WATER DEVELOPMENT MANUAL

UNITED STATES INDIAN IRRIGATION SERVICE

Introduction

Many of the Indians of the United States live in the Southwest where they are forced to depend upon mechanically developed water, and anything done to increase their supply of water or make it more permanent will be of value to them. By means of generalized drawings and explanatory references to them, the following pages are designed with this in view.

The idea is to set up a few standard methods of domestic and range water development based upon practical experience and a recognition of local geologic conditions, also variable natural laws governing underground water movements, such as capillary attraction, surface tension, porosity of different materials, and others.

The immediate objective of this manual is to bring into print detailed information on well drilling and other development methods which will assist engineers, supervisors and other officials in writing specifications and drawing contracts requiring well drilling and other development methods, including sinking of large re-enforced concrete caissons, development of springs, storing water and protecting it against pollution, proper distribution facilities and other operations necessary from locating a drilling site to the distribution of water for consumption.

If standards of well drilling can be effected through the incorporation in drilling contracts of standard practices tending toward uniform methods of developing wells, there is no reason why wells should not be far more permanent, and, in most cases, a greater volume of water developed,

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even to the extent of producing a surplus sufficient for a few acres of garden, lawns and orchards; also, with modern methods, will make it possible to development wells which would otherwise be impossible.

Improvement in oil development has been constant since its beginning, but it must be borne in mind that oil-well development methods have been worked out by high-salaried men, such as hydraulic engineers, technicians and geologists who have directed the publication of information, the study of it, and the actual practice of improved methods to a high degree of standardization; but since much oil-well work is a reverse procedure to that of water development the methods used are not suitable for the latter.

Had the financial inducement existed to have interested men with like ability in water development, standard drilling practices would be on a parity, perhaps, with the oil industry, and a dependable permanent supply of water would exist on Indian reservations and on many farms and ranches where well failures and water shortages are constantly occurring.

Standardization must replace the makeshift and slipshod development work in the important and necessary work of producing water. While certain broad principles are common to all water development projects, their detailed application in individual cases differs. For this reason, formulating a rigid rule to fit all conditions is not feasible, but by applying proper drawings and descriptions to the individual situation encountered in the field, it is believed that information will be available as a guide toward standardizing development work.

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WATER DEVELOPMENT MANUAL

Introduction
Sheet 3

It is extremely unfortunate that no sanitary well drilling code exists under authority of either federal or state governments. A well established code with theoretical as well as practical methods and standards would set up principles of sanitation by which those responsible for water development would be governed, and it would furnish at least something as a properly authorized guide in devising other matters in conjunction with the fixed sanitation practices as specified by such code. In the absence of any regulations governing this work in the Indian Service, this manual is submitted with the hope it will serve as a preliminary step to the adoption of a code.

The principal claim made as to the methods set forth in these pages is their effectiveness as proven by actual experience on the arid Indian reservations of the Southwest states where water is as inaccessible as in any section of the United States. Shortages of water through well failures called for a change to more positive development practices, which resulted in the employment of methods, materials, tools and machinery illustrated by drawings herein.

In many places where well failures had been experienced, subsequent development proved not only a permanent supply but an abundance of water in the same sands. The cause of the failure was: the casing had been sunk into quick-sand or some other treacherous formation, then for lack of knowledge in how to overcome such conditions by sinking the casing farther down, drillers made temporary development and left the well, which later sluffed full of cavings or heaved full of quick-sand, thus shutting off water.

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The permanent supply of water in such a well only awaited proper development which could have been accomplished by using a flap-valve bailer or other tools designed for quick-sand development, and by sinking casing into or through water bearing formation where a greater seepage area would have been opened. Had this operation been followed by the use of screens and filters selected in accordance with the character of the surrounding walls and placed with due regard to extent of the formation penetrated, (as per drawings illustrating problems of this nature) lasting wells, free from obstructions to a dependable water supply would be furnishing all the needs where failures have caused shortages.

Abundance of water will be the rule rather than scarcity when each class of development is handled according to a plan which has proved successful, and as time goes on, experience may show where improvements may be added. Uniformity will naturally follow if such additions are adopted by the insistence on including them, together with original method specified in specifications, because wells and development projects of like character will be equipped with casing, screens and filters common to that group.

Standardization will better produce an adequate water supply, the real purpose of all drilling and development, and it will also promote economy in producing water, by price advantages in buying large lots of fewer sized casing, pumping and other equipment instead of investing more money in smaller quantities of various sizes and kinds.

Economy in maintenance will also be effected in not having to

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maintain so large a stock of replacements, varied in size and kind, and in the use of tools of uniform character. Carried to a final conclusion in a certain section of an Indian reservation, or throughout a small one, sufficient replacements can be conveniently stored on a fair-sized truck adapted to maintenance work so delays and disturbances to water supply can be quickly overcome.

Simultaneously with developing a quantity of water, its quality must be protected, as an abundance of water produced at the lowest cost imaginable may be not only cheap but also extremely dangerous. Thus, when standardization is under consideration, strict attention should be given to sanitary methods and measures.

At the beginning in locating drilling sites, surface drainage should be carefully considered in its relation to all sources of pollution, and wells should be located at highest point on the premises consistent with the general layout, but in any case protected against surface wash.

Pollution from impure sub-surface water is a hidden menace which flows through fissures and crevices, even from distant sources. The proper time to investigate possibilities of such impurities is during the development period and to guard against it then by careful study of geologic conditions and taking every precaution to exclude contamination. A means of doing the latter is shown by drawings and explanatory data in this manual, in properly cementing the casing and sealing the tops of wells by back-filling with impervious material to prevent polluted surface and sub-surface flows from entering a well and mixing

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with the pure water.

To assure an ample supply of water and preserve its purity to the point where it is to serve its ultimate purpose for domestic use, storage facilities enter as a necessary part of the water development. In designing tanks and constructing them, consideration should be given to the fact that water for human consumption is stored in the same reservoir or tank as that for animals. This dual use demands study of not only past and present needs but what future capacity might be required for storage.

From a sanitary standpoint, storage places must be covered to prevent wind-blown contamination. As means of access, man holes with tight fitting caps should be provided. Protection against foreign pollution is thereby attained. This will also exclude sunlight, without which offensive vegetable growths cannot thrive. Fittings and outlets must be protected from frost, and fitted with stop and waste fittings. This is shown by the detailed drawings of frost boxes, tanks, troughs, etc.

Drinking facilities should be given attention and the storage tank should be so designed to make it impossible to dip buckets or containers into the storage tank. Cattle, horses, sheep and goats are customarily watered in many reservation localities at the same place by means of troughs, but in construction methods, due consideration has not been given the small animals. Attention is directed to a drawing of a design which will give a lamb an equal chance to drink with a horse.

It is assumed by the foregoing remarks on development, production

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and distributing facilities for water, that care has been exercised by water development officials in locating sites for development projects for the convenience of the users. This is of utmost importance when livestock needs are under consideration where open range still prevails, as it does on Indian reservations.

The Division of Grazing is responsible for the preservation of range, and controls it through grazing and movement of stock to this or that area as the supply of feed permits grazing, or a scarcity demands abandonment for a time. It can be readily perceived that the location of the water supply in a given area can be made so as to assist in range control by attracting stock when water is made available or removing it when the supply is shut off.

Careful surveys made by grazing officials place them in position to locate centers of such areas, and that knowledge enables those responsible for range control to make an approximate location for the most logical and convenient location for water development in any particular area. Therefore, the Division of Grazing officials should be consulted and the Water Development people should cooperate with them by locating a development project as near the point designated as possible in keeping with local geologic conditions and development and maintenance costs.

In summarizing, the group of drawings and detailed drilling and development data referred to heretofore, covers the matter of water development from practically every source on which Indians of the Southwest depend for a domestic and range supply of water. This, of course,

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depends on locality, where in one, spring water may be the most accessible; in another, a deep well is the only answer; while shallow well water exists in others. Closer study should be made of this phase of the work than has prevailed in the past, when in many instances the least expensive method has been resorted to, not always with due consideration to even the potability of the water.

Any program of development should have as its ultimate aim in Indian village communities, consideration for the fact that regular water and sewer systems are practical for the inhabitants; the need of water for fire protection in both villages and rural homes; and, as heretofore mentioned, protection of drinking water from contamination by writing it in development specifications to be followed by enforcement of them.

The health of an entire community has been seriously affected and lives have been lost through failure of those charged with the responsibility of water development to employ and insist upon positive methods of sanitation. As a measure of health protection against indifferent methods of water development, by which the important factor of sanitation is neglected, if not completely ignored, regulations applicable to the entire Indian Service should be mandatory; these regulations to prescribe the establishment of uniform standards applicable to water development and the methods of procuring and permanently protecting an adequate supply of safe ground water for human consumption. Basic principles, definitions of terms general in scope, and fundamental in character, should be adopted as a basis of such regulations governing the location,

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drilling, development, construction, equipment, maintenance and supervision of wells supplying water for human consumption. In the hopes that the policy of the Indian Service, with regard to development of water, will be deliberately directed toward the above end, this Manual has been prepared as the initial step.

Any program designed to raise the Indians standard of living to that of his white neighbors, will not be complete unless means are provided to insure them a dependable and permanent domestic water supply. The development of water as referred to in these pages is not primarily for irrigation but where it is possible to develop a surplus of water over and above domestic and livestock requirements, it could be advantageously used for irrigating a few acres of garden and fruit trees.

This would be a stabilizing factor in settling Indians in permanent homes and would add fresh fruits and vegetables to their rations, permit home planning and enable them to live as white men do. With such innovations to Indian dwelling places in many reservations of the Southwest states, the Indians will eventually replace the primitive shack, which is frequently abandoned on account of lack of water supply, with HOMES where their children may be raised in comfort, because the Indian is like the white in his affection for his children and feels as keenly the sickness and loss of his offspring.

To accomplish the needs of Indians as set forth in the last few paragraphs, Standardization of water development will have to be undertaken. A study of this manual will reveal one thing in particular, i. e., that development covers many operations in addition to drilling

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"by the foot" which is about the extent of attention given it by contractors and drillers. Equal solicitude on their part to all these other operations must be demanded and enforced if this important work is to be classed as a respectable profession.

The initial demand upon contractors should be made in specifications, after those charged with the responsibility of writing them have carefully studied the job to be done in its relation to standards, as described by drawings adopted, controlling the class and type of development to be done. Enforcement of the corresponding contract must be attained by supervisors who have also thoroughly acquainted themselves with the job and method of development which is to be applied.

The deficiency in water development is due more to a lack of standardization than anything else. If only a few water development standards are made effective by first incorporating them in specifications for contracts, it will be a forward step toward eliminating those contractors and drillers who have come into the business with little or nothing to warrant their being either contractors or well drillers. Drillers with no knowledge of water development methods, using tools and machinery which are not designed and are unfit for the job undertaken, in a go-as-you-please practice of drilling by the foot, give little attention to permanent development methods. The result is that all types of drillers have been doing all types of drilling with all kinds of machinery, and the consequence is all kinds of well equipment which call for like maintenance. Little or no attempt has been made to standardize, and without it there is sure to be a lack of proper supervision, which thwarts the

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success of any business.

The foregoing remarks do not infer that there are no good drillers and conscientious contractors, of which there are many, but even they are handicapped by lack of standardization and will become better drillers and contractors if standardization is made effective. An important result will be to raise the level of a profession in which there is little confidence. Incompetent and careless drillers will have to get in line or leave the business. This may seem harsh but the importance of proper water development, as mentioned heretofore in its relation to health of Indians alone, is too great a factor to let it be endangered by men who should never have become drillers.

One complaint against the well drilling profession is that some contractors will take jobs at a loss in order to get work. As in any work, when this happens, no one is benefitted and everyone from consumer to contractors, (including the latter who bid legitimately) suffers through inferior workmanship. Unfair competition will be removed if specifications call for standard and approved methods of development and if it is made plain that supervisors thoroughly understand what is expected of contractors.

Summarizing the foregoing, the chief purpose of this manual is to serve as a guide in attaining better results in water development. It is evident that this can be best attained by standardizing materials and equipment and the adoption of better methods of construction. This will require careful study of each situation so that the method most suitable will be followed.

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It is very important that before construction begins, both supervising personnel and those who are to actually do the work, have a clear understanding of the project and how it is to be accomplished. Any specifications prepared for water development should include the appropriate drawings and data for that particular type of project.

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PLATES 1 and 2

Plates 1 and 2 illustrate a method of developing a well in fine quick-sand where it is not feasible to use perforated casing or button screens alone, but where it is necessary to add a graded filter-pack around perforated casing or screen, in order to open up a greater seepage area than is possible without the use of filter.

Operation No. 1.

It should be the duty of the supervisor to select screens and material for a properly proportioned filter. First step should be to screen out all over-size by the use of a three-eighths screen, discarding all material larger than three-eighths.

The second step is to take out the under-sized by the use of a one-eighth inch screen, thus leaving a graded aggregate not over three-eighths and not under one-eighth inch in size.

In the event there is too much material of the same size in the mass formed by the second step, the porosity will be too open to exclude fine sand; therefore, it will be necessary to take a third step by use of intermediate screens and further separating gravel so that proper proportions can be had, and by re-mixing them to form the proper porosity desired to conform to the sands of formation encountered.

Operation No. 2.

The proper means of providing this filter in a well is the simple method of sinking a large outside string of casing to a sufficient depth into water-bearing formation, and to place inside string of perforated casing or button type screen, with metal centering guides as shown in plate No. 2.

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Plates 1 and 2 - Descriptive sheet No. 2.

Operation No. 3.

Place graded filter around inside string of casing and remove outside casing by stages, keeping filter material at least ten feet above bottom of casing being removed. Backfill last few feet with soil to prevent surface water from reaching perforated or screened area. All inside casing to have a standard cap or bull plus on bottom of casing to prevent heaving of sand.

In order to prevent graded material from separating, it should be placed in twenty foot stages at one continuous pour pulling casing as mixture is poured. The pouring should be at a rate to insure graded filter material reaching the bottom without bridging between casings. A continuous stream of water should accompany gravel while it is being poured and can be furnished by bailing water from well and dumping it between casings. To insure filter being compact in place attention is again called to the necessity of keeping filter material well above bottom of outside casing while latter is being pulled by stages.

Operation No. 4.

With filter in place swabbing can begin with view of agitating and washing filter and should continue until all fine sand has been brought into well. Swabbing should be done with a close fitting heavy swab or by using a heavy flat-bottom scow or bailer of a little less diameter than casing, and run in a spudding motion up and down through perforated section.

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Plates 1 and 2 - Descriptive sheet No. 3

Operation No. 5.

After swabbing has brought in all the fine sand into the well the next operation is cleaning it out, which should be thoroughly done with a flat-valve bailer, then by pumping or bailing well to its full capacity until it is entirely free from grit or coloring matter, etc.

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PLATE No. 2

Plate No. 2 shows well after inside screen and button screen have been set, and filter poured in place, with outside casing removed; also shows top of well backfilled with water to form seal to exclude surface water, etc.

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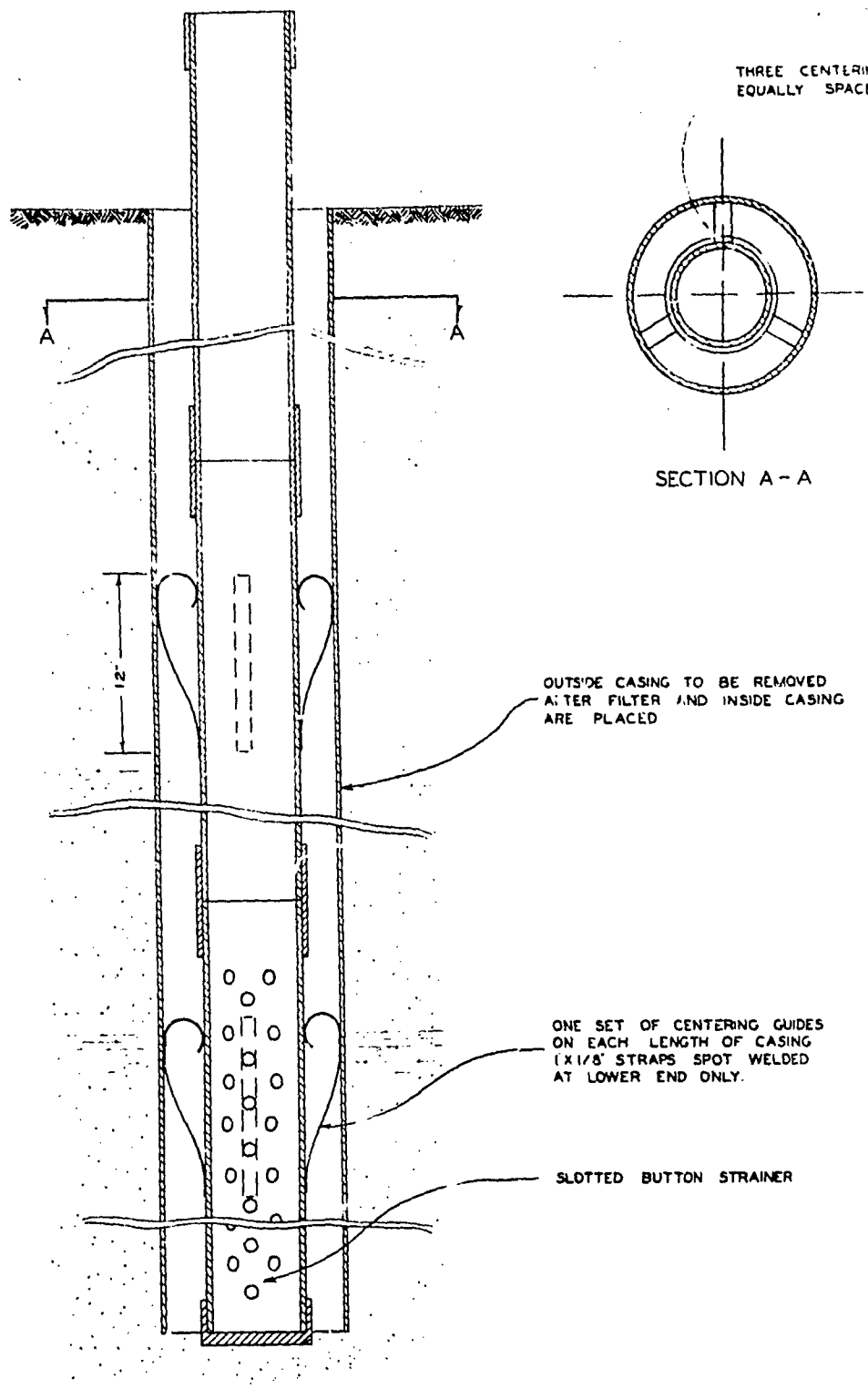
A - PLATE 1



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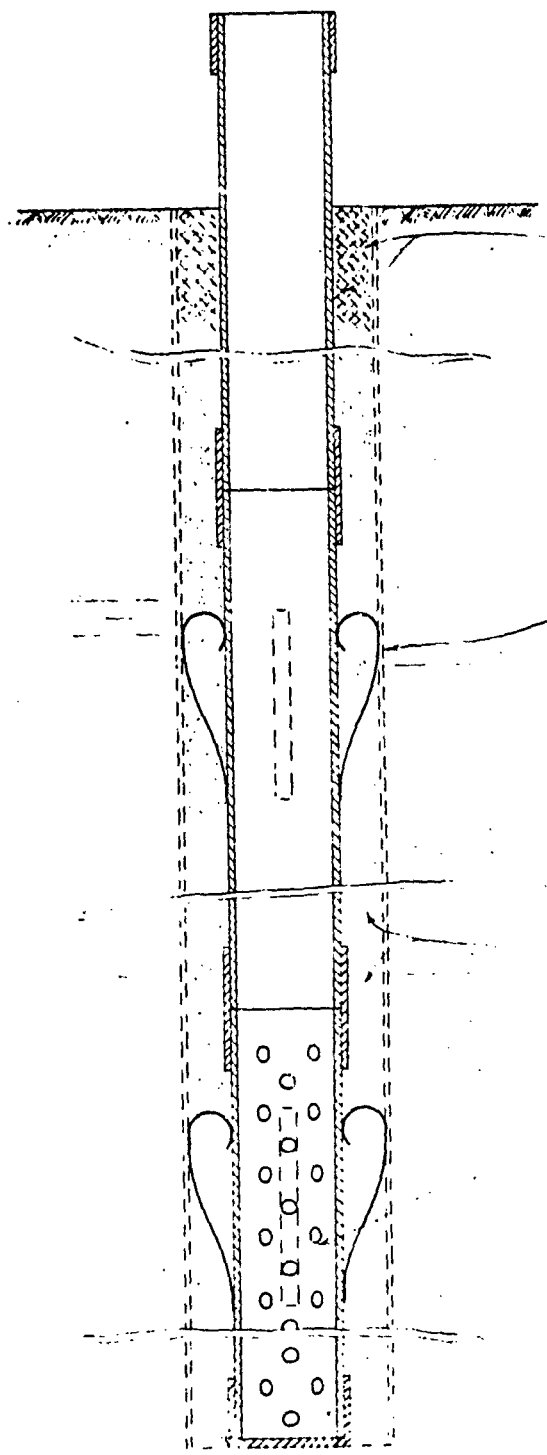
GENERAL PLAN FOR DRILLED WELLS
METHOD OF CENTERING INSIDE CASING
BEFORE PULLING OUTSIDE CASING

SCALE

DESIGNED BY A. H. WOMACK TRACED BY R. I. H.

F. W. 2199



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GENERAL PLAN FOR DRILLED WELLS
FILTER PACK AFTER PULLING CASING

SCALE
DESIGNED BY A H WOMACK — TRACED BY R I H

F. W. 2200

PLATE NO. 3.

Plate No. 3 illustrates a method of developing a well in fine quick-sand where it is necessary to sink a well to a greater depth than can be accomplished by the use of one string of outside casing.

By the method described in this drawing, it is proposed that the outside casing be sunk to not exceed a depth from where it can be pulled and to follow this by sinking an intermediate string of the next smaller size casing to the desired depth. With the use of centering guides, an inside permanent string of casing, including perforated pipe or button type screen, is to be placed as drawing No. 3 indicates. Backfilling and placing of graded filter will be done according to instructions in Plates numbers one and two.

It will be necessary to pull intermediate string by stages, keeping filter material ten to twenty feet above bottom of casing. When intermediate string has been pulled and filter has been placed above bottom of outside casing, the latter can be pulled by stages as in plates one and two.

Care should be taken to backfill upper part of well above filter with impervious material such as fine clay, mud, etc., to serve as a seal to prevent surface water from entering well, as shown in drawing. Bailing and swabbing will be done in accordance with descriptions and drawings one and two.

Care should be taken to see that filter material is reaching bottom at all times, either by estimating amount of filter material placed and the space to be filled, or by sounding at intervals, carefully measuring height of top of filter material to see it is being

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Plate No. 3 - Descriptive Sheet No. 2.

kept well above bottom of casing being filled. Well should be bailed continuously while pouring filter material, and the water dumped in with filter in order to settle it in place and prevent bridging between casings.

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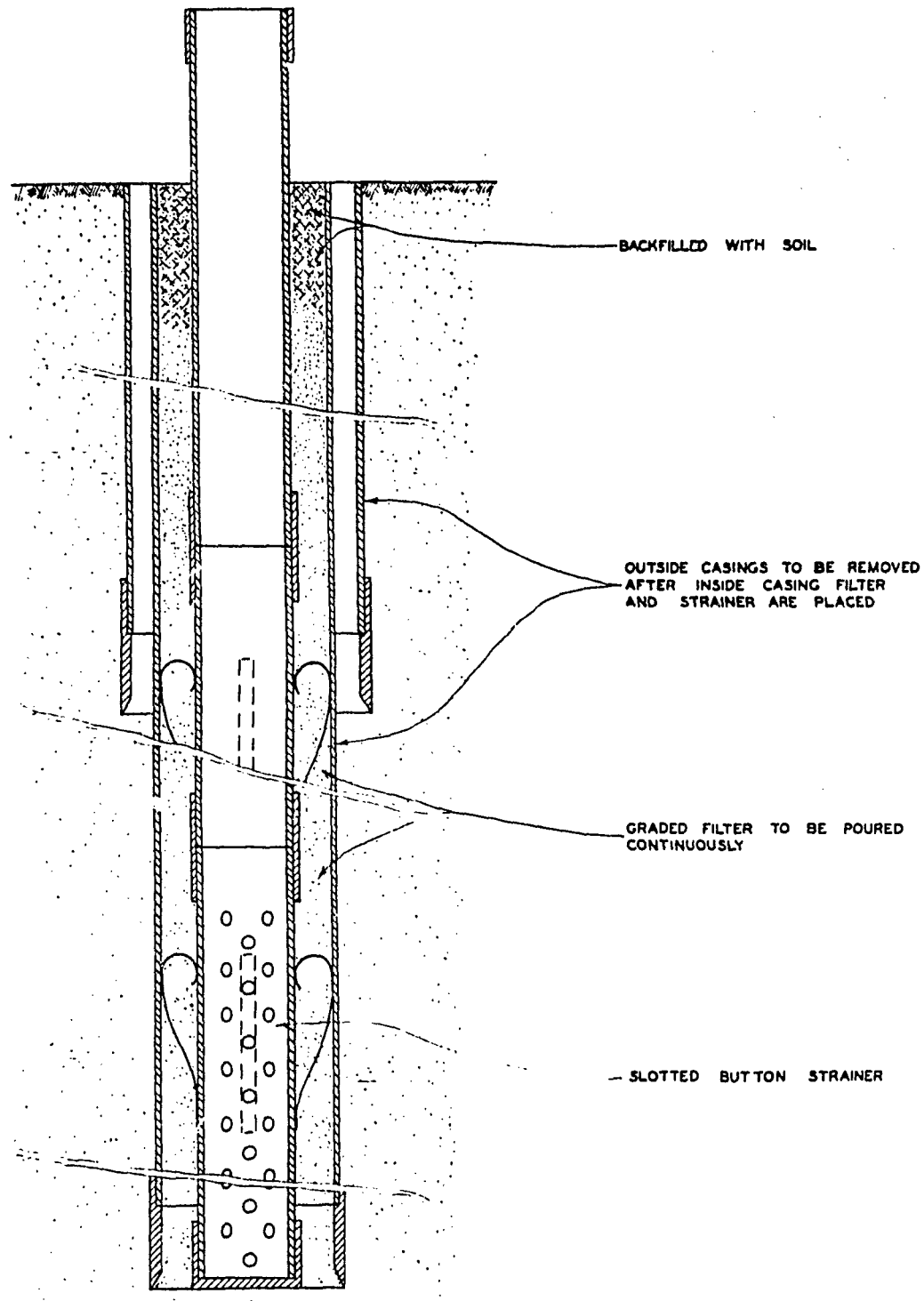
A - PLATE III



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GENERAL PLAN FOR DRILLED WELLS
MUTIPLE STRING FILTER PACK WELL
BEFORE PULLING OUTSIDE CASINGS

SCALE

DESIGNED BY A. H. WOMACK TRACED BY R.I.H.

F.W. 2203

PLATE No. 4.

Plate No. 4 illustrates arrangement of liner perforated pipe or button screen, to be used as a liner where well has been drilled through more or less solid water bearing formation, yet a liner is required to prevent caving of soft sand-stone, etc. This drawing also illustrates the method of increasing the size of liner by the use of a swaged nipple on which an inverted steel drilling shoe is placed.

In shallow wells where it is not necessary to use inverted steel drilling shoe on top of liner, a swage nipple may be used and belled out to inside diameter of casing. A simple method of landing liner in casing is also illustrated in this drawing, which may be substituted in the event that short string liner is to be used where casing spear is not available. Under such conditions, liner may be landed by the use of a lead, as described in the drawing, which is to be jarred out and recovered.

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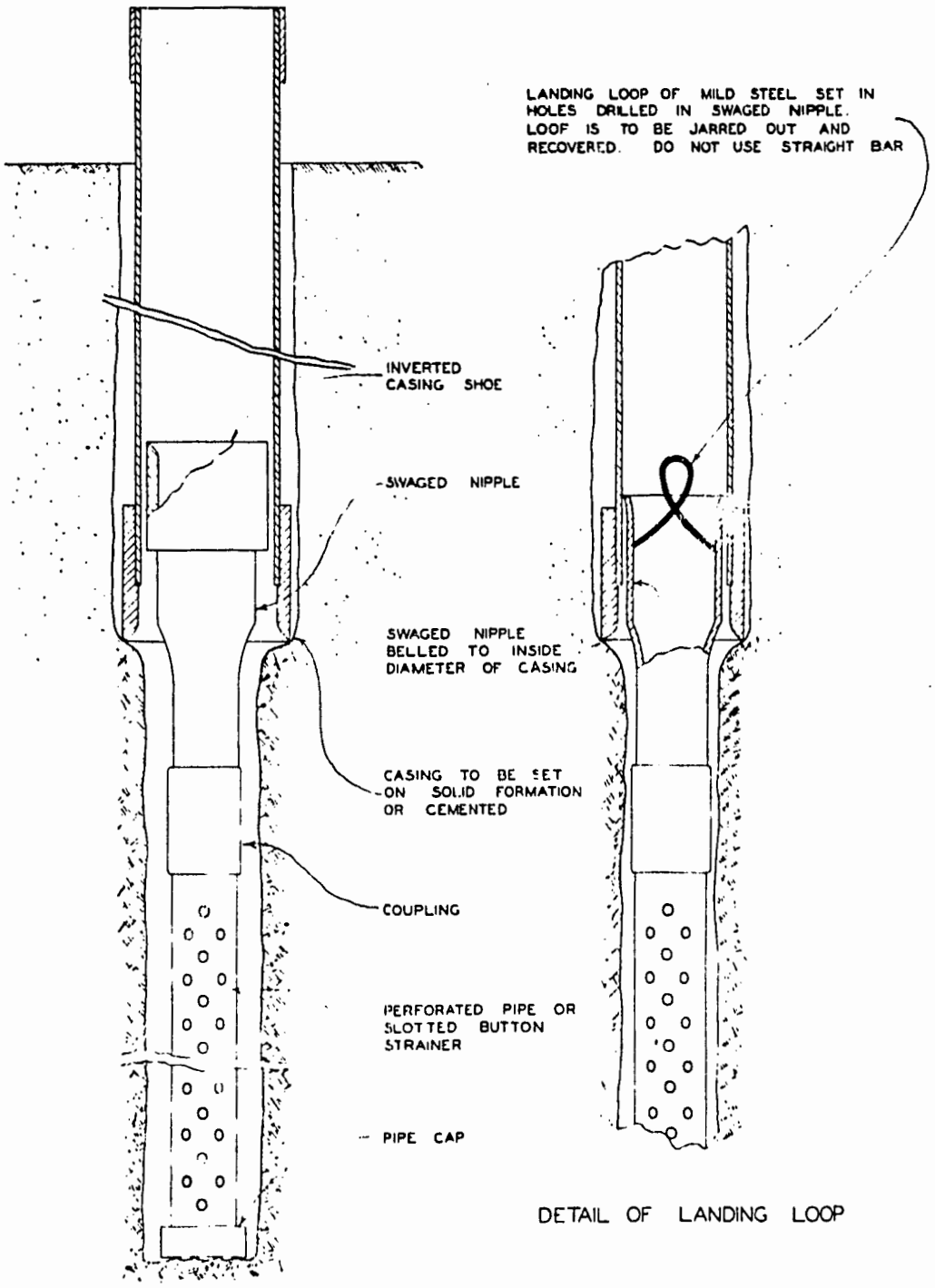

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GENERAL PLAN FOR DRILLED WELLS
CROSS SECTION OF LINER IN PLACE

SCALE

DESIGNED BY A.H WOMACK — TRACED BY R.T.H

F. W. 2205

PLATE No. 5.

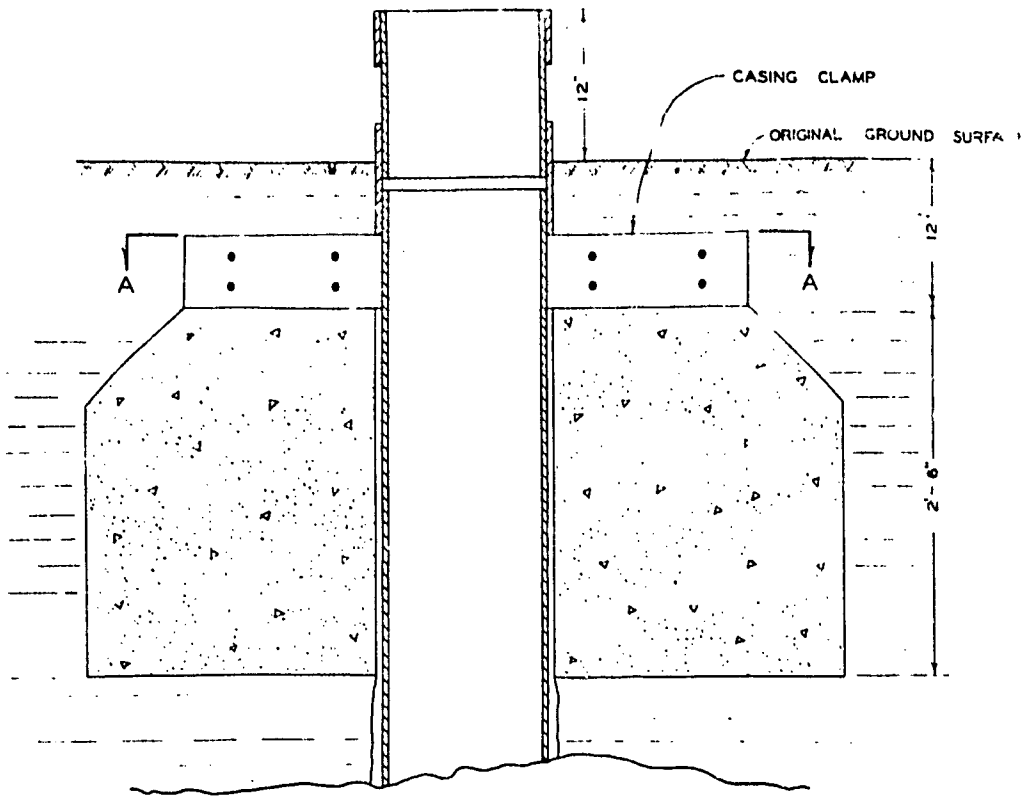
Plate Number 5 is a cross section of concrete pier and clamp for well head. The purpose of this is to strain and clamp up inside string of casing in order to insure perfect alignment on long strings of casing.

The two piers are to be formed as in drawing, after cement has properly set. The hydraulic jack may be used to strain casing, then clamped under collar of casing after which all space around casing is to be backfilled, and the remaining space, indicated on drawing, filled with concrete to form a complete concrete base around well-head casing.

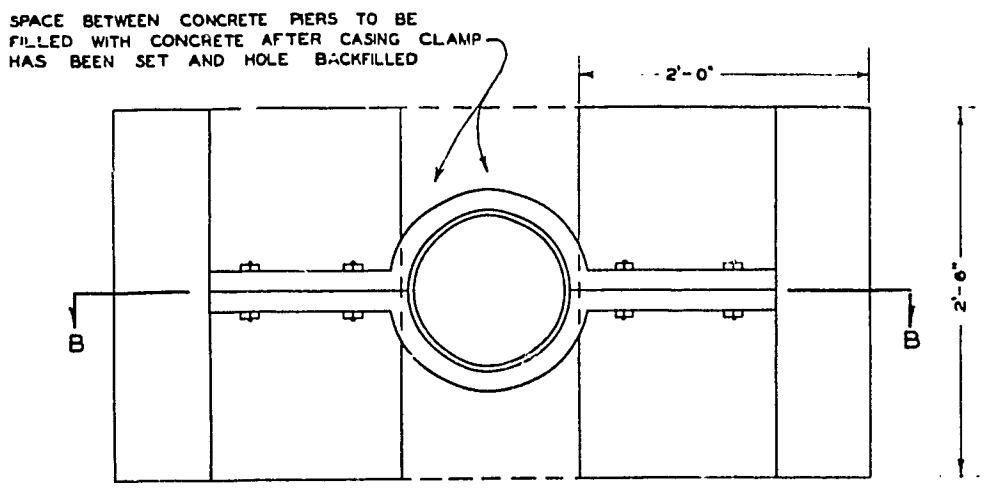
F. W. 2206

A - PLATE V

TO BE USED ON LONG STRINGS



SECTION B-B



PLAN
SECTION A-A

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GENERAL PLAN FOR DRILLED WELLS
CLAMP AND CONCRETE CASING SUPPORT

SCALE

DESIGNED BY A. H. WOMACK — TRACED BY R.I.H.

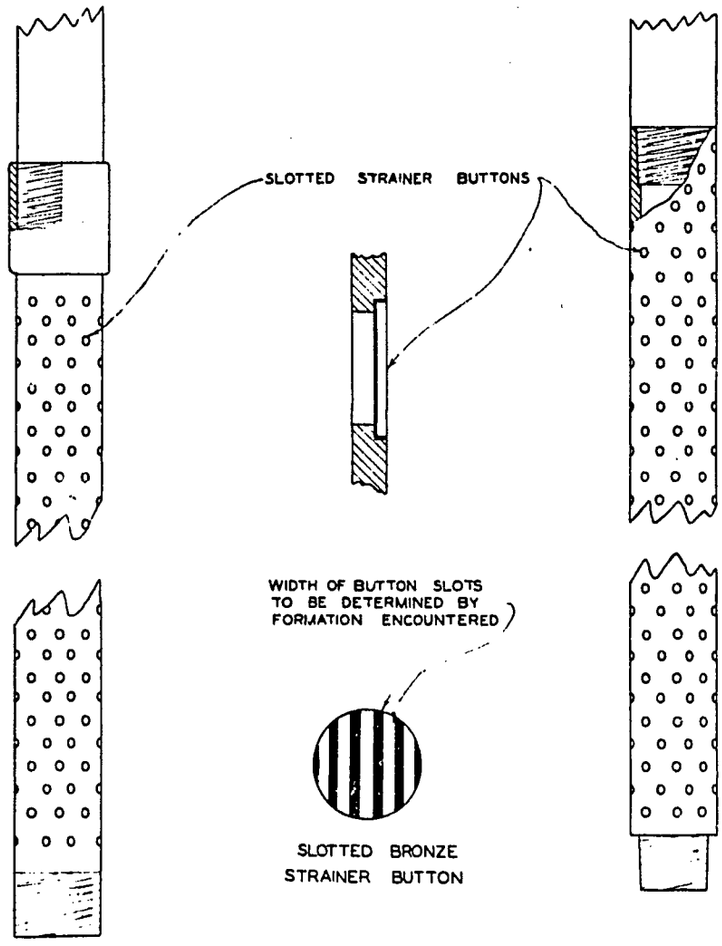
F.W. 2207

PLATE No. 6.

Plate No. 6 is a detailed drawing of an approved type of slotted button screen or strainer which can be had in many sizes, made of either standard pipe or standard API casing, and can be furnished with threaded flush joints or standard couplings. After necessary machine work of threading screens and setting slotted buttons is completed, the screen is to be galvanized.

This screen is especially recommended on account of its durability and wide range of use as it can be had in any size slot openings to conform with formations encountered.

F. W. 2208



COUPLING JOINT STRAINER

FLUSH JOINT STRAINER

NOTE - STRAINERS ARE TO BE GALVANIZED AFTER SLOTTED BRONZE BUTTONS ARE SET

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GENERAL PLAN FOR DRILLED WELLS
WIRELESS SLOTTED BUTTON STRAINER

SCALE

DESIGNED BY A H WOMACK — TRACED BY R T H

F. W. 2209

PLATE No. 7.

Plate No. 7 shows cross section of a generalized casing log, and illustrates the general arrangement of a multiple string of casings together with shoe, general arrangement of liner and screen in place, but is not to be understood as describing an arrangement of casing of finished well because, where final development will permit, much of the casing is removed and salvaged.

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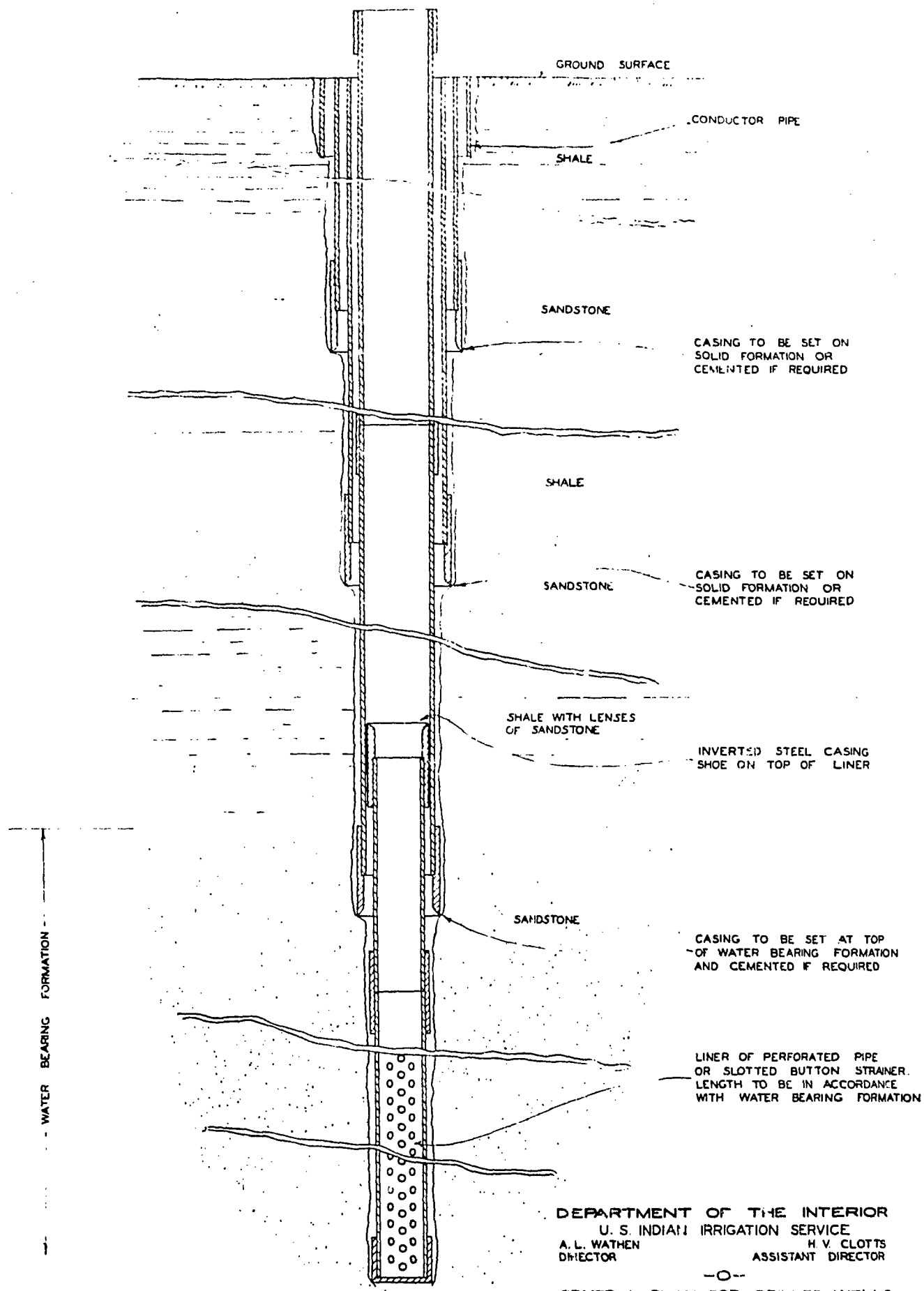
A - PLATE VII



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GENERAL PLAN FOR DRILLED WELLS
DEEP WELL CASING LOG

SCALE

DESIGNED BY A. H. WOMACK TRACED BY R.I.H.

F.W. 2211

PLATE No. 8.

Plate No. 8 illustrates a well-known method of cementing well-casing by the process known as two-plug method, also shows design, size and shape of plugs to be used. This is recommended as a positive and practical method which can be accomplished without the use of hydraulic pumps. Among several reasons for the practicability of this method, an important one is that in the event a water-bearing formation has been drilled through before the cementing and setting of casing, it will only be necessary to bridge or back-fill to the settling point in order to cement the casing.

By means of three separate drawings the method is illustrated step by step as a guide for the contractor and supervisor in charge of drilling activities. These drawings, it will be noted, are designated as steps; No. one illustrating casing charged with cement between top and bottom plug to be driven to bottom of well; No. two showing casing after it has been raised to permit egress of cement up into annular space between casing and wall. Number two also shows that the cement has been driven from casing by driving top plug down on to bottom plug, and number three illustrates casing re-set in final position with cement trapped behind the casing.

The work of cementing a well in this manner is accomplished by seven successive operations, as follows:

First:-

Backfill or bridge up to bottom of casing, making sure that bridge or fill is firm.

Second:-

Raise casing up two-thirds the distance of the length of bottom plug.

F. W. 2212

Plate No. 8 - Descriptive sheet No. 2.

Third:-

Bail out all casings.

Fourth:-

Insert bottom plug and drive it near top of water.

Fifth:-

Dump quick-setting or oil-well cement (mixed to plastic consistence) on bottom plug and drive plug and cement as far as is necessary to have the required amount of cement, as determined by volume.

Sixth:-

Insert top plug and drive plugs and cement to bottom, forcing cement up and around pipe to fill the necessary annular space required between casing and surrounding walls, using water, if necessary, to counter-balance outside pressure.

Seventh:-

Lower casing to final position as shown in step No. 3.

The last operation is to drill out plugs, but before doing so ample time must be allowed to elapse to insure proper setting of cement. This is to be determined in accordance with cement manufacturer's instructions as to length of time required for type of cement used.

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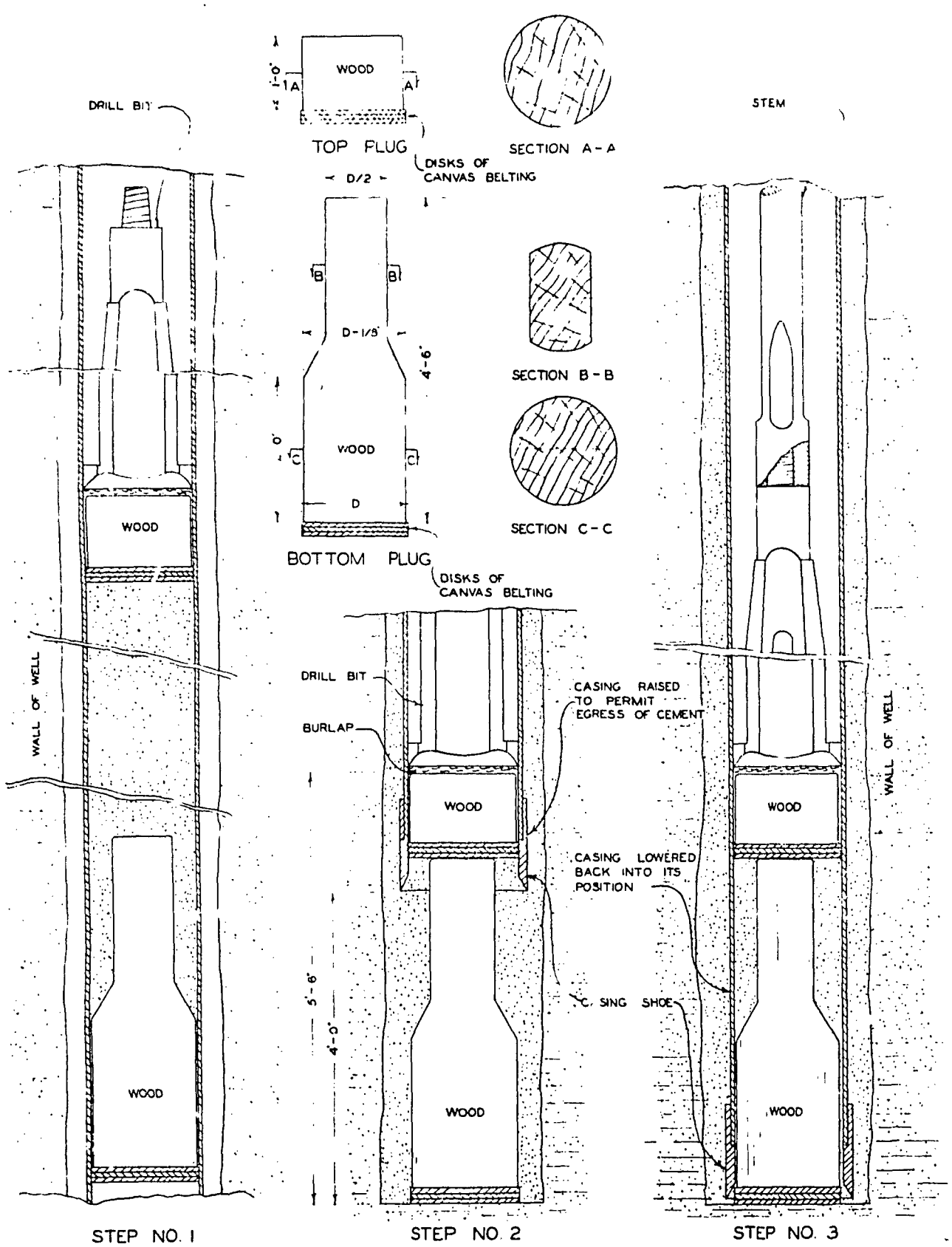
A - PLATE VIII



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GENERAL PLAN FOR DRILLED WELLS
TWO PLUG METHOD OF CEMENTING CASING

F. W. 2214

SCALE

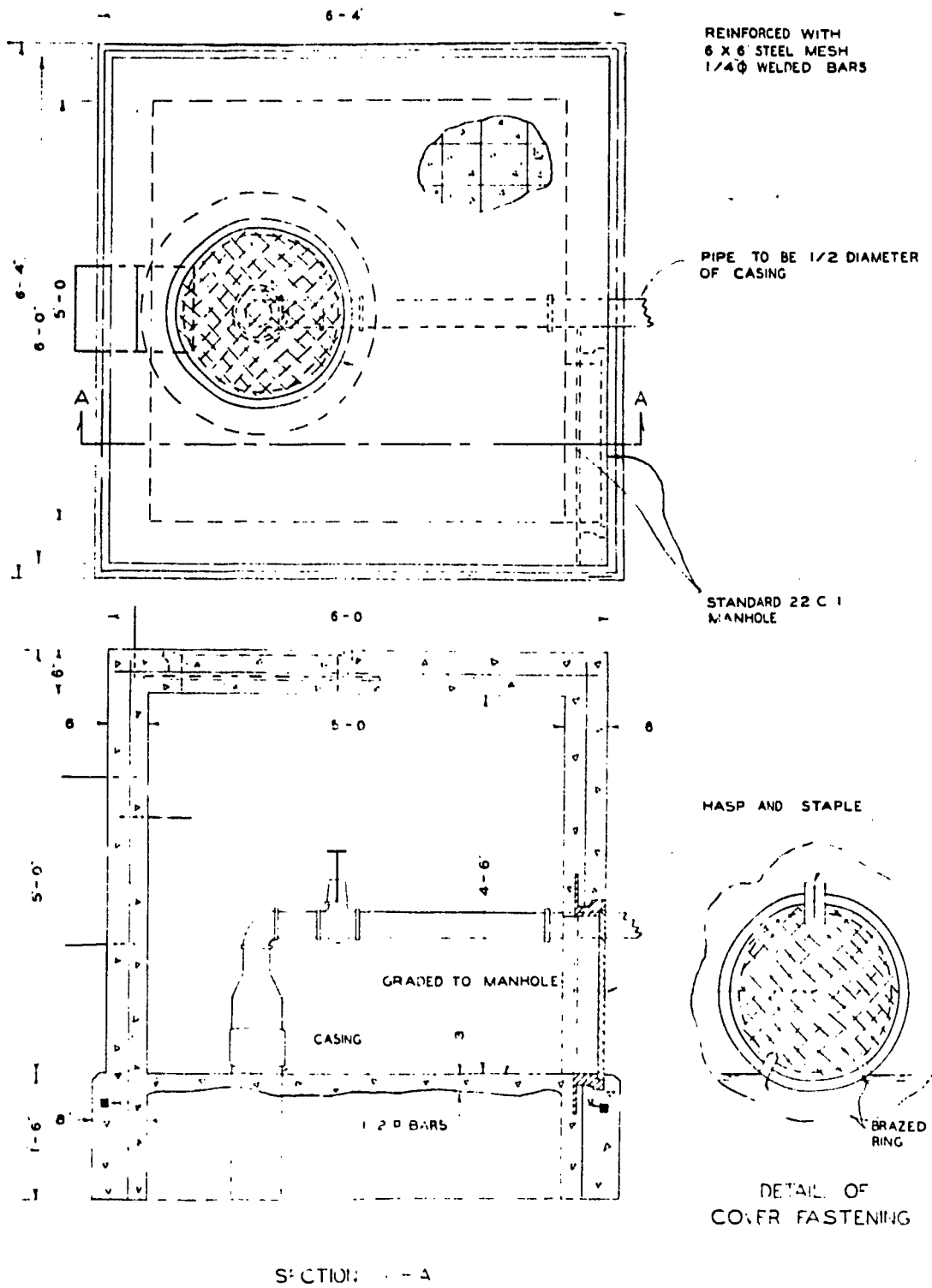
DESIGNED BY A. H. WOMACK TRACED BY R.I.H.

PLATE No. 9.

Plate No. 9 illustrates an Artesian well head and reinforced concrete inclosure which is designed to protect well head from frost, providing the valve is closed in compliance with the laws governing flow of Artesian wells.

It is believed that this drawing is sufficiently complete in plan and cross section to be useful in designing construction. It provides for a standard C. I. man-hole in roof of frost box directly over the well to be used in the event it is necessary to repair or clean out well. A similar constructed man-hole is in the side of frost box at floor level which is large enough to permit the use of wrenches and tools for making repairs.

F. W. 2215



DEPARTMENT OF THE INTERIOR
U S INDIAN IRRIGATION SERVICE
A L WATHEN, DIRECTOR — H V CLOTTS, ASSISTANT DIRECTOR

GENERAL PLAN FOR DRILLED WELLS
CONCRETE FROST BOX FOR ARTESIAN WELLS

SCALE

DESIGNED BY A H WOMACK — TRACED BY RIH

F.W. 2216

PLATE No. 10.

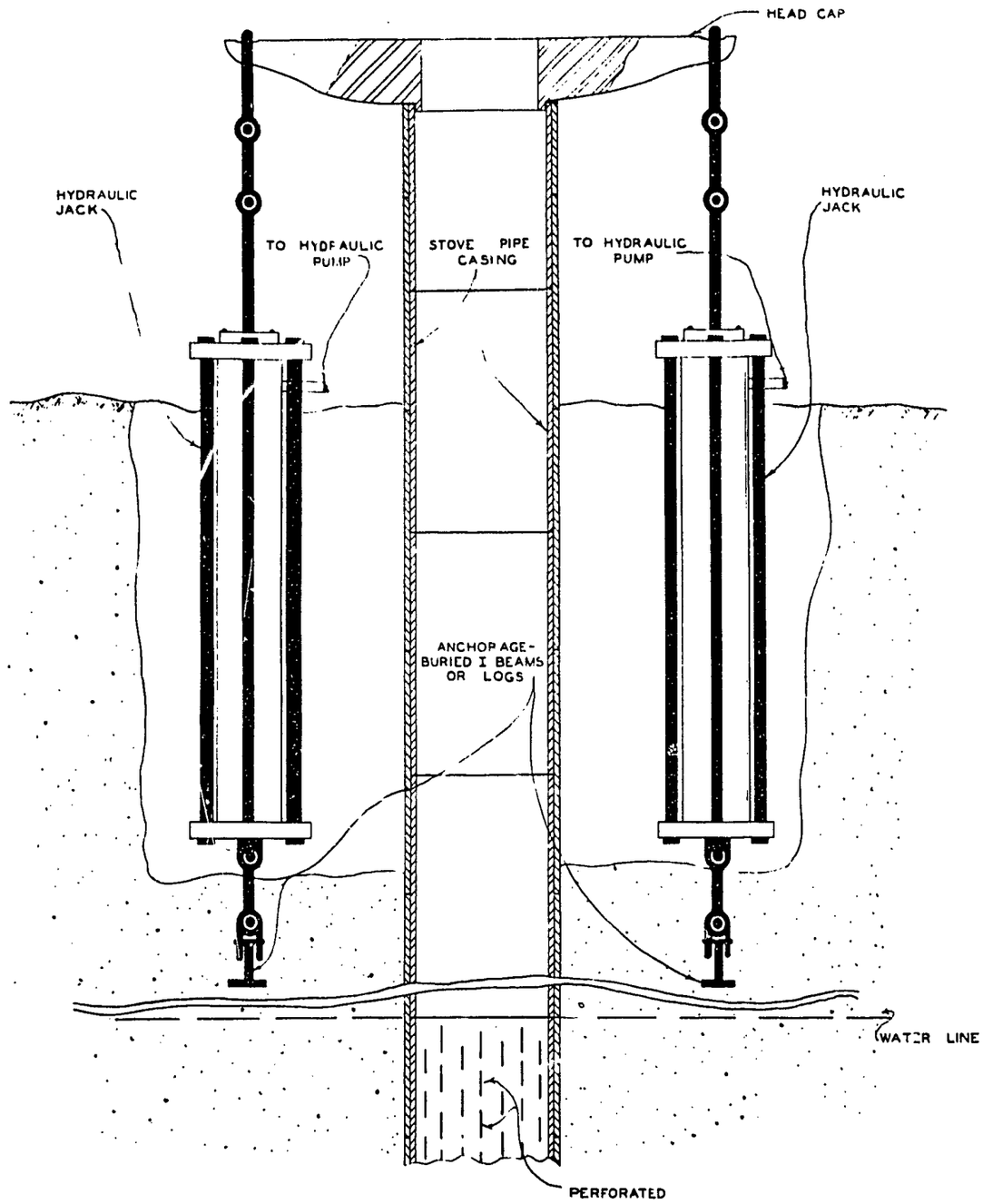
Plate No. 10 illustrates a method of sinking a well by the use of standard slip-joint double stove-pipe casing with the aid of hydraulic jacks. This method of development is to be followed where coarse sand and gravel prevail but is not to be used in fine sand formation.

The method consists of sinking sectional standard double stove-pipe casing into or through water-bearing formation to bed rock or shale, if possible. In the event the casing does not reach some original formation and is still in heaving or caving material it will be necessary to cement bottom with a few feet of concrete, using a dumping bailer to place cement.

After the cement has properly set, the well may be developed in the usual way by perforating the casing through the water-bearing formation with a rotary perforator or knife method. Care should be taken in selecting size of perforations, taking into consideration sizes of gravel encountered and seeing that perforations are slightly less in size than the medium sized water-bearing gravel.

After well has been cemented on bottom, (where necessary to do so) and casing has been perforated according to above instructions, further development should consist of swabbing and cleaning out as directed and illustrated by drawings one and two.

F.W. 2217



DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE

A. L. WATHEN, DIRECTOR
H. V. CLOTTS, ASSISTANT DIRECTOR

-O-

GENERAL PLAN FOR DRILLED WELLS
CALIFORNIA TYPE OF WELL

F.W. 2218

SCALE

DESIGNED BY A.H. WOMACK TRACED BY R.I.H.

INTRODUCTION

Reinforced Concrete Caissons

The series of five plates designated respectively as I, II, III, IV, and V, of Series D, illustrate and describe in detail the construction and use of a large sized reinforced concrete caisson.

These caissons are designed for use where shallow development is possible, and where larger quantities of water are required than can be developed by drilling methods, or where it is necessary to provide water for schools, agencies, hospitals, communities, etc. In addition to making it possible to develop a larger quantity of water, the caisson also provides a means of storage, thereby shortening the hours of pumping time.

Where water requirements, as above indicated, justify its use, the caisson method of development is especially adaptable to quick-sand and gravel formations. Caissons have been and can be successfully used in projects to a depth of fifty or sixty feet, and, while the specimen illustrated in these drawings is twelve feet across at the widest part, caissons may be constructed in varying sizes with diameters deviating from six to sixteen feet. With this feature of flexibility, development may be adjusted in accordance with porosity or density of surrounding formation, which combined with depth, provides a wide range of latitude in the amount of water which may be developed.

When sufficient quantity of water is developed, and caisson is still in leaving material, by excavating underneath it in the form of an inverted cone and the bottom cemented by placing concrete of proper mixture, (under water) and allowing cement to set before pumping out

F.W. 2219

water, the bottom will be protected against future heaving of sand, and all water will come through the infiltration ports.

It will be noted by drawings that the caisson is designed with bottle-neck shape. This is for the purpose of overcoming surface resistance, but where it is found necessary to sink deeper than can be accomplished by the caisson's own weight, resistance may be overcome by loading top with extra weights.

F.W. 2220

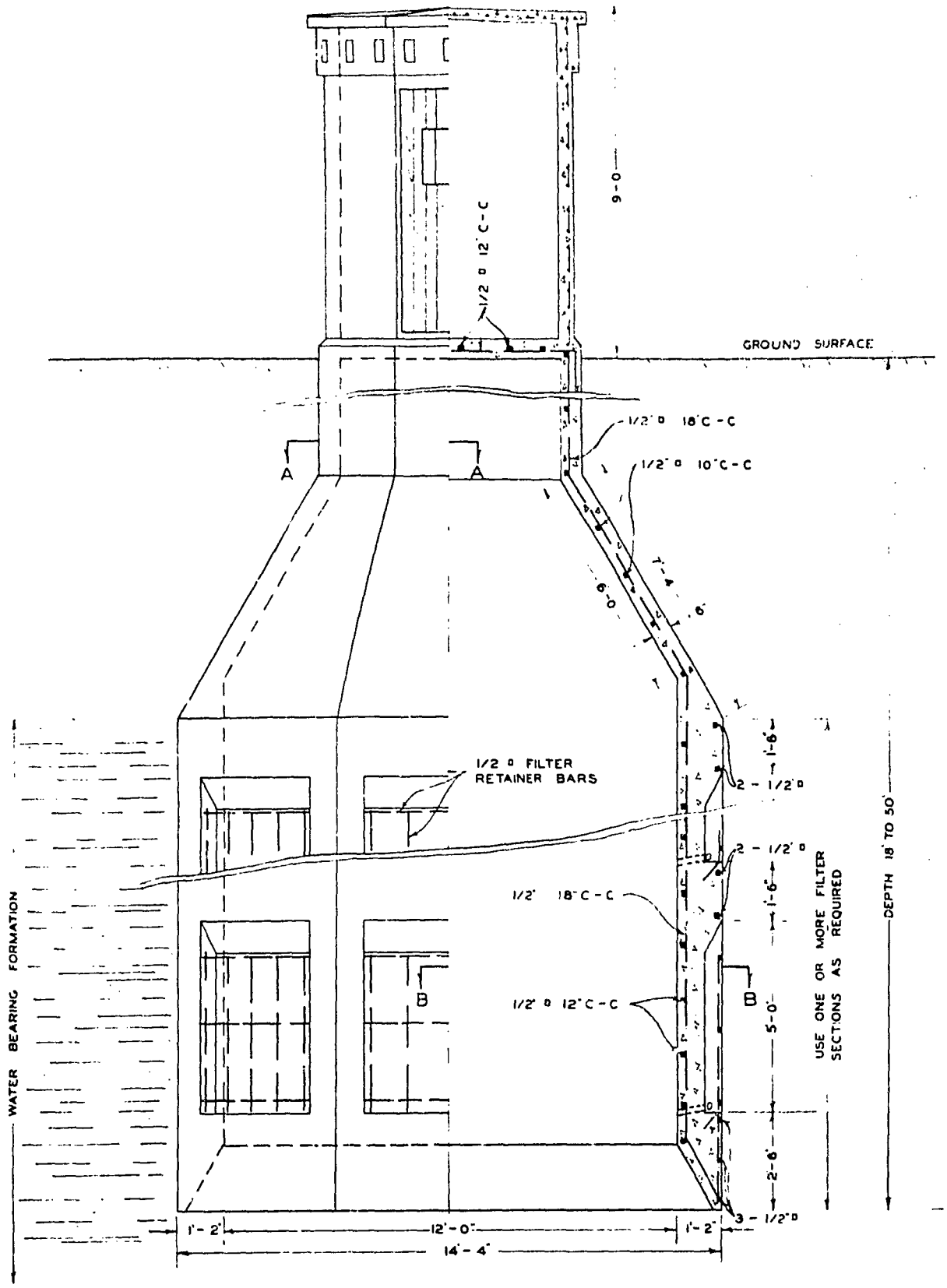
PLATE I, of SERIES "D".

Concrete Caisson

Plate No. I of Series D is a general plan and cross section of the reinforced concrete caisson, and illustrates the general arrangement of the complete caisson.

F. W. 2221

D - PLATE 1



HALF ELEVATION HALF SECTION

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE
A. L. WATHEN, DIRECTOR — H. V. CLOTTS, ASSISTANT DIRECTOR

F. W. 2222

GENERAL CAISSON LAYOUT
STANDARD 12' BOTTLE NECK CAISSON
SCALE
DESIGNED BY A. H. WOMACK — TRACED BY R. I. H.

PLATE II, of SERIES "D".

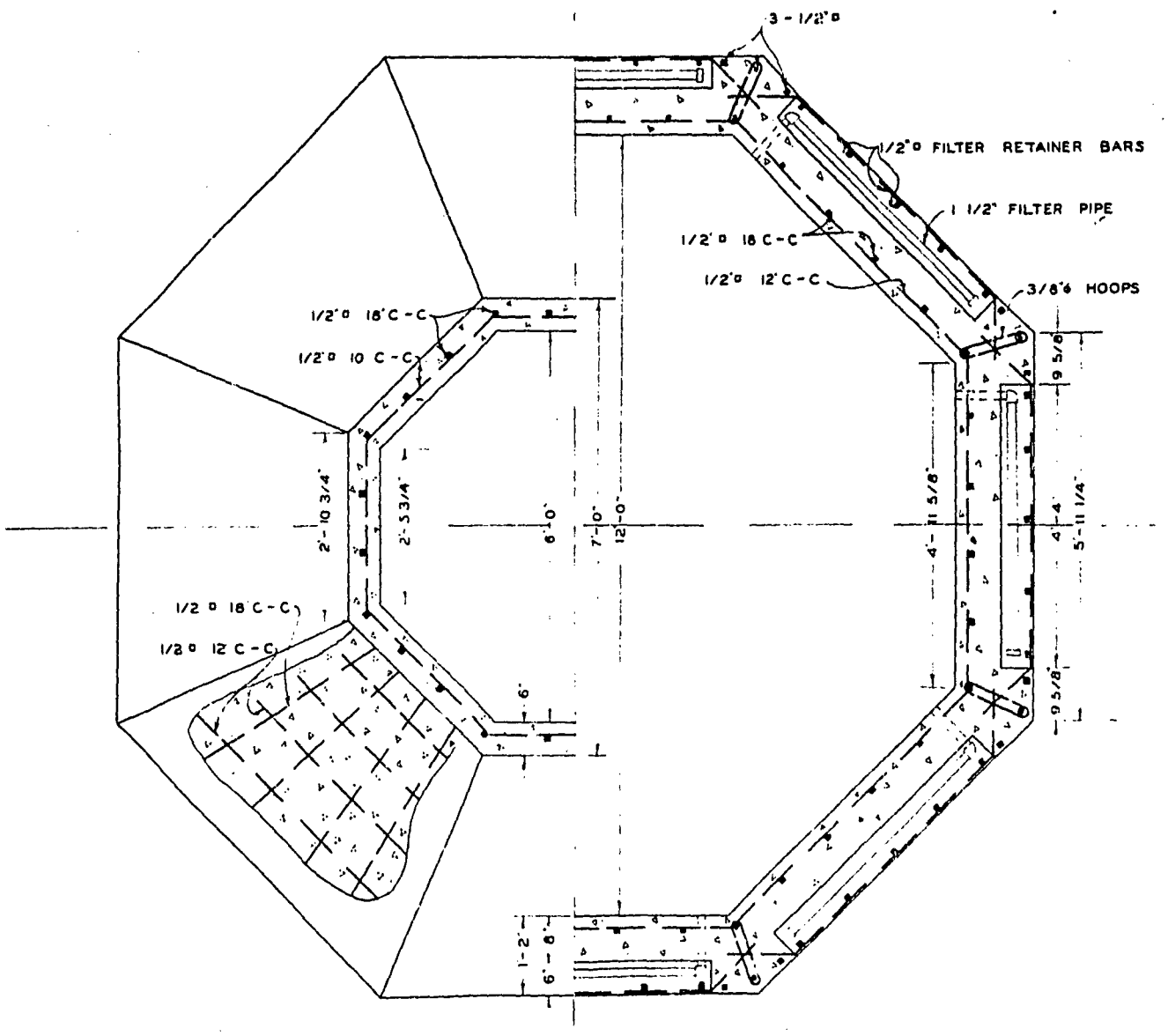
Concrete Caisson

Plate No. II of Series D is horizontal cross-sections of the caisson.

F. W. 2223

CV-6417-201

NN001652



HALF SECTION A - A HALF SECTION B - B

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE

A. L. WATHEN, DIRECTOR
H. V. CLOTTS, ASSISTANT DIRECTOR

-O-

GENERAL CAISSON LAYOUT
STANDARD 12' BOTTLE NECK CAISSON

SCALE

DESIGNED BY A. H. WOMACK TRACED BY R.I.H

F.W. 2224

PLATE III of SERIES "D".

Concrete Caisson

Plate No. III of Series D, illustrates the method of attaching the steel shoe, if required by formation encountered. This sheet shows the form of the bottom of the shoe, infiltration ports, method of placing filter, metal screens to support graded filter, reinforcing steel, slotted pipe with weep slots, etc.

FILTER MATERIAL

It should be the duty of the supervisor to select screens and material for a properly proportioned filter. First step should be to screen out all over-size by the use of a three-eighths inch mesh screen, discarding all material larger than three-eighths inch.

The second step is to take out all the under-sized by the use of a one-eighth inch screen, thus leaving a graded aggregate not over three-eighths and not under one-eighth inch in size.

In the event there is too much material of the same size in the mass formed by the second step, the porosity will be too open to exclude fine sand; therefore, it will be necessary to take a third step by use of intermediate screens and further separate gravel so that proper proportions can be had, and by remixing them to form the proper porosity desired to conform to the sands of the formation encountered.

PLACING FILTER

The method of placing filter is illustrated in this drawing, which is to simply pack filter material back of screen.

As is illustrated in drawing showing detailed cross-section covering arrangement of infiltration ports, they are built in each section

F. W. 2225

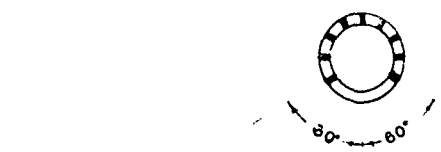
as needed. The required number of infiltration ports must be determined by density of surrounding water-bearing sand, i. e., if the sand is very fine, the water movement through it is naturally slow - thus requiring more infiltration ports than are necessary where development is through gravel formation which offers less resistance to seepage.

The construction of a caisson is carried on at the well site, and, after forms have been laid, reinforcing steel has been centered and concrete poured to level of forms and sufficient time has elapsed for concrete to set, the forms are removed and filters placed. Then, by excavating underneath caisson shoe the caisson should be sunk until top of it reaches level of ground. At this point forms are raised and reset preparatory to pouring another section. This process is to be repeated until caisson has reached the required depth to develop quantity of water desired.

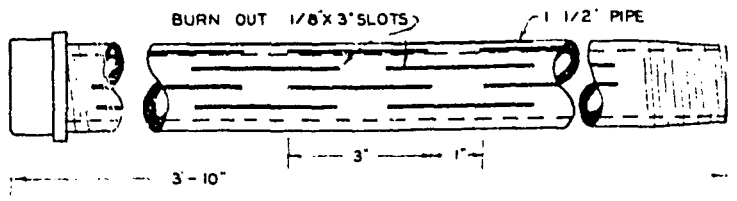
Plate III of Series D also illustrates arrangement of piping at bottom of infiltration ports, showing detail of how piping is to be slotted and set up with weep slots in the upper two-thirds of the pipe circumfrence. Weep slots are to be one-eighth inch wide by three inches in length as shown in drawings to be placed in pipe with slots up and attached by short nipple which leads water through concrete wall to the interior of the caisson.

F. W. 2226

D - PLATE III

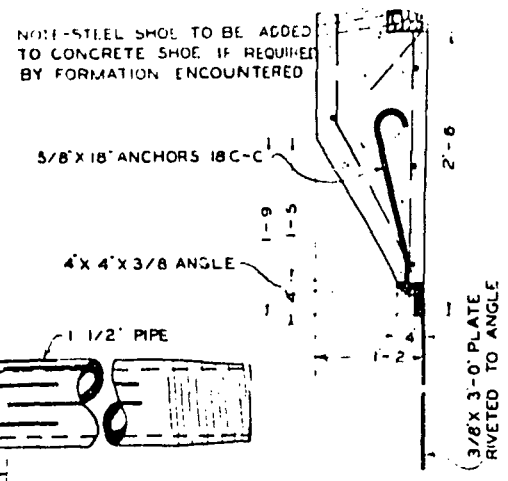


CROSS SECTION

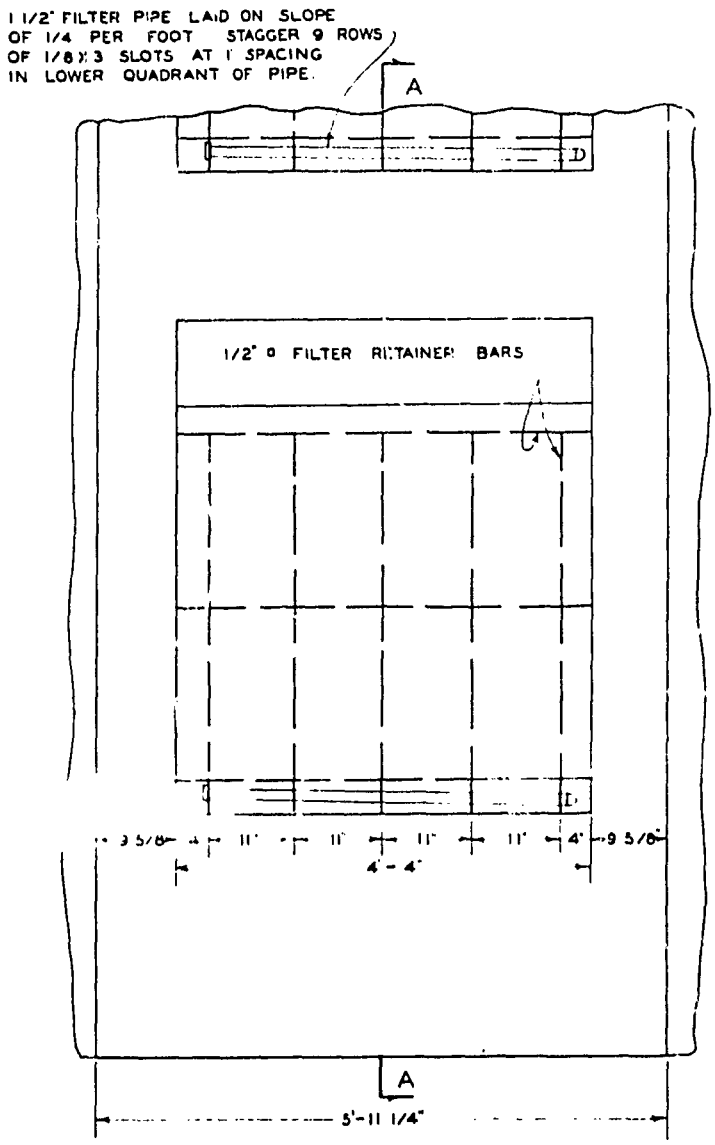


BOTTOM VIEW

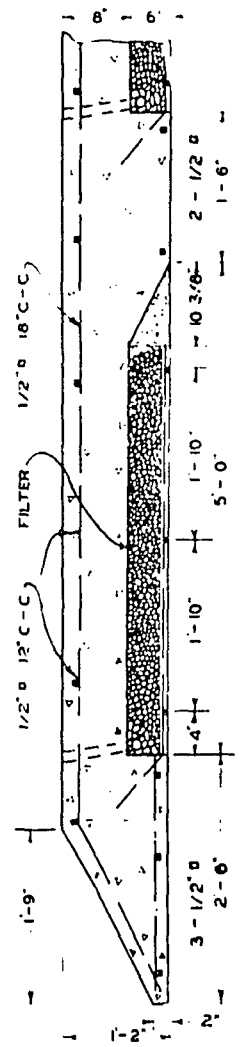
FILTER PIPE DETAILS
SCALE



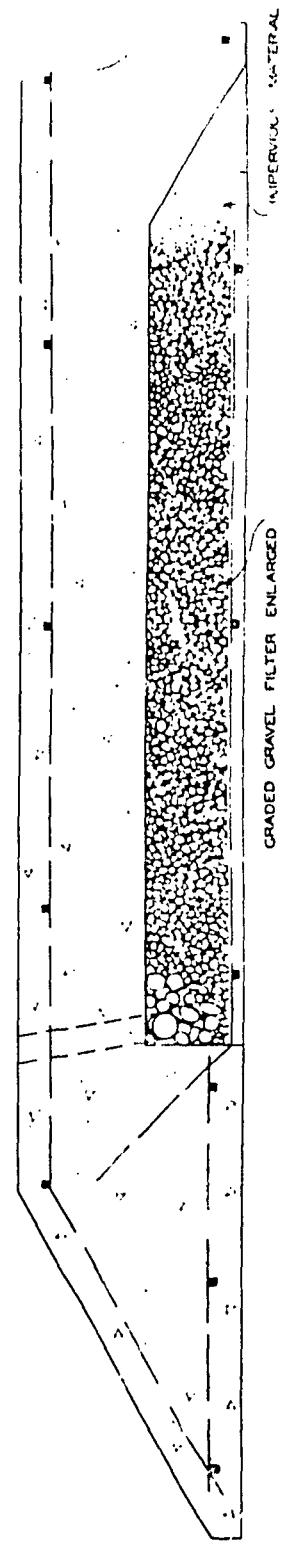
CROSS SECTION
STEEL SHOE
SCALE



ELEVATION OF FILTER PANEL
SCALE



SECTION A - A
CONCRETE SHOE
SCALE



CROSS SECTION
FILTER IN PLACE
SCALE

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE
A.L. WATHEN, DIRECTOR
H. V. CLOTTS, ASSISTANT DIRECTOR

-O-

GENERAL CAISSON LAYOUT
DETAIL OF FILTER PANEL AND SHOE

SCALE AS INDICATED
DESIGNED BY A. H. WOMACK
TRACED BY R.I.H.

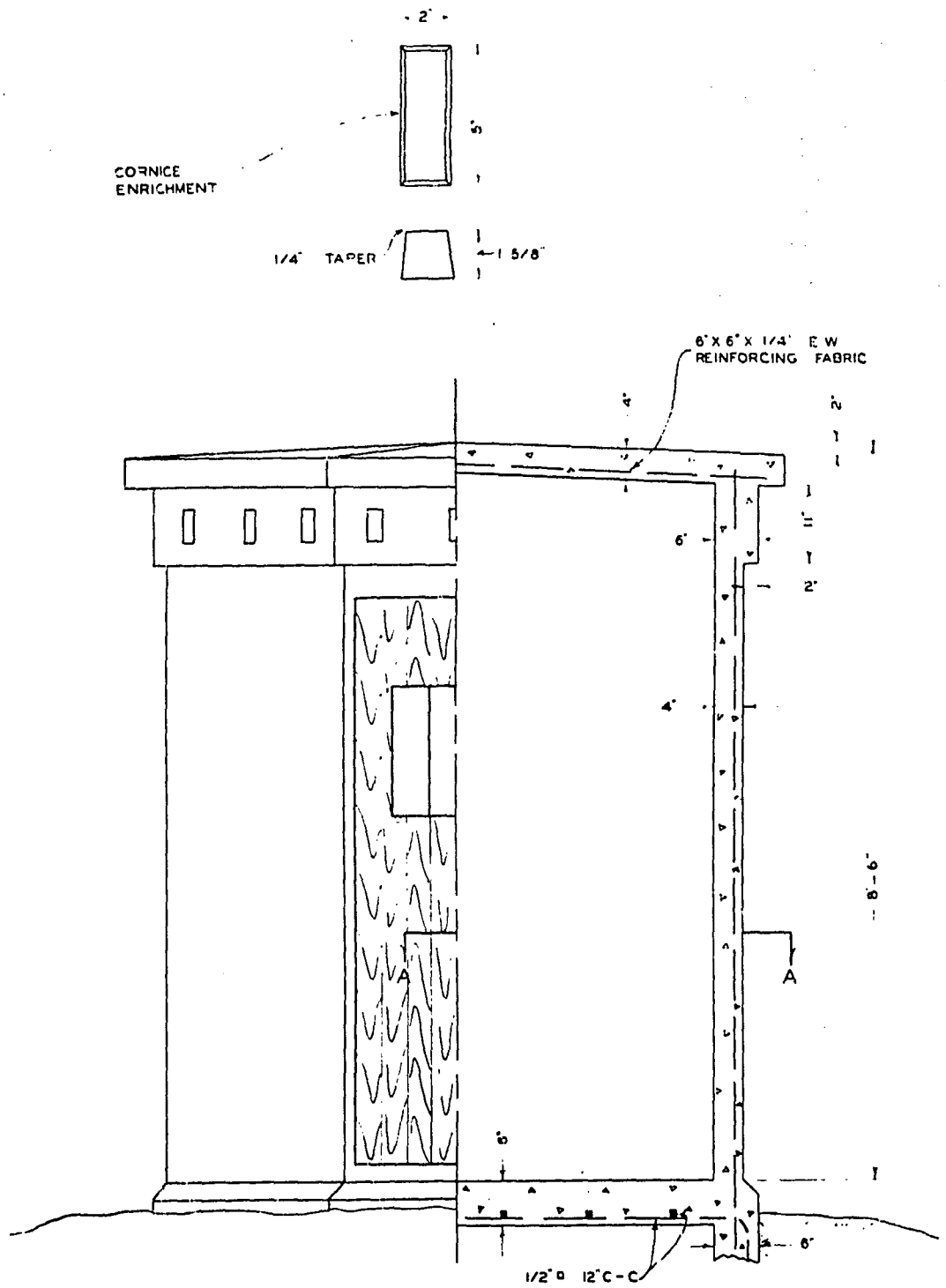
F.W. 2227

PLATES IV & V, of SERIES "D".

Reinforced Concrete Pumphouse

Plates IV and V of Series D illustrate a reinforced concrete pumphouse which is an extension of concrete caisson, and shows a general cross section and plan including floor details, cast iron manhole and cornice details. This is believed to be sufficient in detail to be used in construction

F. W. 2228



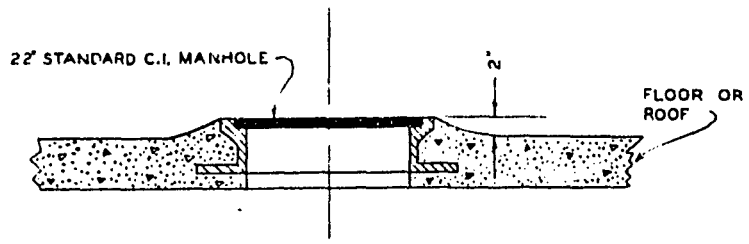
HALF ELEVATION HALF SECTION

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE
A. L. WATHEN, DIRECTOR — H V CLOTTS, ASSISTANT DIRECTOR

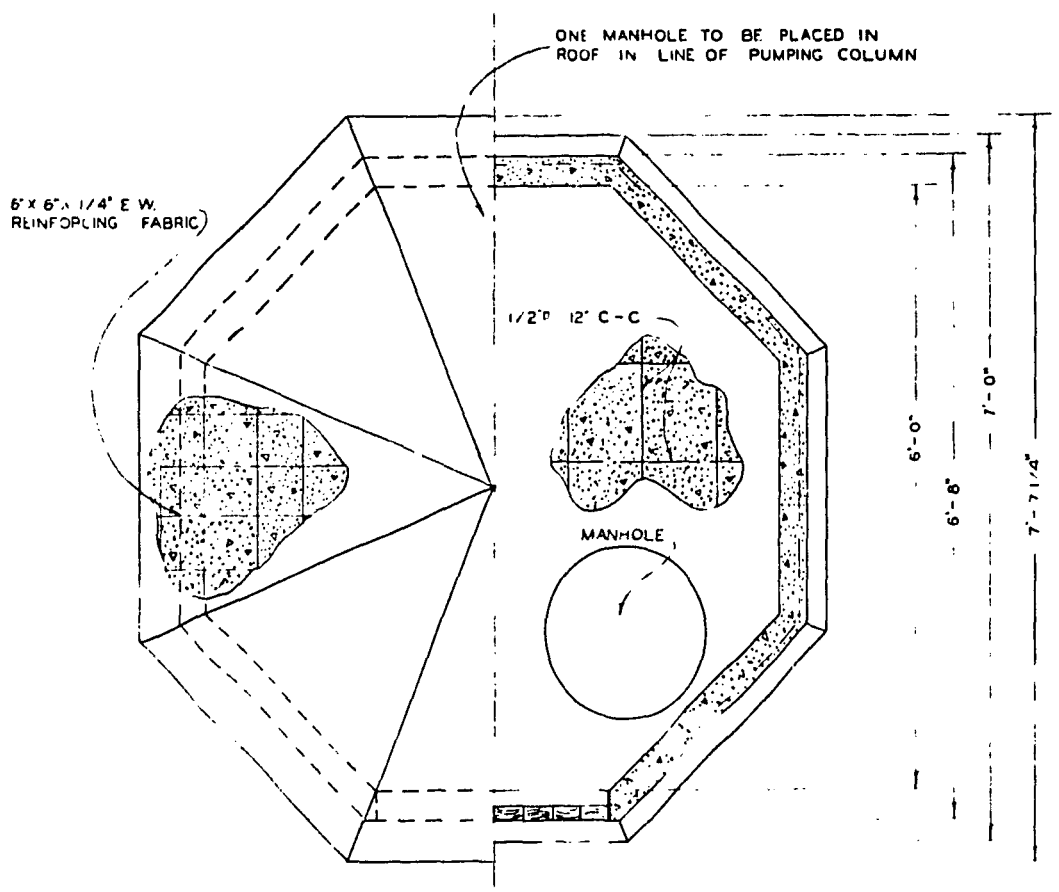
F.W. 2229

-O-

GENERAL CAISSON LAYOUT
STANDARD 12' BOTTLE NECK CAISSON
DETAIL OF CONCRETE PUMP HOUSE
SCALE
DESIGNED BY A.H. WOMACK TRACED BY R.I.H.



DETAIL OF MANHOLE



HALF PLAN HALF SECTION A-A

DEPARTMENT OF THE INTERIOR
U S INDIAN IRRIGATION SERVICE
A L WATHEN, DIRECTOR
H V CLOTTS, ASSISTANT DIRECTOR

-O-

GENERAL CAISSON LAYOUT
DETAIL OF CONCRETE PUMP HOUSE

SCALE

DESIGNED BY A H WOMACK TRACED BY R.I.H

F.W. 2230

PLATES VI & VII, of SERIES "D".

Stone Pumphouse

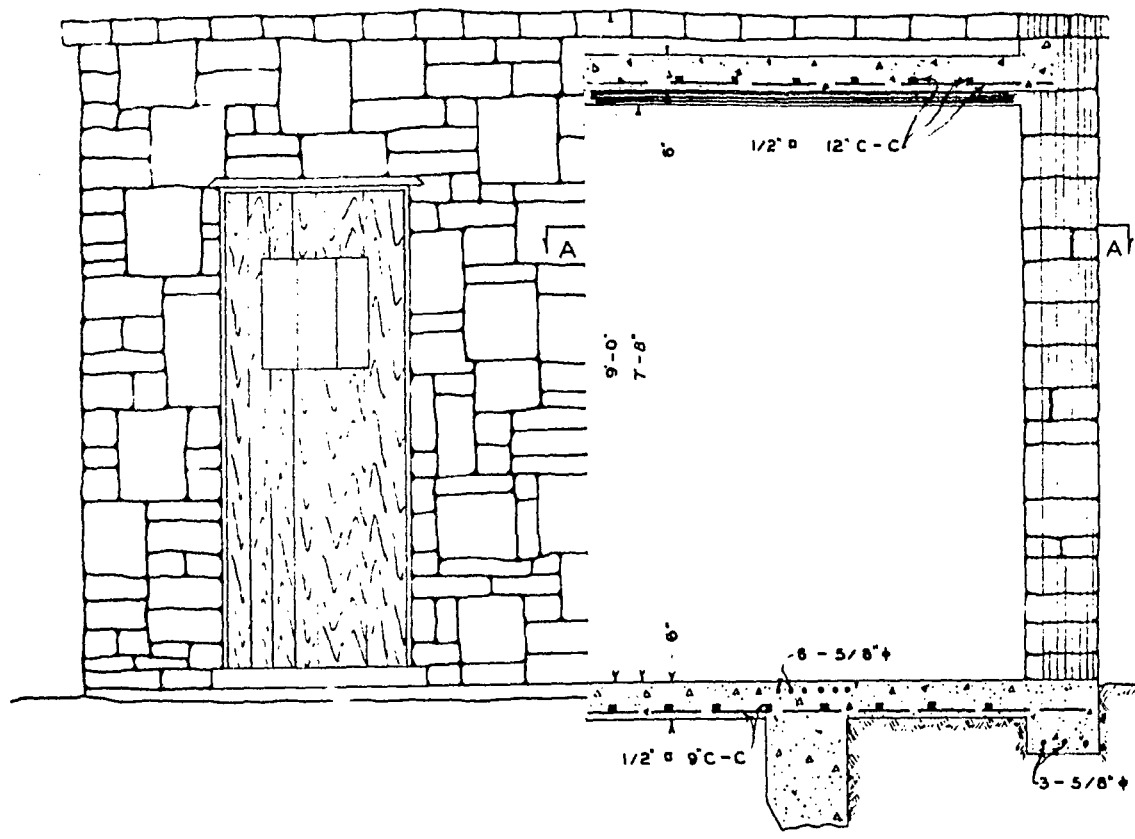
Plates VI and VII of Series D represent a stone pumphouse which is to be used over caisson and where more room is required than is available for pumping, as is illustrated in plan on Plate IV.

This design of pumphouse is arranged by extending brackets and reinforced concrete girders from top of concrete caisson by cantilever methods to support stone walls. The purpose of this arrangement in placing pumphouse on concrete caisson is to avoid unequal settlement of filled in earth between pumphouse foundation and caisson. It is believed that sufficient information is shown on these drawings to enable the designing of this pumphouse but in the event that more detailed drawings are needed they will be furnished by the department named on this sheet.

F.W. 2231

STANDARD 22 C.I MANHOLE

DETAIL OF MANHOLE



HALF ELEVATION

HALF SECTION B - B

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE
A. L. WATHEN, DIRECTOR — H. V. CLOTTS, ASSISTANT DIRECTOR

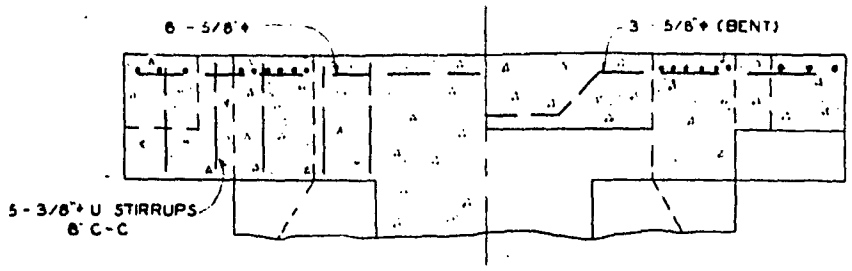
-O-

GENERAL CAISSON LAYOUT
DETAIL OF STONE PUMP HOUSE

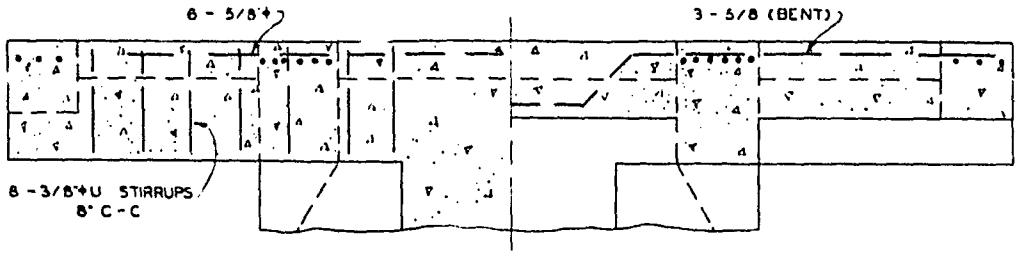
SCALE

DESIGNED BY A.H. WOMACK — TRACED BY R.I.H.

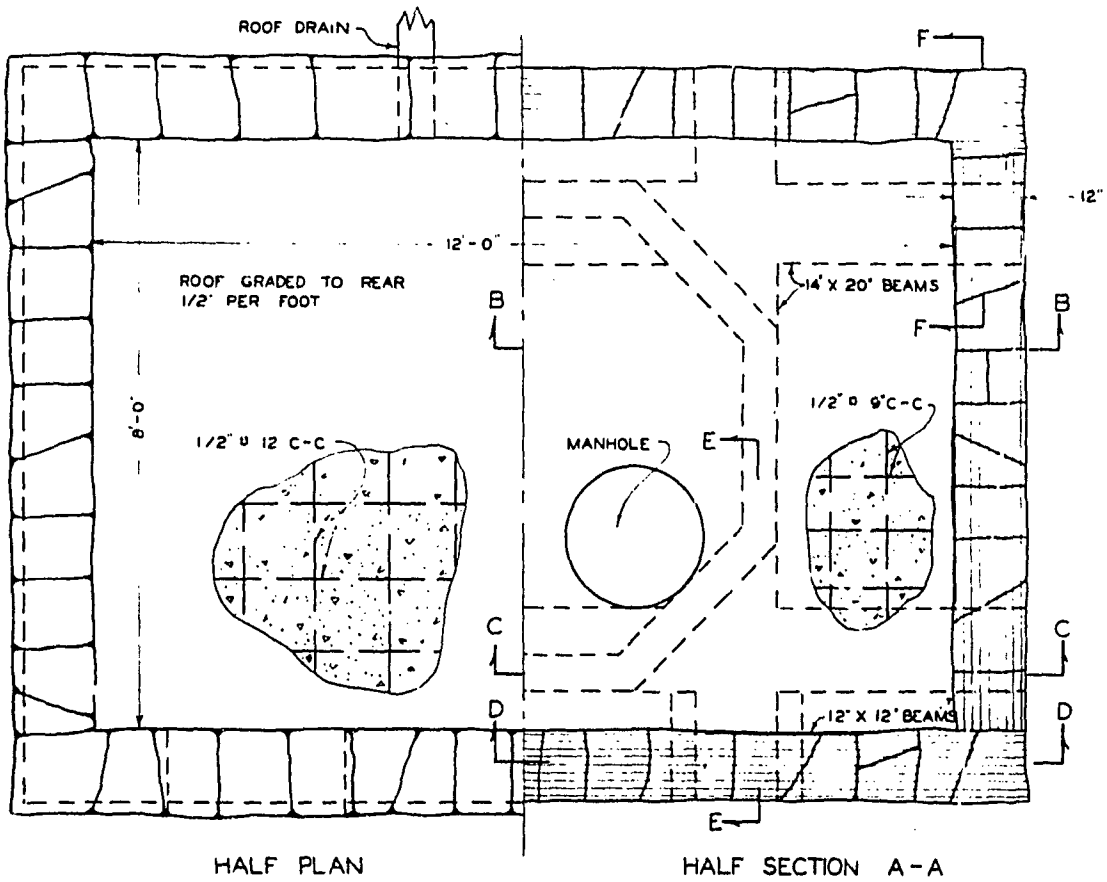
F. W. 2232



HALF SECTION E-E HALF SECTION F-F



HALF SECTION C-C HALF SECTION D-D



HALF PLAN HALF SECTION A-A

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE
A L. WATHEN, DIRECTOR — H V CLOTTS, ASSISTANT DIRECTOR

-O-

GENERAL CAISSON LAYOUT
DETAIL OF STONE PUMP HOUSE

SCALE

DESIGNED BY A. H. WOMACK TRACED BY R.I.H.

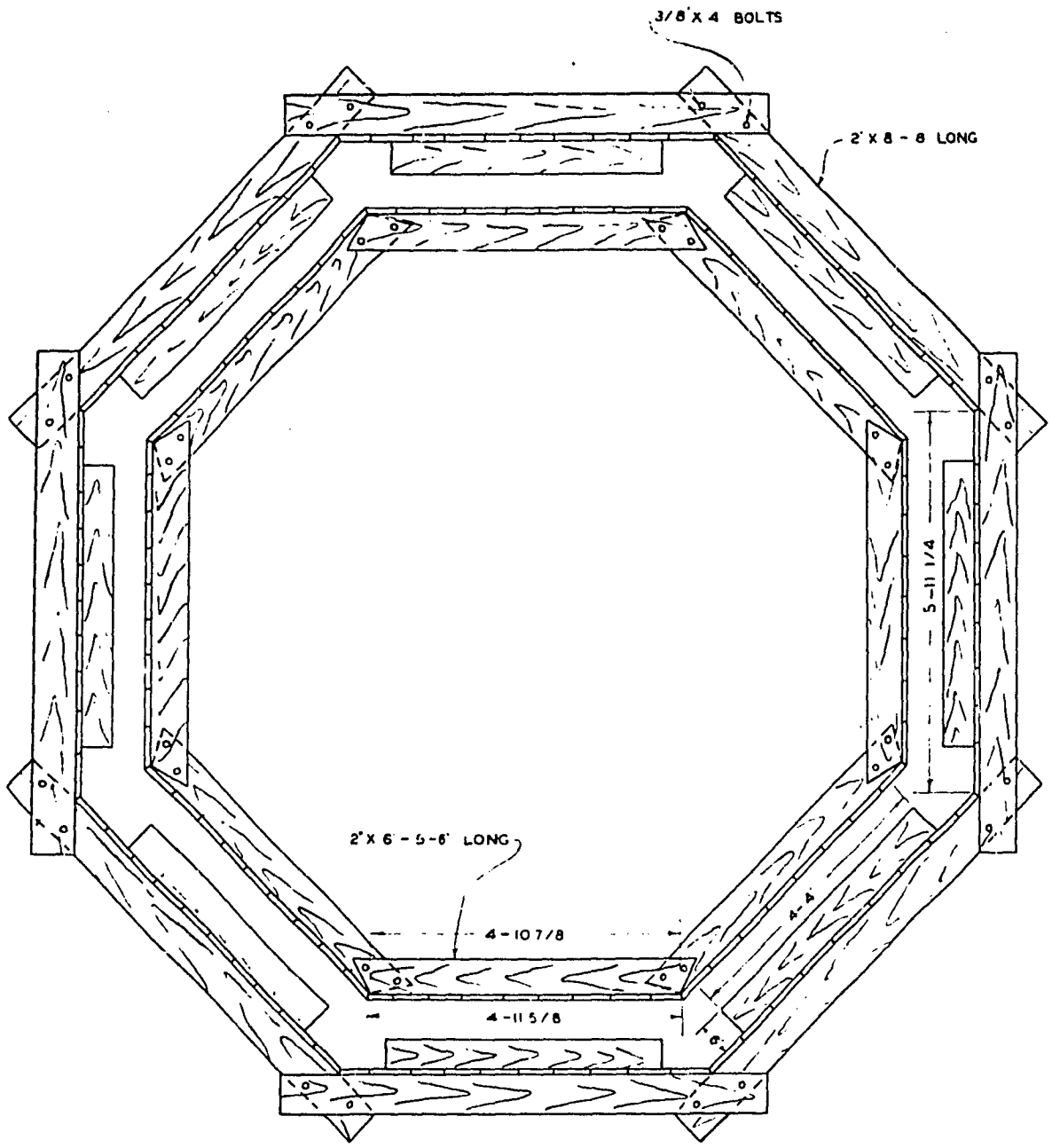
F.W. 2233

PLATES VIII & IX, of SERIES "D".

Plates VIII and IX of Series D are general caisson layout form details, showing lengths of girth material of forms, both of the lower and upper portion of the caisson, and it is believed to be of sufficient detail to be used as a working drawing.

F.W. 2234

D - PLATE VIII



FILTER SECTION

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE

A. L. WATHEN, DIRECTOR
H. V. CLOTTS, ASSISTANT DIRECTOR

-O-

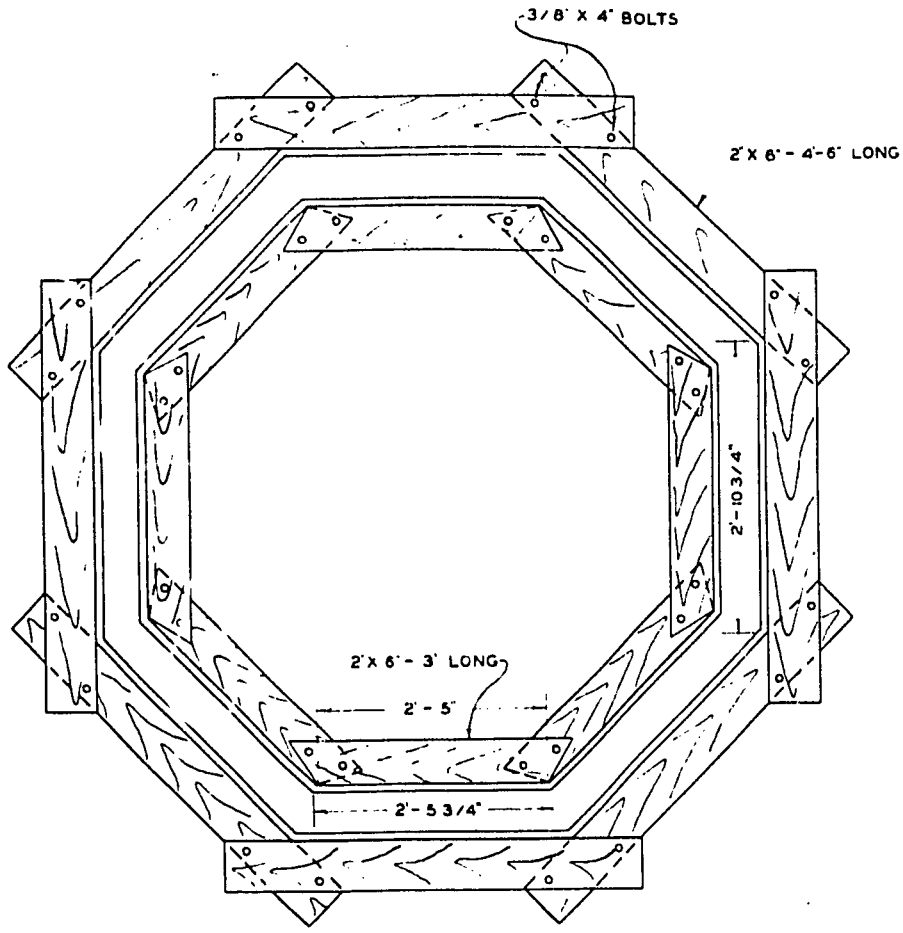
GENERAL CAISSON LAYOUT
FORM DETAILS

SCALE

DESIGNED BY A.H. WOMACK TRACED BY R.I.H.

F.W. 2235

D - PLATE



SHAFT SECTION

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE
A.L. WATHEN, DIRECTOR
H. V. CLOTTS, ASSISTANT DIRECTOR

-O-

GENERAL CAISSON LAYOUT
FORM DETAILS

SCALE

DESIGNED BY A.H. WOMACK TRACED BY R.I.H.

F. W. 2236

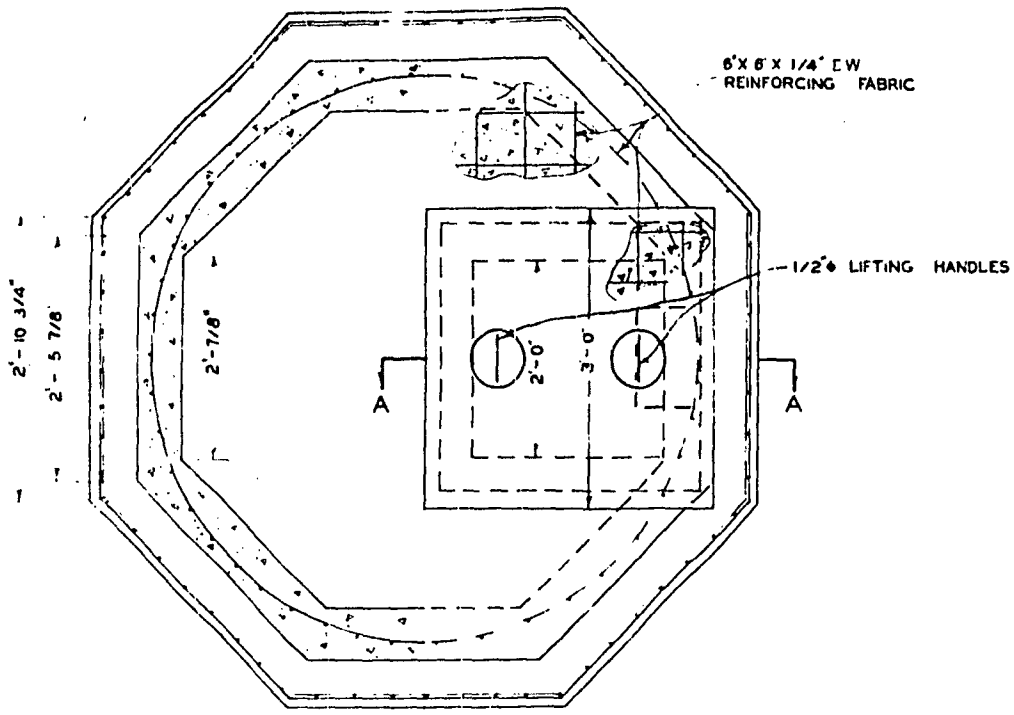
PLATE XVI of SERIES "D"

Shallow Well Caisson

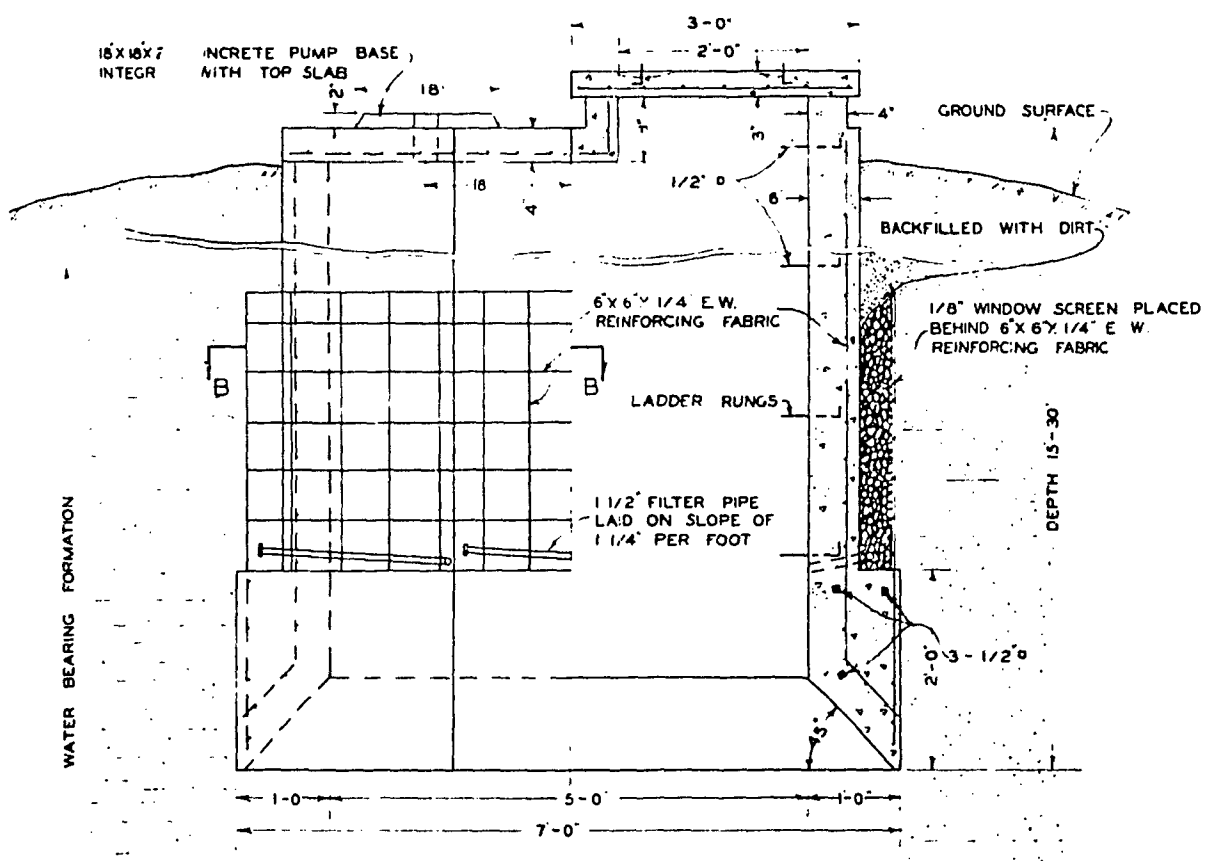
Plate XVI of Series "D" illustrates a shallow well caisson to be used where shallow water may be developed for domestic or stock water, where only sufficient water is necessary to supply a windmill or other small pumping units.

If the formation is coarse, as in gravel, hand excavation can be done from inside of caisson with the aid of a portable pump, in order to lower water levels. The caisson wall serves as cribbing to prevent cave-ins, reducing to a minimum the amount of material to be removed, and affords very effective protection to workmen doing the excavating. When formations are fine and inclined to heave, caisson can be sunk by excavating with clamshell or orange-peel excavator and accomplished under water, keeping water at its natural level to counter-balance outside pressure.

F. W. 2237



HALF SECTION B-B HALF PLAN



HALF ELEVATION HALF SECTION A-A

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE
A. L. WATHEN, DIRECTOR — H. V. CLOTTS, ASSISTANT DIRECTOR

-O-

GENERAL CAISSON LAYOUT
SHALLOW WELL CAISSON

SCALE

DESIGNED BY A. H. WOMACK — TRACED BY R.I.H.

F. W. 2238

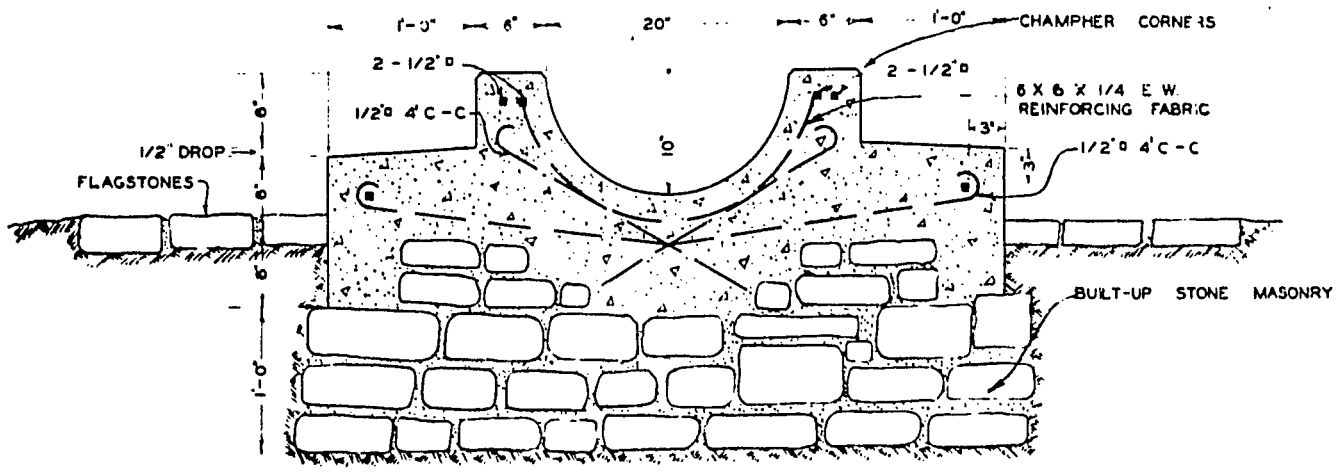
Working descriptions of attached drawings will be prepared and attached after receipt of instructions from the Office.

F.W. 2239

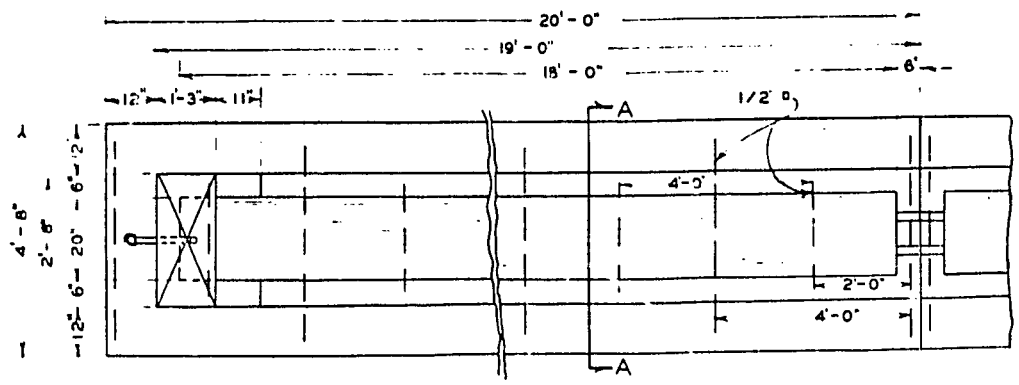
V-6417-201

NN001668

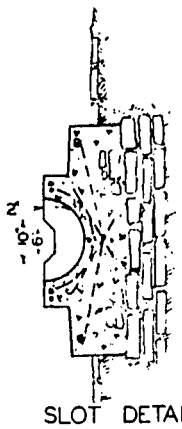
F - PLATE I



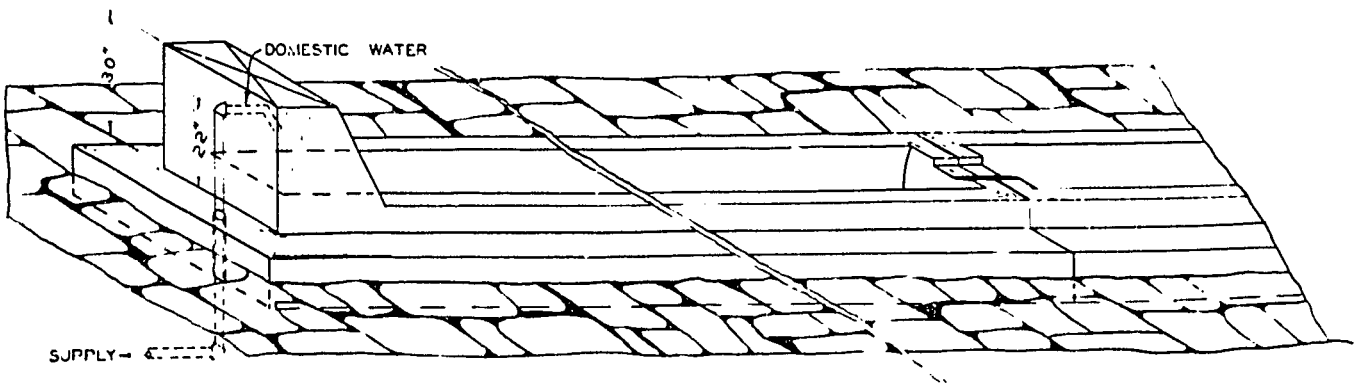
SECTION A-A
SCALE



PLAN
SCALE



SLOT DETAIL



ISOMETRIC VIEW
SCALE

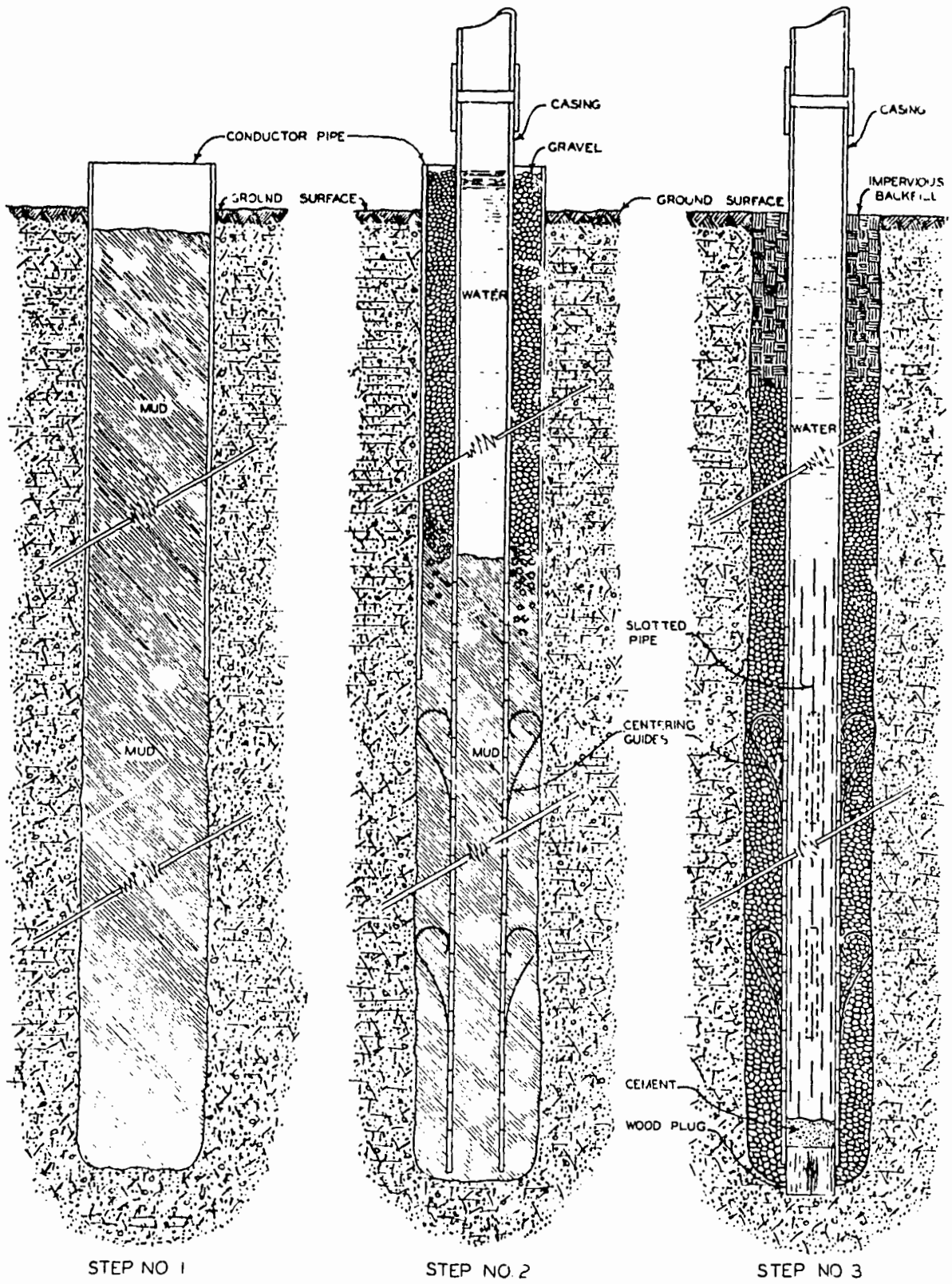
DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE
A. E. WATHEN, DIRECTOR — H. V. CLOTTS, ASSISTANT DIRECTOR

WATER DISTRIBUTION
STOCK WATERING TROUGH

SCALE AS INDICATED
DESIGNED BY A. H. WOMACK — TRACED BY R. T. H.

F. W. 2240

A - PLATE XX



DEPARTMENT OF THE INTERIOR
U S INDIAN IRRIGATION SERVICE
A L. WATHEN, DIRECTOR
H V CLOTTS, ASSISTANT DIRECTOR

-0-

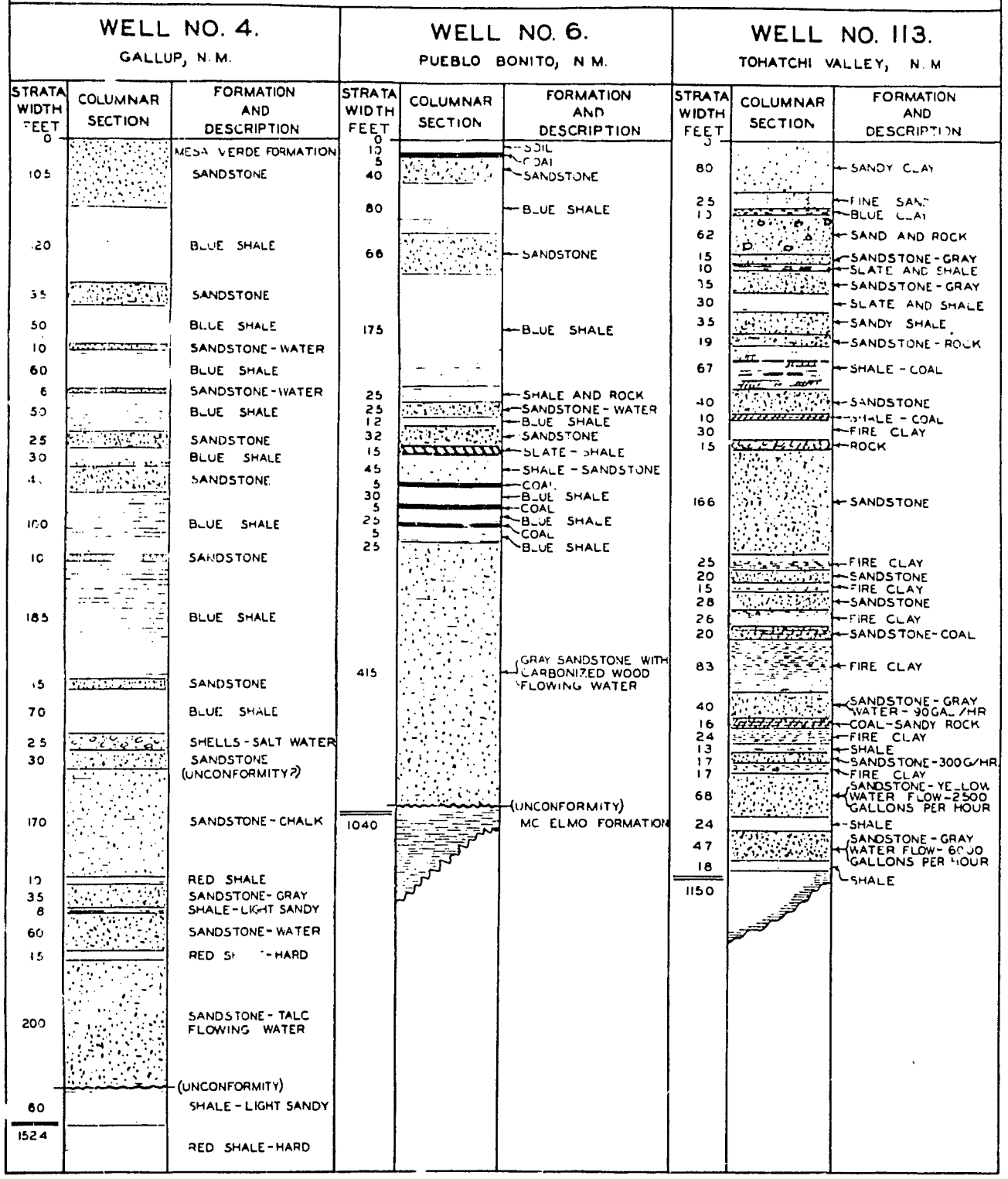
GENERAL PLAN FOR DRILLED WELLS
ROTARY DEVELOPED WELL

NO SCALE

DESIGNED BY A H. WOMACK TRACED BY R I.H

F.W. 2241

FLOWING WELLS IN THE NAVAJO COUNTRY



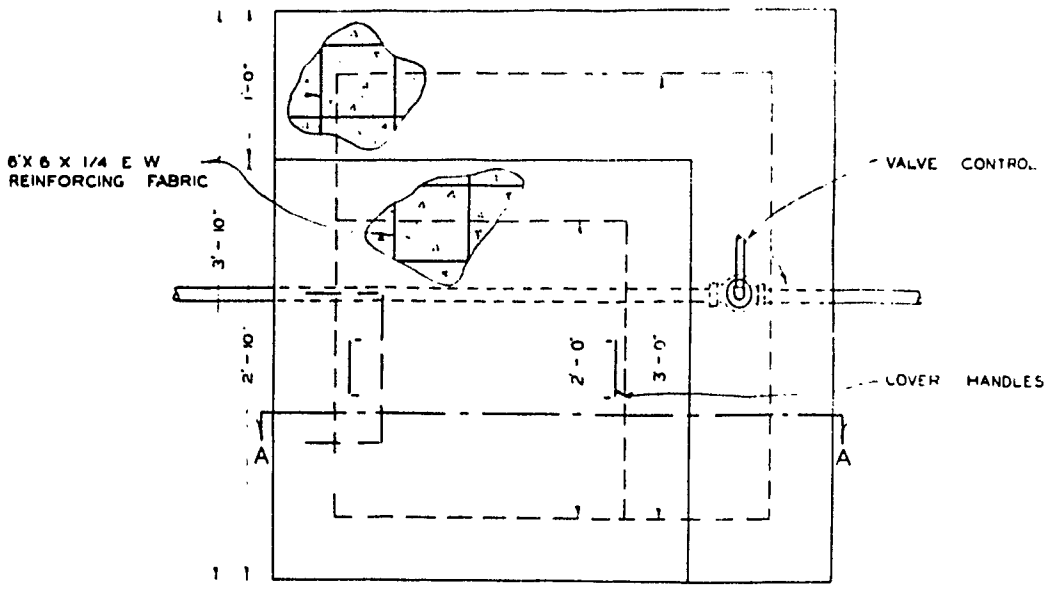
DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE
A. L. WATHEN, DIRECTOR — H. V. CLOTTS, ASSISTANT DIRECTOR

—O—

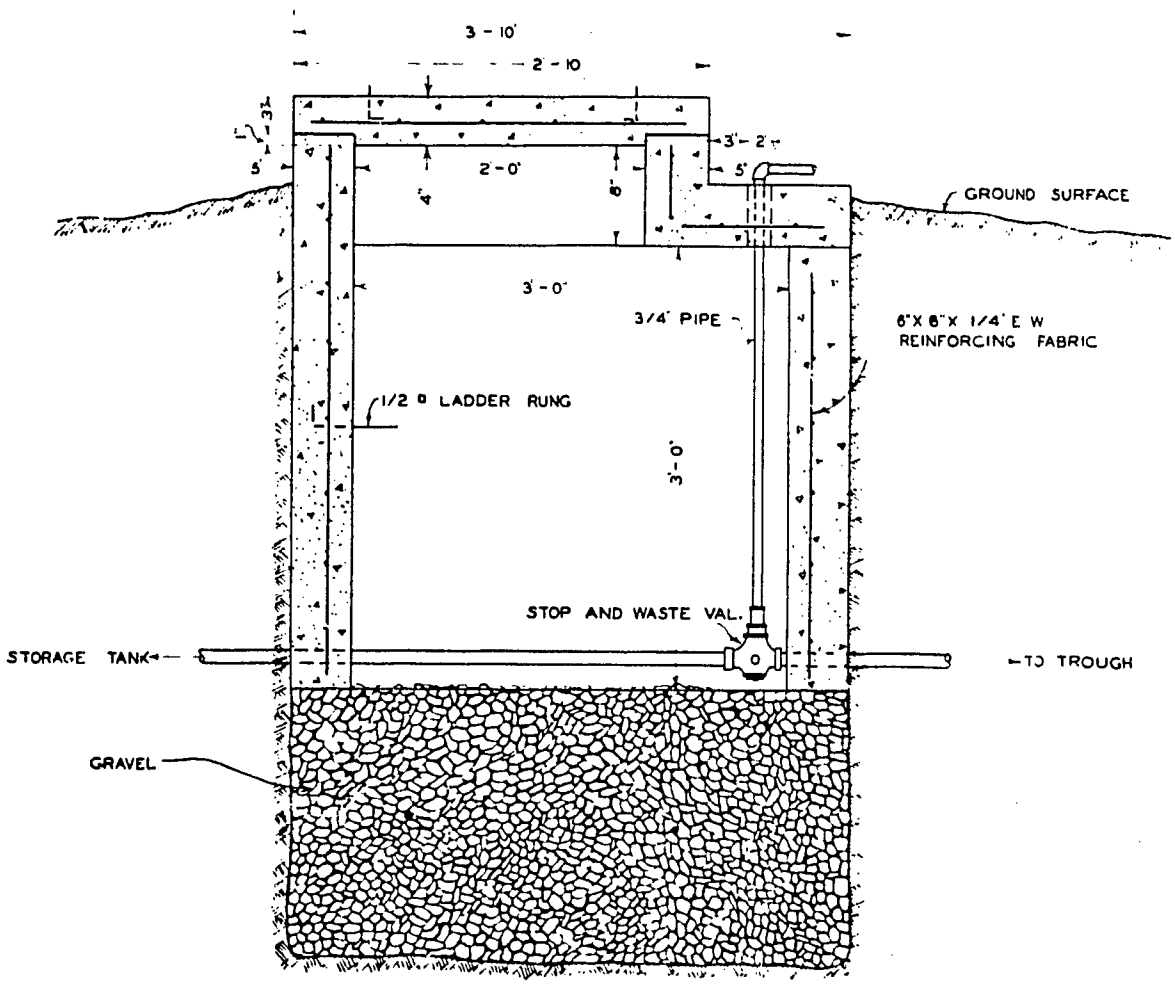
F. W. 2242

GENERALIZED LOGS OF FLOWING WELLS
SOUTHERN AND EASTERN NAVAJO

SCALE
BY A. H. WOMACK — TRACED BY R.I.H



PLAN



SECTION A-A

DEPARTMENT OF THE INTERIOR
U. S INDIAN IRRIGATION SERVICE
A L. WATHEN, DIRECTOR
H V CLOTTS, ASSISTANT DIRECTOR

-O-

WATER DISTRIBUTION
CONCRETE FROST BOX

SCALE
DESIGNED BY A.H. WOMACK TRACED BY [illegible]

F.W. 2243

GENERALIZED COLUMNAR SECTION OF SEDIMENTARY STRATA NAVAJO COUNTRY

		FORMATION	COLUMNAR SECTION	THICKNESS IN FEET	DESCRIPTION
QUATERNARY		EOLIAN			
		LAVA — ASH			UNCONFORMITY
TERTIARY	EOCENE	CHUSKA SANDSTONE		700 TO 900	GRAY AND WHITE LENSES OF CONGLOMERATE
					UNCONFORMITY
		TOHATCHI SHALE (TOHATCHI SCHOOL)		200 TO 1100	SHALES AND THIN SANDSTONE WITH LENSES OF LIGNITE.
					UNCONFORMITY
CRETACEOUS	UPPER CRETACEOUS	POST — MESA VERDE		100 TO 300	SHALES AND SANDSTONE MIXED WITH COAL.
		MESA VERDE (GALLUP)		275 TO 800	MASSIVE SANDSTONE AT BASE AND TOP WITH ARENACEOUS AND ARGILLACEOUS SHALES AND WORKABLE COAL. FOSSILS OF THE MONTANA AGE
	CRETACEOUS	MANCOS SHALE (KEAMS CANYON AGENCY; POLACCA-CROWN POINT AGENCY; SHIPROCK AGENCY)		500 TO 800	DRAB ARGILLACEOUS AND ARENACEOUS SHALES WITH LENSES OF COAL AND LIMESTONE. FOSSILS OF THE COLORADO AGE.
		DAKOTA SANDSTONE		0 TO 295	GRAY AND BROWN COARSE SANDSTONE WITH PLANT FOSSIL.
					UNCONFORMITY
JURASSIC?		McELMO (KAYENTA SCHOOL)		400 TO 700	GREEN, WHITE, AND GRAY SANDSTONE AND SHALES WITH BEDS OF GYPSUM. FOSSILS OF THE MORRISON AGE
JURASSIC		McELMO (KAYENTA SCHOOL)		400 TO 700	GREEN, WHITE, AND GRAY SANDSTONE AND SHALES WITH BEDS OF GYPSUM. FOSSILS OF THE MORRISON AGE.
					UNCONFORMITY
	LA PLATA GROUP	NAVAJO SANDSTONE		400 TO 1000	LIGHT, RED, MASSIVE, FINE GRAINED, CROSS-BEDDED SANDSTONE. LIMESTONE NEAR TOP. CLIFF MAKER.
		TODILTO		3 TO 300	LIMESTONE, CALCAREOUS, AND ARENACEOUS SHALES
		WINGATE SANDSTONE		30 TO 450	MASSIVE CROSS-BEDDED, BRIGHT RED SANDSTONE CLIFF MAKER.
					UNCONFORMITY
TRIASSIC		CHINLE (CHINLE SCHOOL; FORT DEFIANCE AGENCY)		500 TO 1182	SHALE WITH THIN LIMESTONE AND SANDSTONE. CONGLOMERATE VERIGATED AND BANDED PINK, RED AND CHOCOLATE COLOR. ABUNDANT FOSSIL FORESTS
		SHINARUMP CONGLOMERATE		20 TO 100	ABUNDANT PETRIFIED WOOD.
					UNCONFORMITY
CARBONIFEROUS	PERMIAN?	DE CHELLY SANDSTONE (CITY OF HOLBROOK; TUBA CITY AGENCY)		0 TO 585	LIGHT RED CROSS-BEDDED SANDSTONE CLIFF MAKER.
		MOENCOPI		300 TO 500	CHOCOLATE, RED, AND BANDED ARENACEOUS SHALES AND THIN SANDSTONE, GYPSIFEROUS FOSSIL PLANTS.
					UNCONFORMITY
	PENNSYLVANIAN	AUBREY (LEUPP AGENCY)		0 TO 1000	KAIBAB LIMESTONE BUFF AND RED SANDSTONE AND LIMESTONE. FOSSILS OF THE PENNSYLVANIAN AGE.
					UNCONFORMITY
PRE-CAMBRIAN?					MASSIVE AND BEDDED GRAY QUARTZITE

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE

A. L. WATHEN, DIRECTOR
H. V. CLOTTS, ASSISTANT DIRECTOR

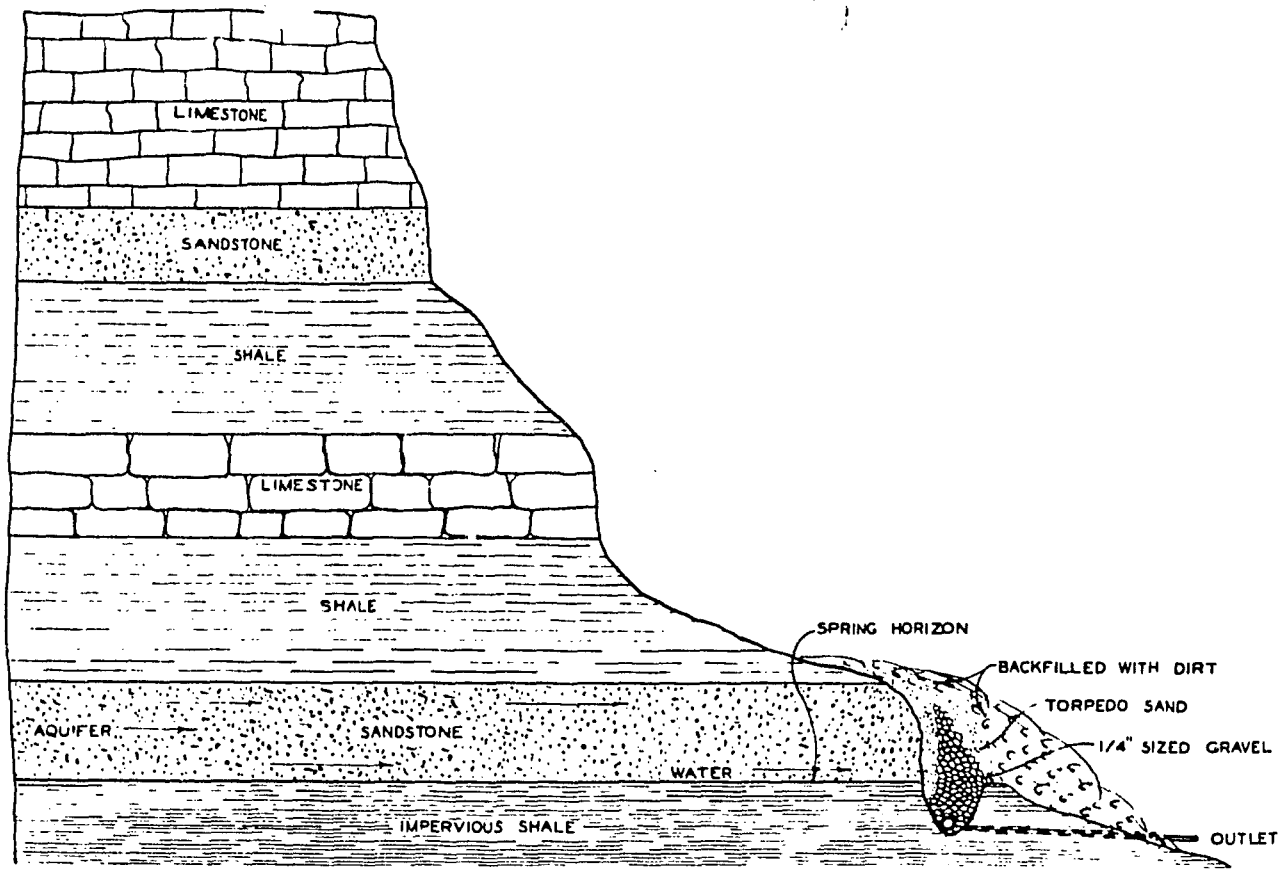
NO SCALE

BY A. H. WOMACK

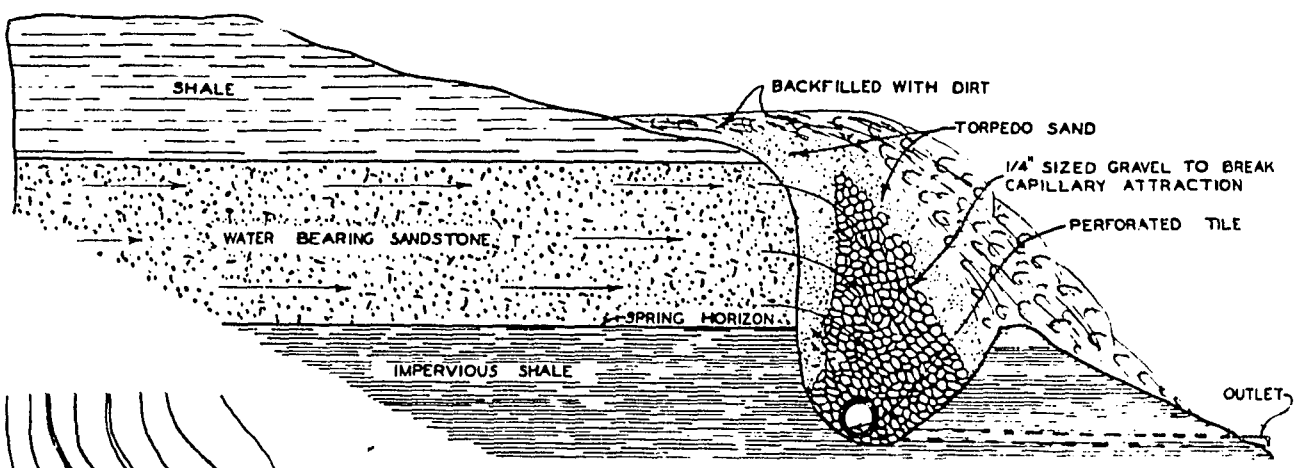
TRACED BY R. I. H.

F.W. 2244

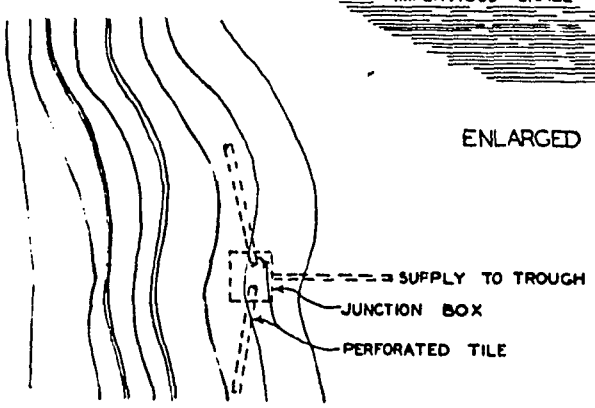
J - PLATE I



CROSS SECTION



ENLARGED CROSS SECTION



GROUND PLAN

F. W. 2245

DEPARTMENT OF THE INTERIOR
U. S. INDIAN IRRIGATION SERVICE
A. L. WATHEN, DIRECTOR — H. V. CLOTIS, ASSISTANT DIRECTOR

-O-

SPRING DEVELOPEMENT
CROSS SECTION OF SPRING FILTER

NO SCALE

DESIGNED BY A. H. WOMACK — TRACED BY R.I.H.