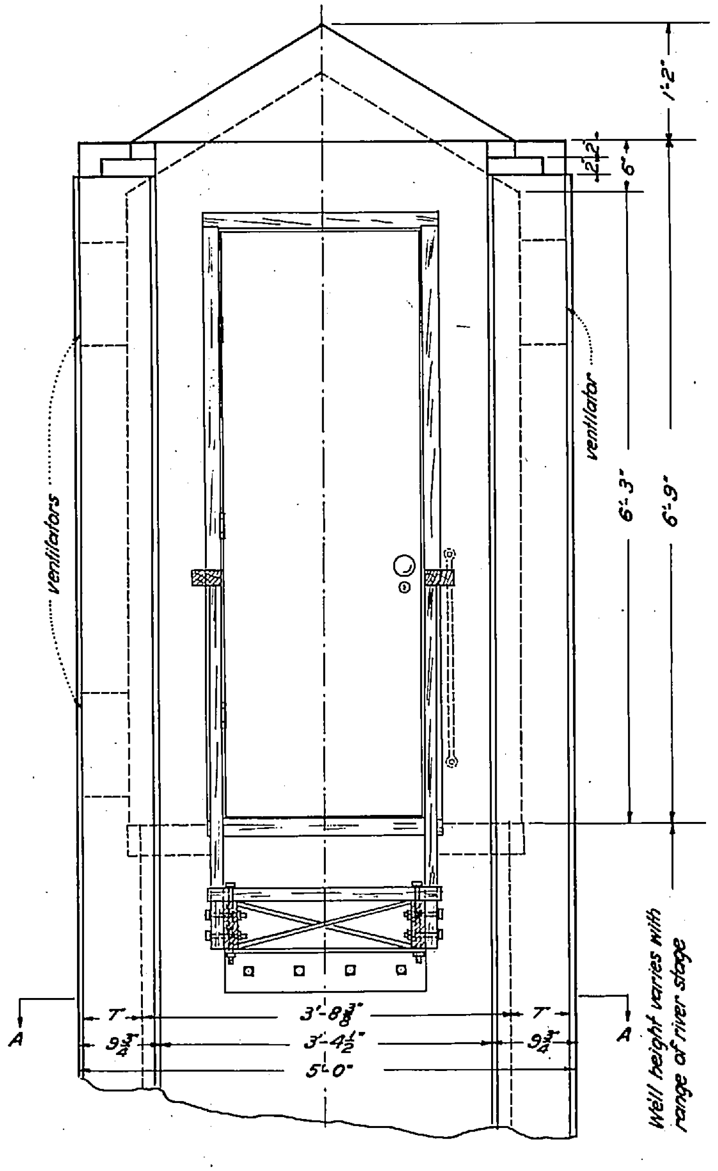
Hardware and miscellaneous.--

As req.	6d to 40 d common nails.
1	set of steel roof forms.
As req.	Oil for forms.
As req.	Pure lead and oil paint; color to match concrete.
As req.	Galvanized pipe nipples, not necessarily threaded (to be placed in forms for intake).
6	Ventilators.
As req.	Galvanized wrought-iron pipe for intake, riser, and pump.
As req.	Galvanized tees, nipples, unions, etc.
As req.	Brass gate valves.
As req.	Gate valve keys.
1	Roof bracket for rope block (optional).
As req.	Brackets for riser pipe and valve key, two for each key.
1	Flushing tank.
1	Lift pump with brass-lined cylinder.
As req.	Galvanized-steel ladder or manhole steps.
1	½" x 5" x 5" x 2' steel angle for footwalk support.
As req.	½" bolts and malleable lead anchors for ladder, gage planks, footwalk support, etc.
1	Hand hold, to be placed above trap door.

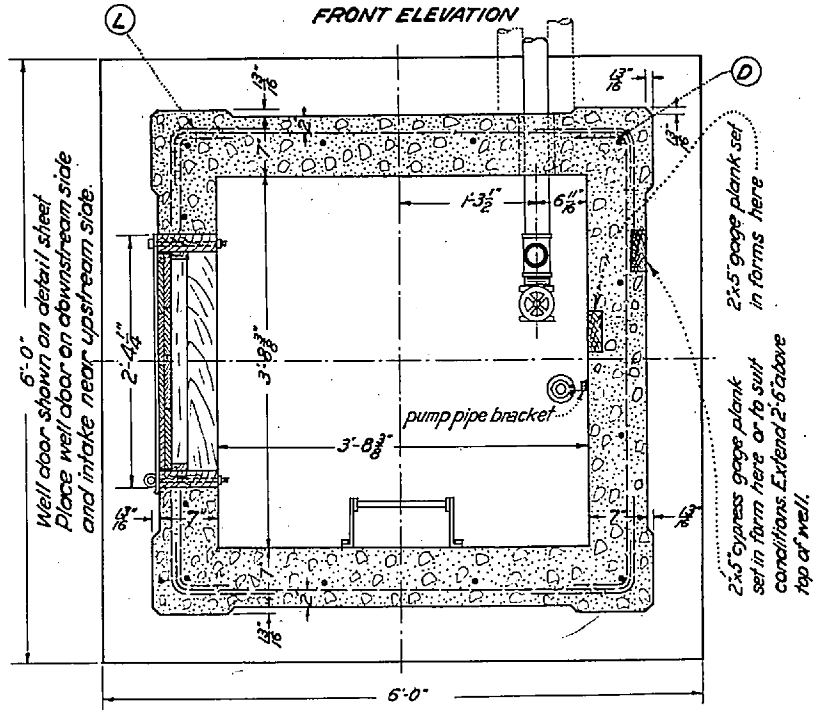
As req.	Galvanized bar locks and bolts for doors as shown on plans.
3 pairs	4" brass or sherardized butt hinges, pin not removable.
1 pair	3-inch brass or sherardized butt hinges, pin not removable.
1 pair	5-inch tee hinges, for trap door.
1	Flush trap door ring, with stove bolts.
1	6-inch galvanized safety hasp for house door (optional).
2	Large D handles or refrigerator-door handles for house and well doors, with stove bolts.
2	Hooks and eyes, for trap door and shutter.
1	10-inch hook and eye, to hold shutter open.
As req.	Bolts for footwalk.
As req.	Padlocks.
As req.	Galvanized-iron wire.



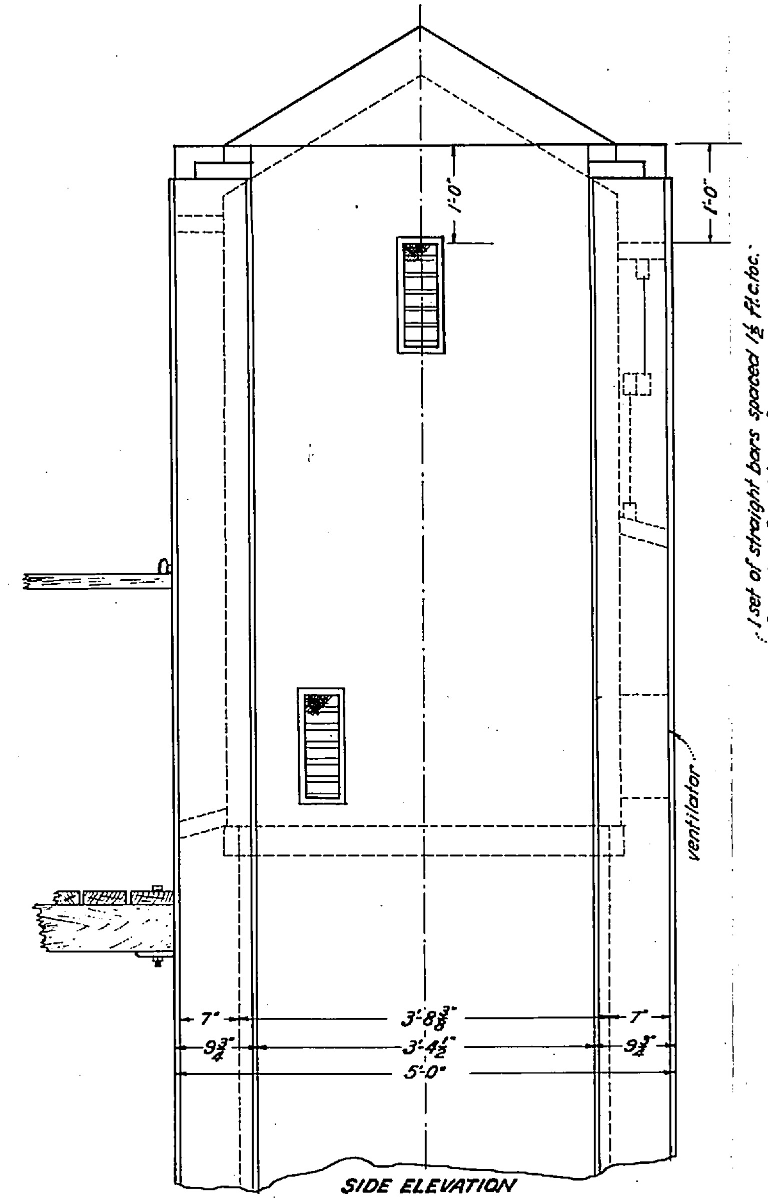
SECTION ON ℄



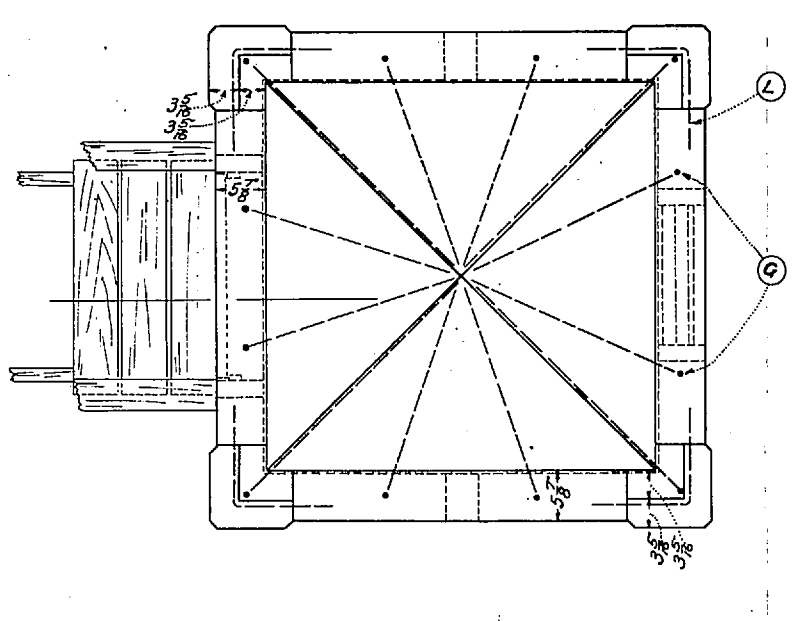
FRONT ELEVATION



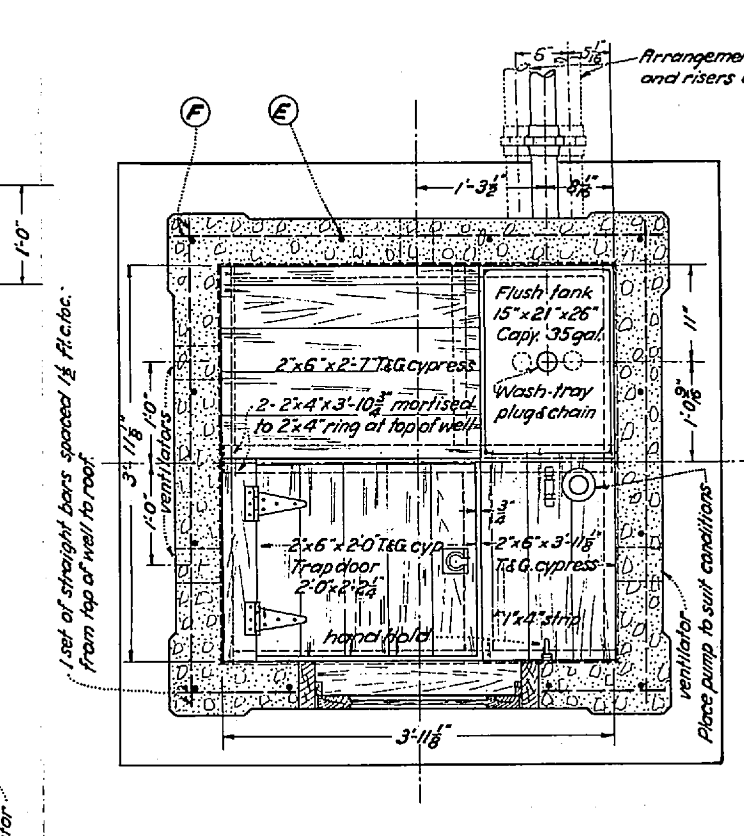
SECTION AA



SIDE ELEVATION

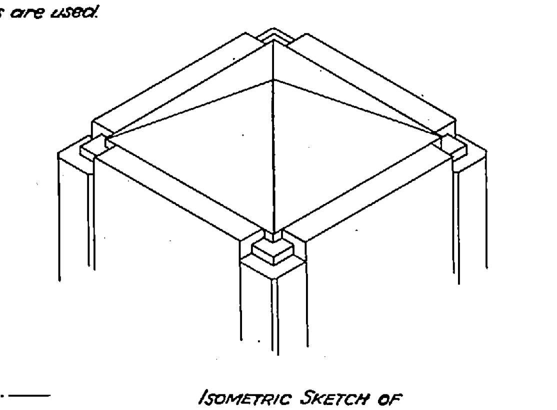


ROOF PLAN



SECTION BB

If well door is on right hand side reverse right and left arrangement of plan shown above so that riser and pump pipes will not block well door.



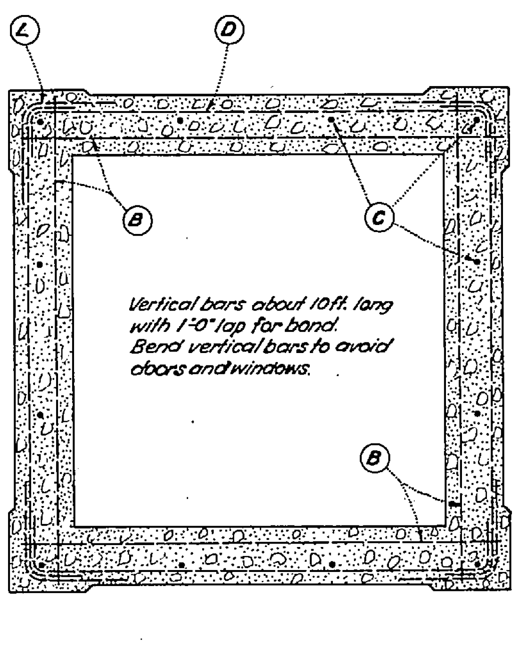
ISOMETRIC SKETCH OF ROOF AND CORNICE DESIGN

NOTE

Quantities:- Footing 1.0 cu.yd., well 0.4 cu.yd. per foot of height, house 2.6 cu.yd. Order 6 sacks of cement, 0.5 cu.yd. sand, and 0.9 cu.yd. 1 inch stone or gravel per cu.yd. of 1:2:4 concrete.
Screen bank-run gravel through ¾" mesh screen and use 1:2:4 mix.
Woodwork:- Use most durable wood on market for door frames, gage planks, flooring, etc. Paint with 3 coats of pure lead and oil paint. Color to match concrete.
Concrete:- 1:2:4 mix throughout.
Pipe:- Standard galvanized wrought iron water pipe or extra strong galvanized wrought iron water pipe. Latter is preferred.

SCHEDULE OF REINFORCING STEEL

LOCATION	MK.	NO. REQD	SEC.	LENGTH	SHAPE
Footing	(A)	36	½" φ	6'-4"	5'-8" hooked (4")
Well (horizontal below ground level)	(B)	as reqd	do	4'-10"	straight
Well (vertical)	(C)	do	do	as reqd.	do
Well (horiz.) and 1 set (4) at roof level	(L)	do	do	2'-0"	L 1'-0" x 1'-0"
Well (horizontal)	(D)	do	do	5'-3"	4'-7" hooked (4")
House (vertical)	(E)	12	do	6'-7"	straight
do (horizontal)	(F)	16	do	4'-10"	do
Roof	(G)	12	⅜" φ	2'-10"	do
Intermediate grade, new billet reinforcing steel thruout.					



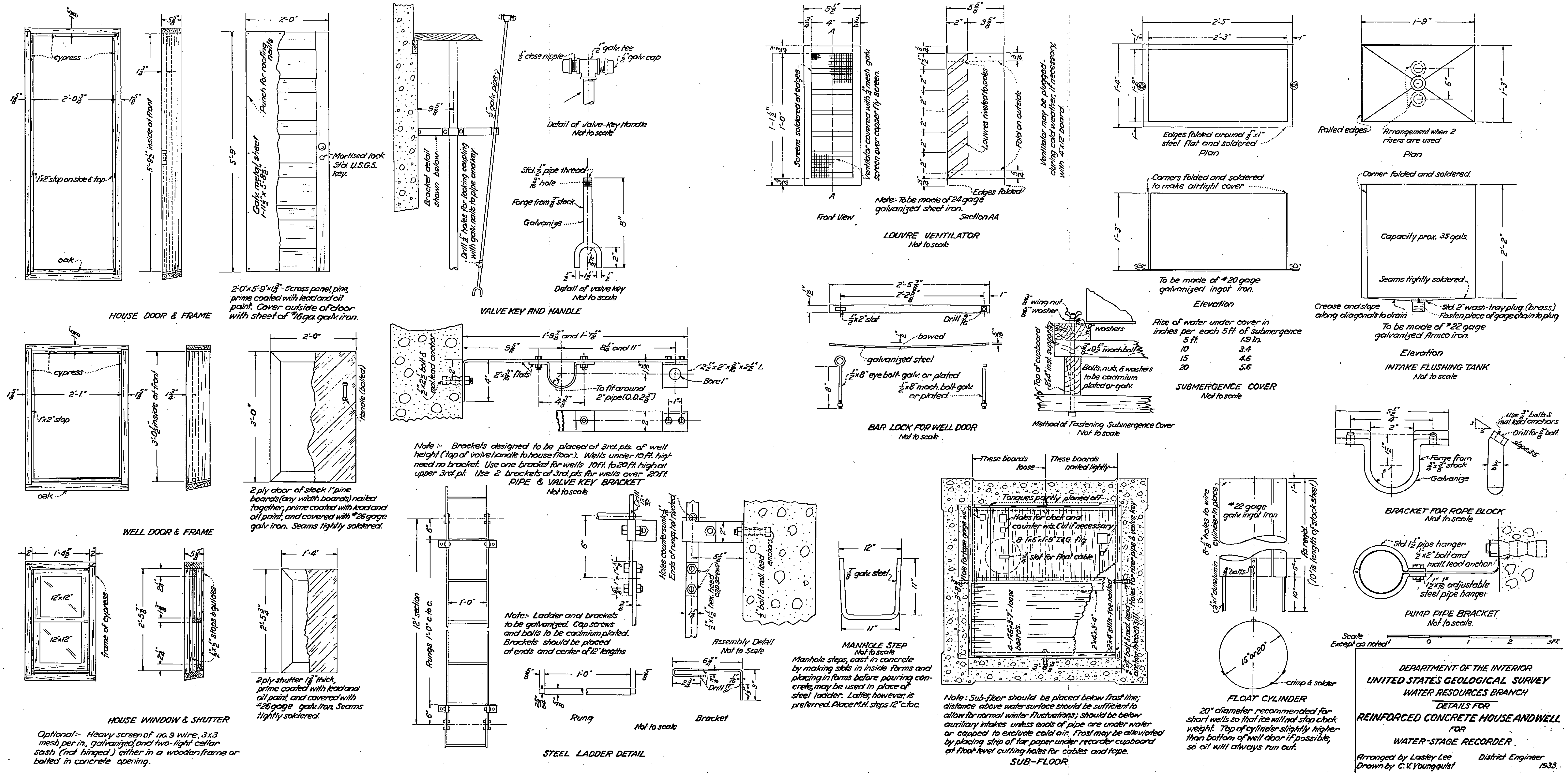
POSITION OF STEEL IN WALLS BELOW GROUND LEVEL

Scale 1 0 1 2 3 FT.

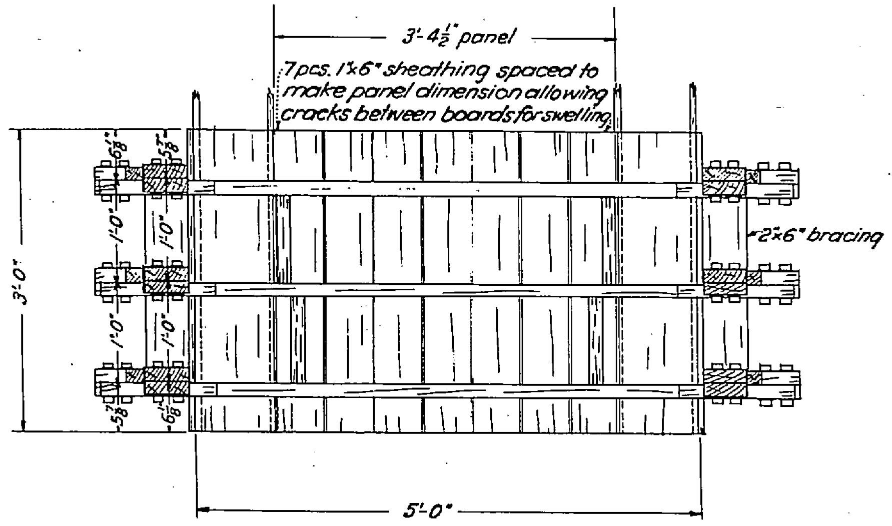
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

PLANS FOR
REINFORCED CONCRETE HOUSE AND WELL
FOR
WATER-STAGE RECORDER

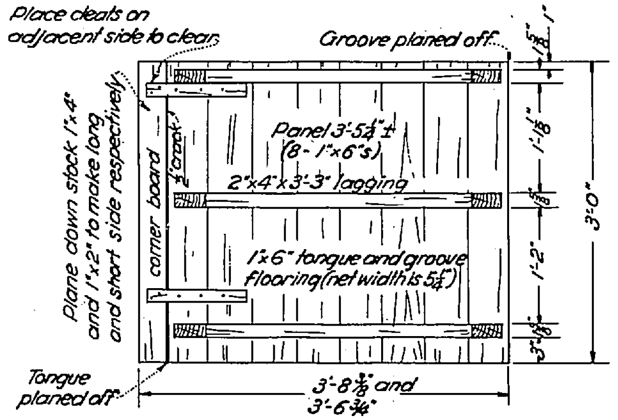
Arranged by Lasley Lee, District Engineer
Drawn by C. V. Youngquist
1933



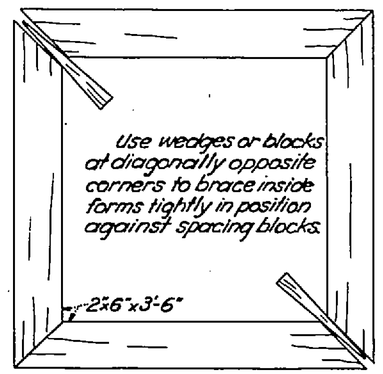
HOUSE DOOR & FRAME
cypress
2'-0 3/8"
1x2" stop on side & top
oak
5'-9 1/2" inside at front
2'-0"
Punch for roofing nails
Galv. metal sheet 1'-1 1/2" x 5'-8 1/2"
Mortised lock Std. U.S.G.S. key.
2'-0"x5'-9"x1 3/8"-5 cross panel, pine, prime coated with lead and oil paint. Cover outside of door with sheet of #16 ga. galv. iron.
VALVE KEY AND HANDLE
Bracket detail shown below
Drill 1/4" holes for locking coupling with galv. nails to pipe and key
3/4" galv. pipe
1/2" close nipple
1/2" galv. tee
1/2" galv. cap
Detail of Valve-Key Handle
Not to scale
Std. 1/2" pipe thread
3/8" hole
Forge from 7/8" stock
Galvanize
Detail of valve key
Not to scale
WELL DOOR & FRAME
cypress
2'-1"
1x2" stop
oak
3'-0 1/2" inside at front
2'-0"
3'-0"
Handle (bolted)
2 ply door of stock 1" pine boards (any width boards) nailed together, prime coated with lead and oil paint, and covered with #26 gage galv. iron. Seams tightly soldered.
1'-9 7/8" and 1'-7 1/8"
9 5/8"
8 1/4" and 11"
2 1/2"x3/16" flats
To fit around 2" pipe (O.D. 2 3/8")
2 1/2"x2"x3/16"x2 1/2" L
Bore 1"
Note:- Brackets designed to be placed at 3rd. pts. of well height (top of valve handle to house floor). Wells under 10 ft. high need no bracket. Use one bracket for wells 10 ft. to 20 ft. high at upper 3rd. pt. Use 2 brackets at 3rd. pts. for wells over 20 ft.
PIPE & VALVE KEY BRACKET
Not to scale
HOUSE WINDOW & SHUTTER
12"x12"
12"x12"
frame of cypress
1/2"x2" stops & guides
1'-4"
2ply shutter 1 3/8" thick, prime coated with lead and oil paint, and covered with #26 gage galv. iron. Seams tightly soldered.
Optional:- Heavy screen of no. 9 wire, 3x3 mesh per in. galvanized, and two-light cellar sash (not hinged) either in a wooden frame or bolted in concrete opening.
12' section
Rungs 1'-0" c. to c.
1'-0"
Note:- Ladder and brackets to be galvanized. Cap screws and bolts to be cadmium plated. Brackets should be placed at ends and center of 12' lengths
Holes countersunk. Ends of rungs not riveted.
Assembly Detail
Not to Scale
Rung
Bracket
Not to scale
STEEL LADDER DETAIL
LOUVRE VENTILATOR
Not to scale
Front View
Section AA
Screens soldered at edges
Ventilator covered with 1/4" mesh galv. screen over copper fly screen.
Louvres riveted to sides
Fold on outside
Edges folded
Ventilator may be plugged during cold weather, if necessary, with 4"x12" board.
Note:- To be made of 24 gage galvanized sheet iron.
BAR LOCK FOR WELL DOOR
Not to scale
1/2"x2" slot
bowed
galvanized steel
1/2"x8" eye bolt - galv. or plated
1/2"x8" mach. bolt - galv. or plated
MANHOLE STEP
Not to scale
3/4" galv. steel
Manhole steps, cast in concrete by making slots in inside forms and placing in forms before pouring concrete, may be used in place of steel ladder. Latter, however, is preferred. Place M.H. steps 12" c. to c.
These boards loose
These boards nailed lightly
Tongues partly planed off
Holes for clock and counter wts. Cut if necessary
8-1x6x1'-9" T&G flg.
Slot for float cable
SUB-FLOOR
Note: Sub-floor should be placed below frost line; distance above water surface should be sufficient to allow for normal winter fluctuations; should be below auxiliary intakes unless ends of pipe are under water or capped to exclude cold air. Frost may be alleviated by placing strip of tar paper under recorder cupboard at float level cutting holes for cables and tape.
Method of Fastening Submergence Cover
Not to scale
wing nut
washer
washers
1/2"x8 1/2" mach. bolt
Bolts, nuts, & washers to be cadmium plated or galv.
Edges folded around 1/8"x1" steel flat and soldered
Plan
Corners folded and soldered to make airtight cover
To be made of #20 gage galvanized ingot iron.
Elevation
Rise of water under cover in inches per each 5 ft. of submergence
5 ft. 1.9 in.
10 3.4
15 4.6
20 5.6
SUBMERGENCE COVER
Not to scale
Rolled edges
Arrangement when 2 risers are used
Plan
Corner folded and soldered.
Capacity prox. 35 gals.
Seams tightly soldered.
Crease and slope along diagonals to drain
Std. 2" wash-tray plug (brass) Fasten piece of gage chain to plug.
To be made of #22 gage galvanized Armco iron.
Elevation
INTAKE FLUSHING TANK
Not to scale
#22 gage galv. ingot iron
bolts
FLOAT CYLINDER
15" or 20"
crimp & solder
20" diameter recommended for short wells so that ice will not stop clock weight. Top of cylinder slightly higher than bottom of well door if possible, so oil will always run out.
BRACKET FOR ROPE BLOCK
Not to scale
Use 3/8" bolts & mal. lead anchors
Forge from 3/8"x3/8" stock
Galvanize
Std. 1 1/2" pipe hanger
1/2"x2" bolt and mall. lead anchor
adjustable steel pipe hanger
PUMP PIPE BRACKET
Not to scale.
Scale Except as noted
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH
DETAILS FOR
REINFORCED CONCRETE HOUSE AND WELL
FOR
WATER-STAGE RECORDER
Arranged by Lasley Lee District Engineer
Drawn by C. V. Youngquist 1933.



OUTSIDE PANEL FORM



INSIDE PANEL FORM

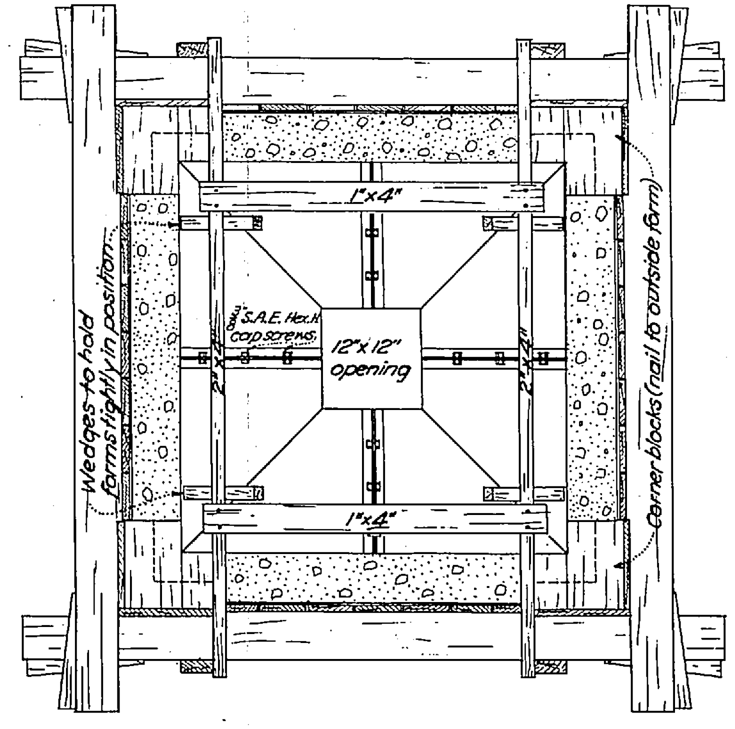


INSIDE LOOSE BRACES

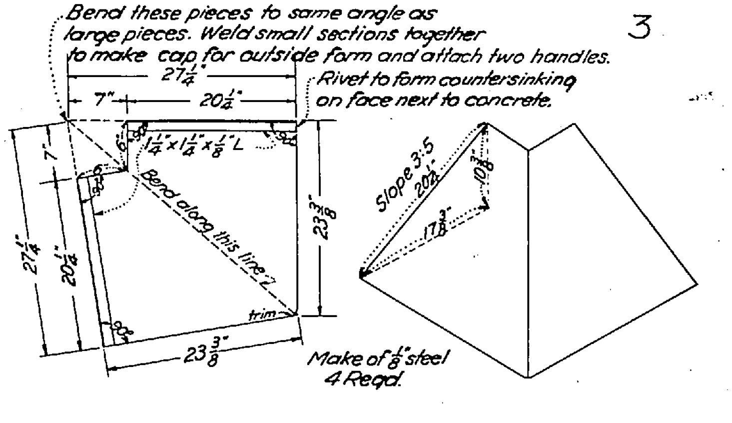
Three sets of these loose braces for bottom set or lift of inside forms and two sets for remaining lifts. Braces supported by lagging on forms. Braces not to be nailed to forms, but fitted tightly with wedges or blocks

NOTE

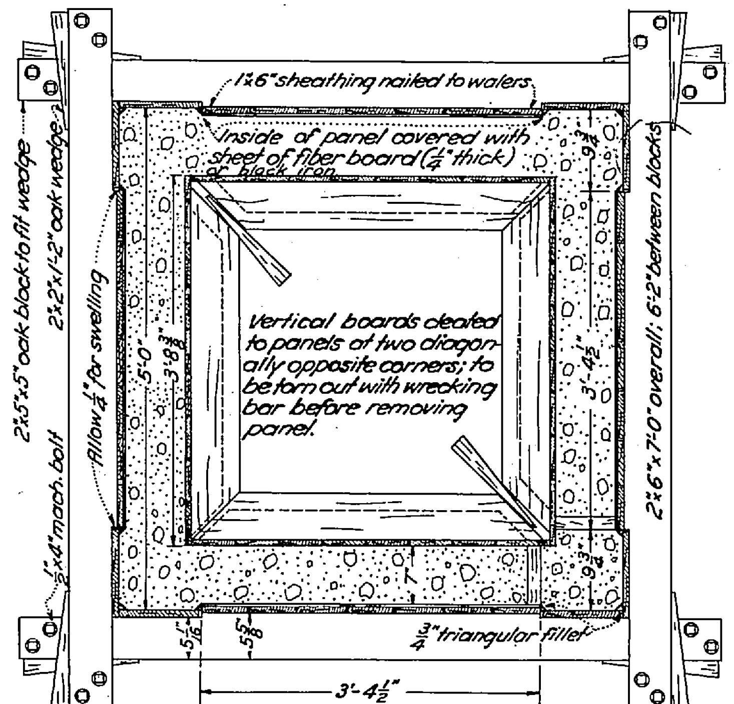
After pouring footing and before placing outside forms compute the number of panels of outside forms required to reach the roof line. Any fractional part of a panel should be made by rings of 2" plank on the footing in order that top panel form comes out flush with roof line. For convenience in setting successive forms start inside panels about 6 inches lower than outside panels. Three sets or lifts of outside and inside forms are necessary. Same forms used on several successive jobs. Use same inside panel forms and inside loose braces in house, using wider corner boards on panels and blocks with loose braces. Remove outside and inside forms, wherever possible, on day following pouring. Use good quality of yellow pine lumber.



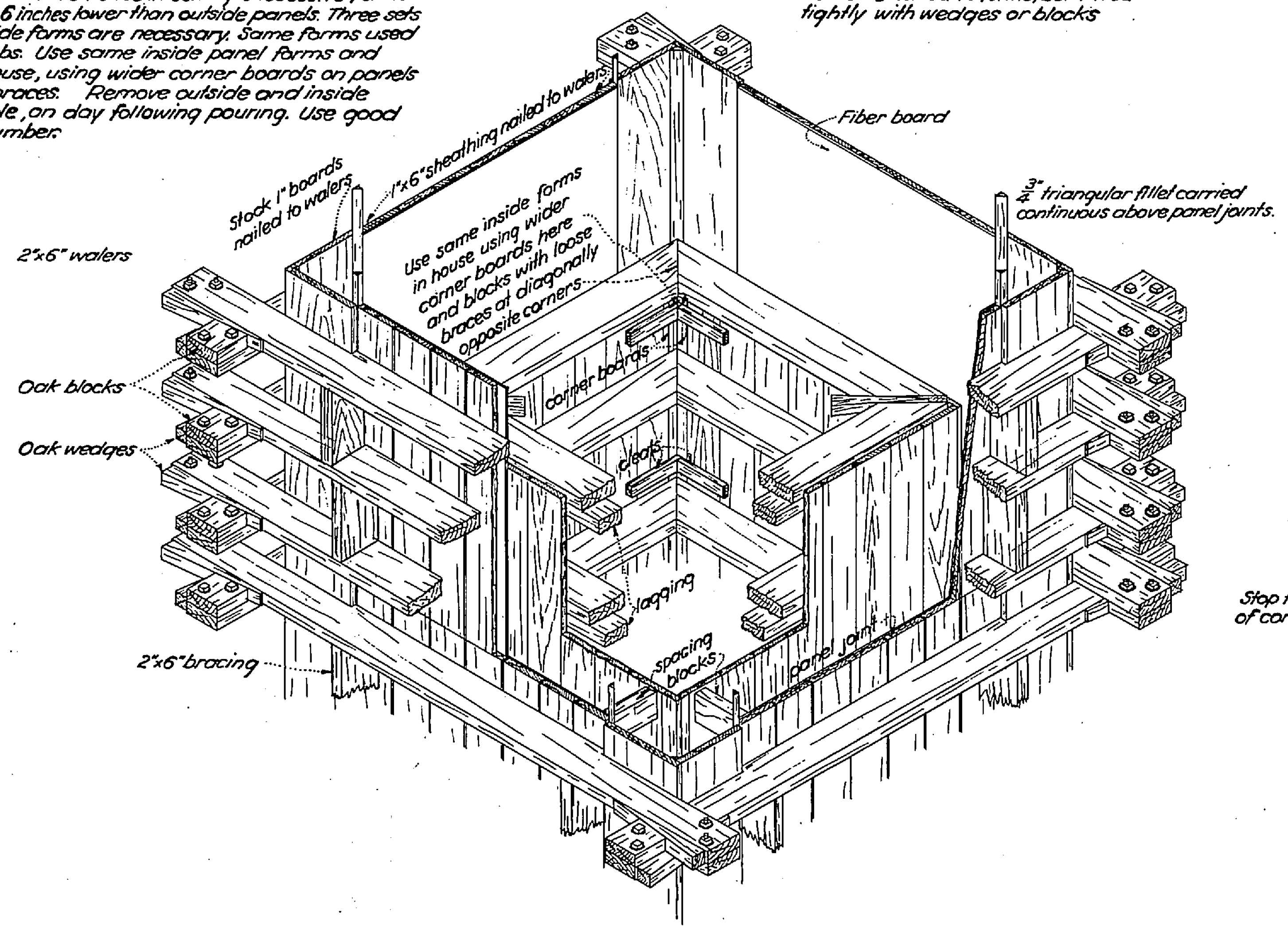
PLAN OF ROOF FORM ASSEMBLY



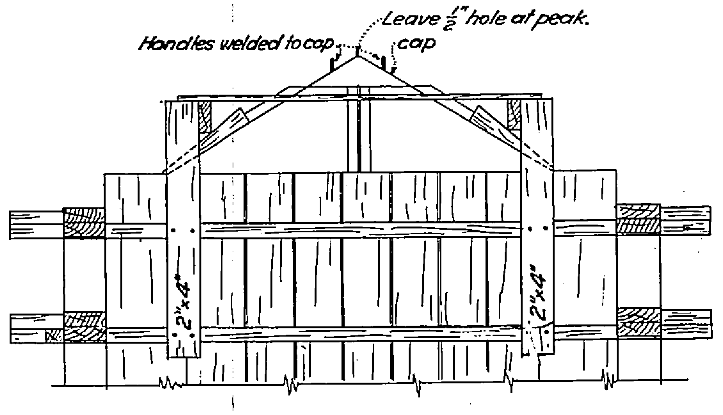
OUTSIDE ROOF FORM



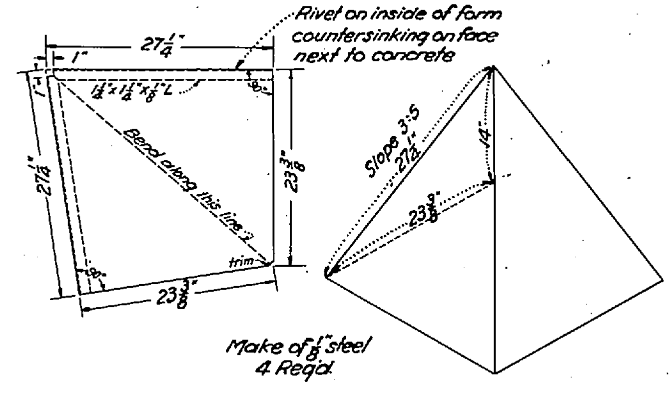
PLAN OF FORMS



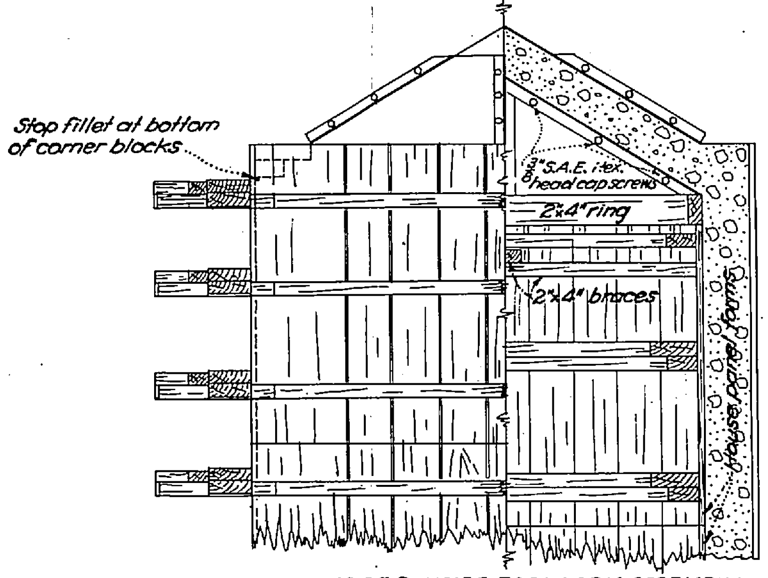
ASSEMBLY OF FORMS



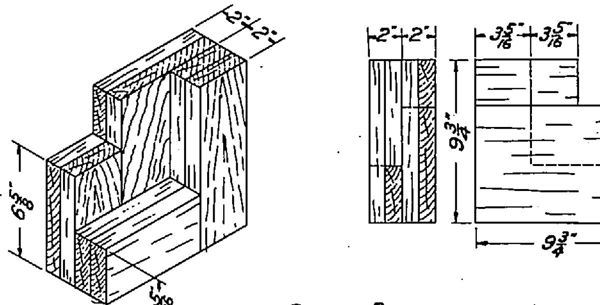
ELEVATION OF ROOF FORM ASSEMBLY



INSIDE ROOF FORM



OUTSIDE & INSIDE ROOF FORM ASSEMBLY



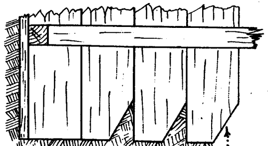
CORNER BLOCKS
Not to Scale

Scale 1 0 1 2 3 FT.

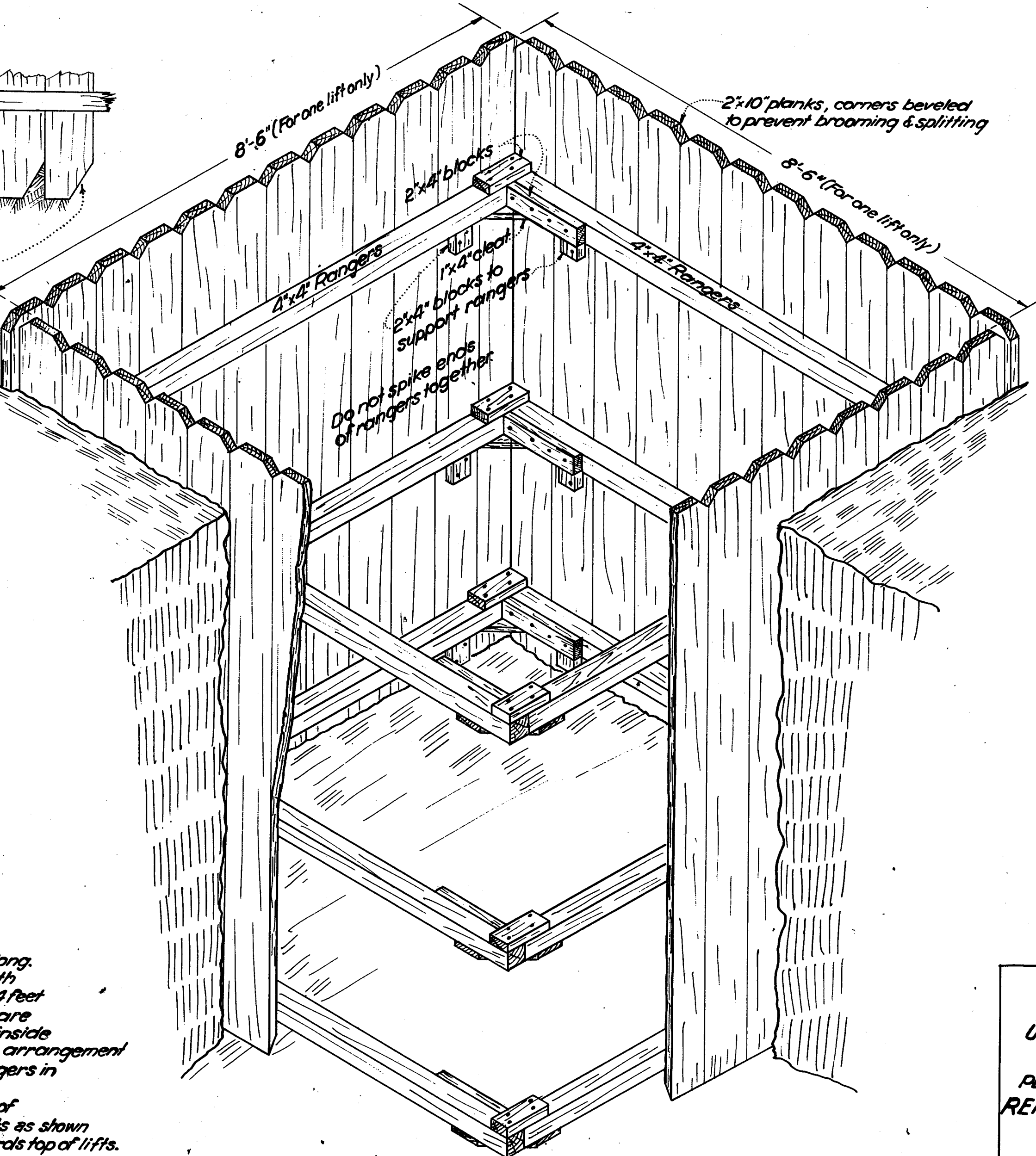
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

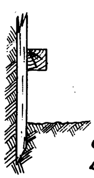
PLANS FOR FORMS FOR
REINFORCED CONCRETE HOUSE AND WELL
FOR
WATER-STAGE RECORDER

Arranged by Lasley Lee, District Engineer
Drawn by C. V. Youngquist 1933



Bevel one corner and turn bevel as shown to make tight joint.





If in gravel, bevel one edge and turn bevel as shown.

Wakefield Type Shoring (For use in quicksand)

Modified Wakefield Type Shoring (For use in quicksand or mud)

Note:-

Use three sets of rangers to each lift.

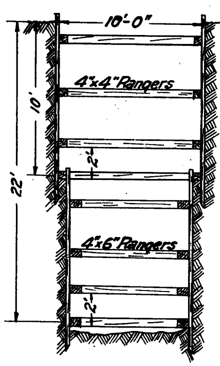
Place all planks in position around rangers before driving to insure tight joints and to keep planks vertical.

Do not drive beveled planks deeply in advance of excavation or they will tend to spread out at the bottom.

Use a hickory maul in preference to a steel sledge to prevent splitting and breaking of plank.

Caution:-

Rangers and sheeting are designed for average conditions of sand and gravel corresponding to C = 0.30 in Rankine's formula for earth pressure and are not designed for use in considerable depths of soft mud or quicksand. Conditions approaching the latter require much heavier rangers.



SECTION SHOWING TWO LIFTS OF SHORING

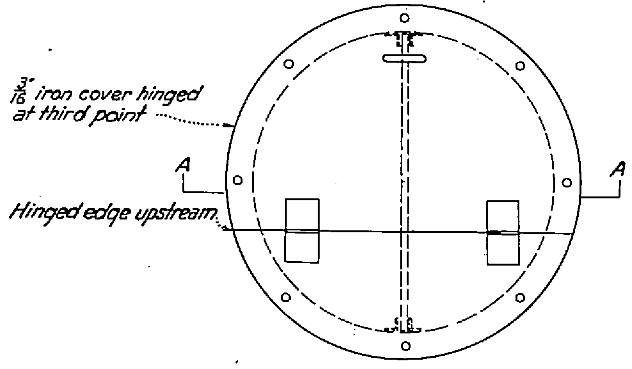
Use planks 10-14 feet long. If excavating to a depth much greater than 10-14 feet make opening 10'-0" square and drive second lift inside of first using the same arrangement of braces. Use 4"x6" rangers in lower lift.

Use a maximum spacing of rangers at bottom of lifts as shown increasing spacing towards top of lifts.

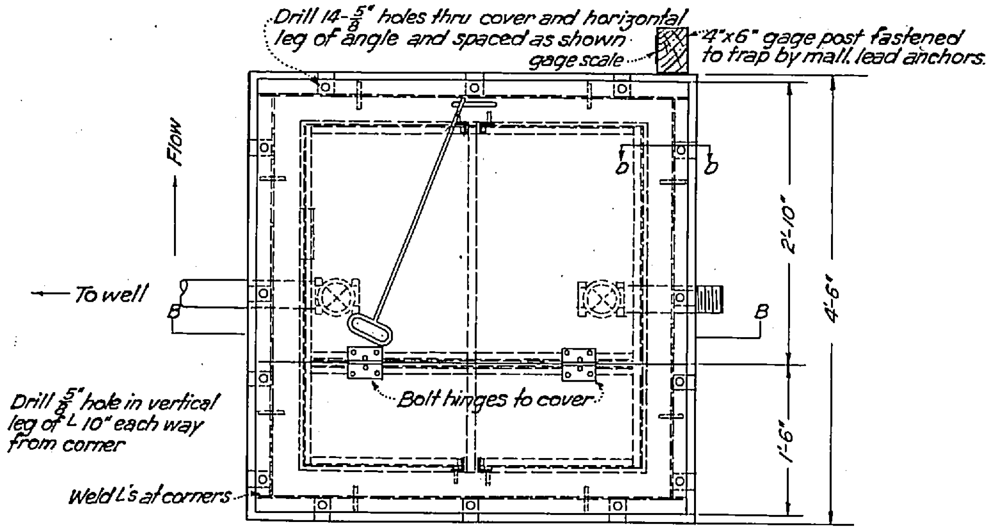
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

PLANS FOR SHORING OF EXCAVATION FOR
REINFORCED CONCRETE HOUSE AND WELL
FOR
WATER-STAGE RECORDER

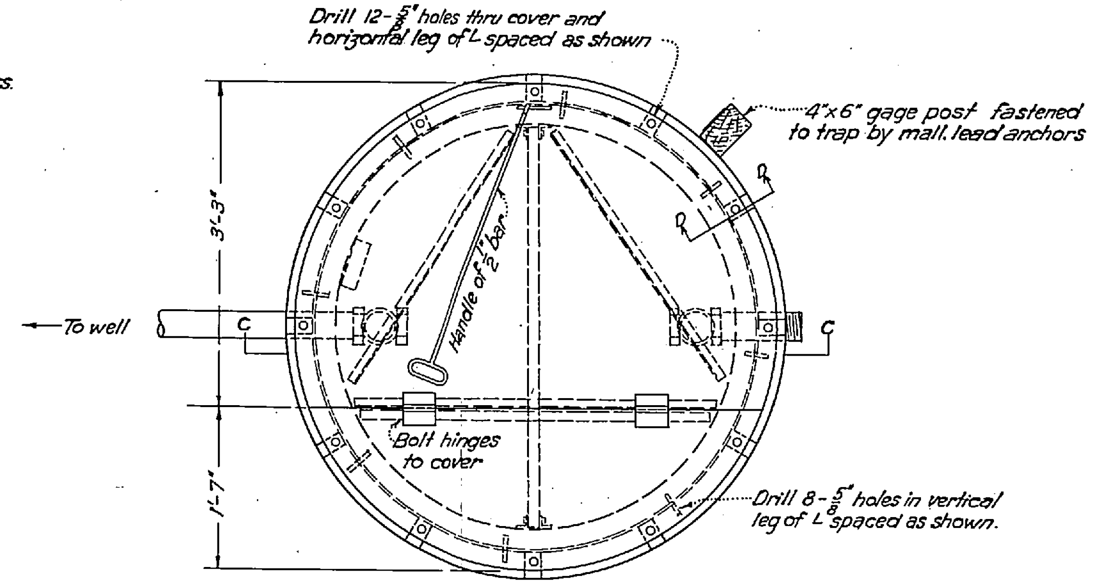
Arranged by Lasley Lee, District Engineer
Drawn by C. V. Youngquist
1933



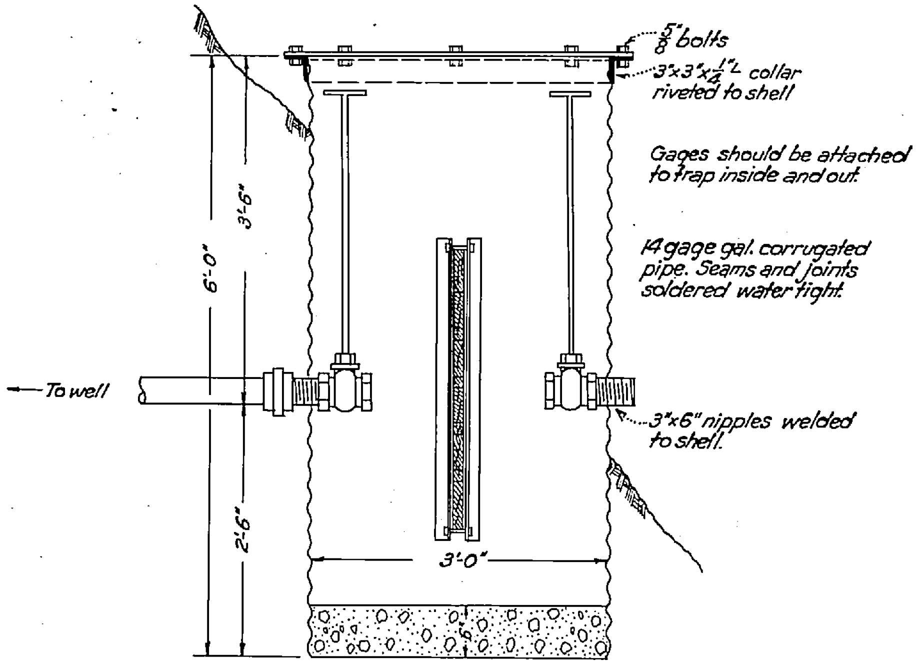
PLAN



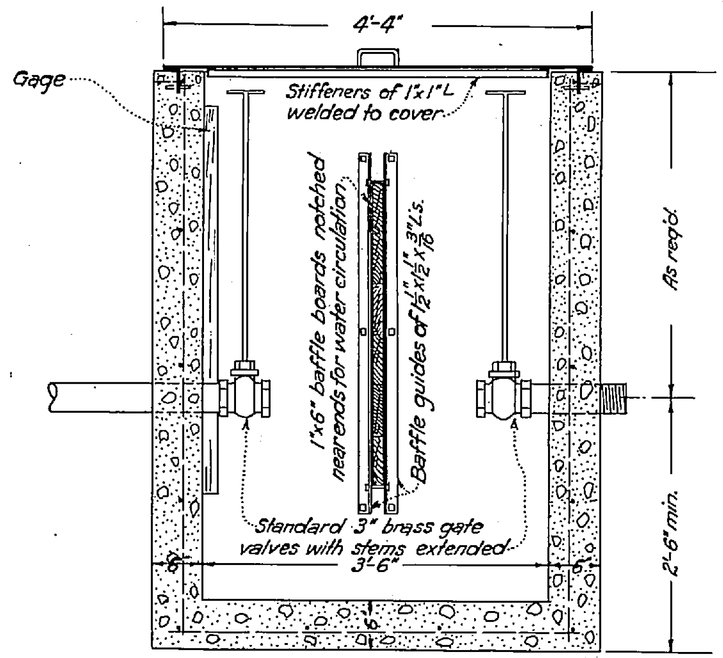
PLAN



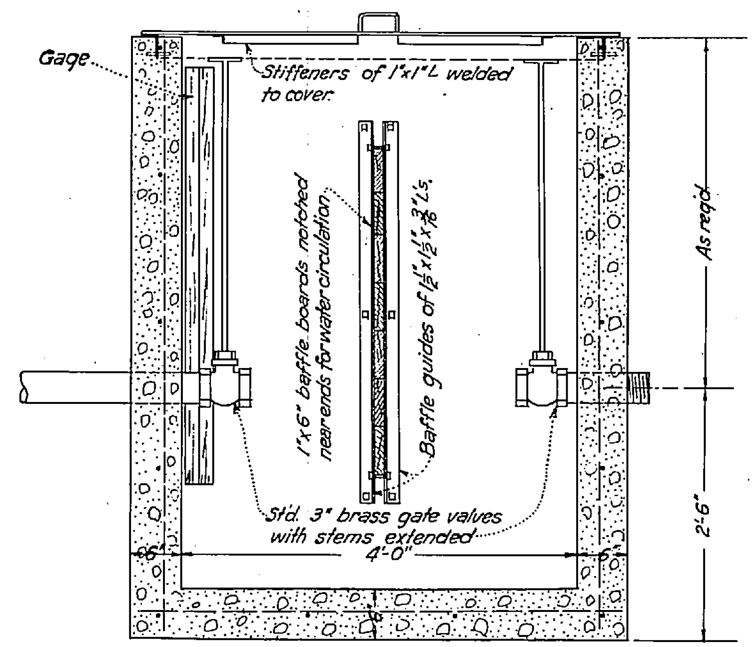
PLAN



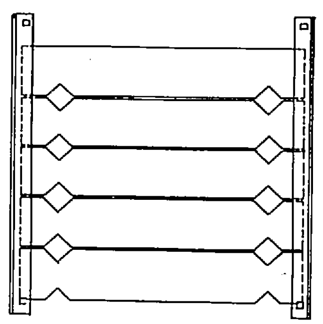
SECTION A-A



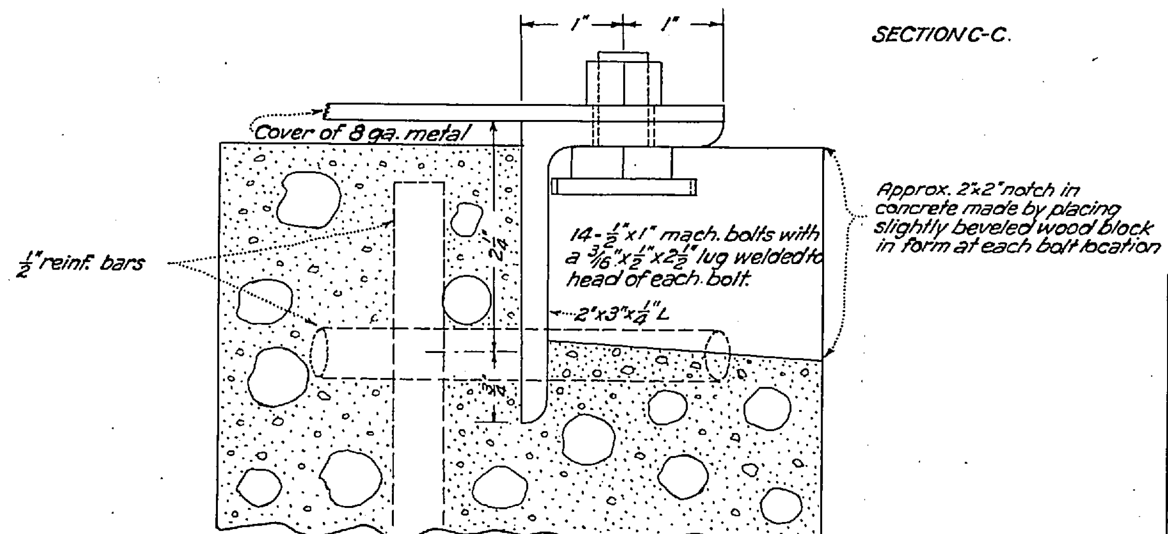
SECTION B-B



SECTION C-C



DETAIL OF BAFFLE
No Scale



SECTION DD
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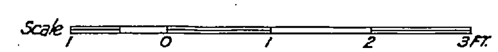

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

PLANS FOR
SILT TRAPS
FOR
WATER-STAGE RECORDER

Arranged by C.E. Ellsworth, District Engineer
Drawn by C.V. Youngquist, 1933