WATER DEVELOPMENT NAVAJO and HOPI RESERVATIONS

March 9 1918

6 cy Respectfully forwarded to the Commissioner of Indian Affairs, ~~with the recommendation that it be~~ for reference

W. S. Hanna
Supt. of Irrigation

6—1143

DEPARTMENT OF THE INTERIOR

UNITED STATES INDIAN IRRIGATION SERVICE

SUPERINTENDENT OF IRRIGATION

Albuquerque N. M., February 9, 1918.

Mr. W. M. Reed,
Chief Engineer,
WASHINGTON.

My dear Mr. Reed:

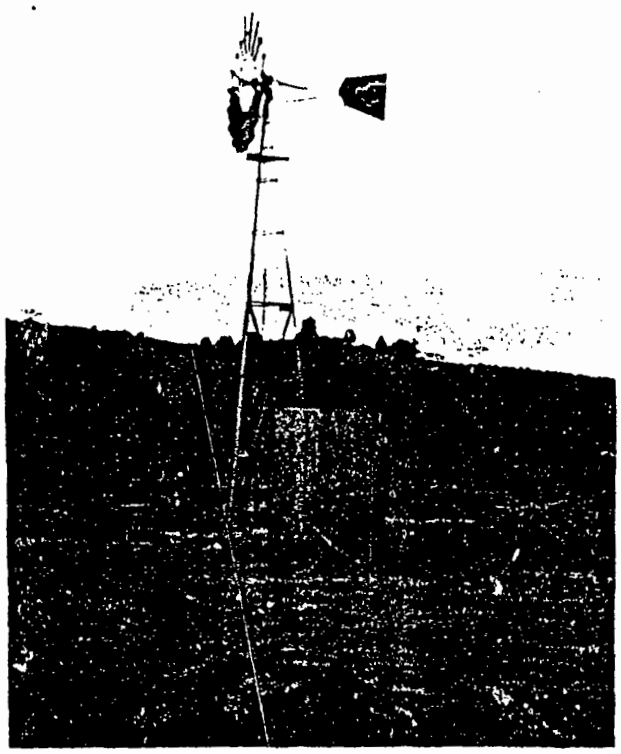
Complying with your request of January 25th, 1918, I am herewith transmitting a history of the underground water development on the Navajo and Hopi Reservations, Arizona and New Mexico.

I would refer you to my project histories Vol. 3, and to the Annual Reports submitted to you for the years 1912 to 1917, both inclusive for additional information and other illustrations regarding this work.

Very respectfully,

N. J. Robinson

Superintendent of Irriagation.



A WELL IN THE DESERT.

A typical well in the Navajo Country.

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WATER DEVELOPMENT FOR THE HOPI AND NAVAJO INDIANS.

The area covered by the Navajo and Hopi Reservations in Arizona and New Mexico, while not absolute desert, is an arid country, having a very scanty rainfall which is very irregularly distributed throughout the year.

The rainfall records and the character and distribution of plant life show aridity at the present time. The geologic and archeologic evidence alike indicate that it has been arid for thousands of years, and the geographical position, topographical surroundings and climatic history indicates that aridity will continue. The deficient rainfall and its unfavorable distribution through the year; extensive drifting sands, a topography of canyon, mesa and arroyo; drying winds; and the elevation above the sea determines for this region an unsatisfactory water supply.

The greater part of this region is of a character on which the average white man would be unable to more than exist, although the Indian population from generations of living here, manages not only to make a precarious living, but in many instances what would be considered a competency by the white man.

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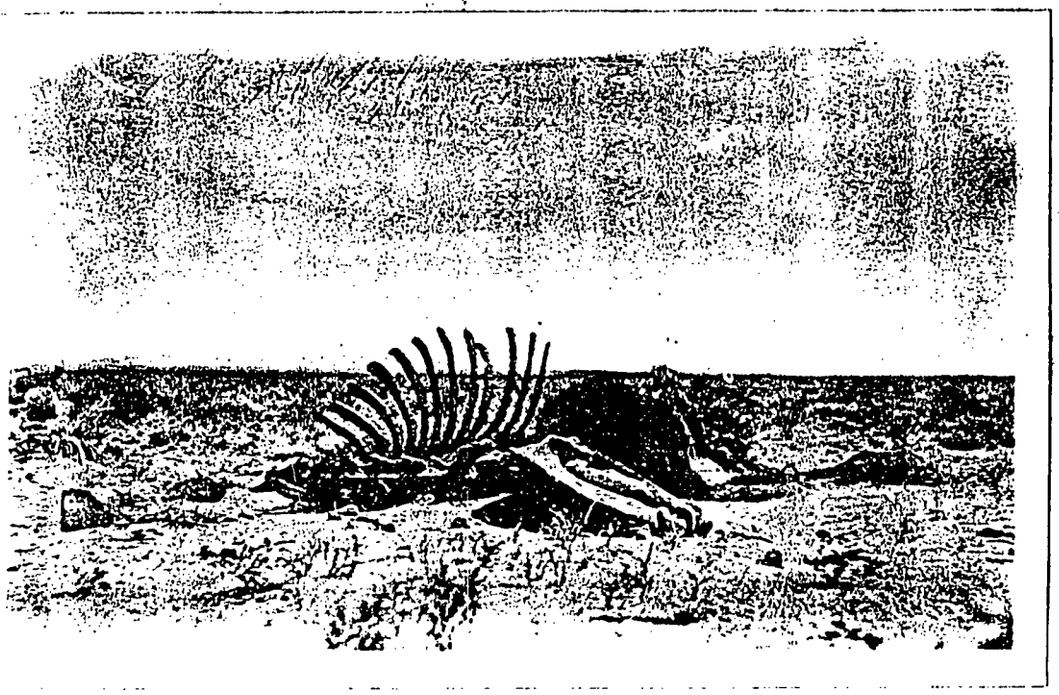
Nellan Nevell



TOO FAR TO WATER.

There is much country where the feed is plentiful, but the water is lacking, and the long journey from the watering places to the feeding grounds prove too much for much of the stock with this result.

While the rainfall is very scanty it is still sufficient to bring to maturity grass and other vegetation in most parts of this country, forming good grazing at some parts of the year.

Notwithstanding the fact that the feed conditions are fair for grazing, the size of the flocks and herds of the Indians have been limited heretofore from the fact that the water supply has been insufficient and there are great tracts of land where no surface water exists, other than an occasional small spring or seep or in temporary water holes following storms. In other words, the limit of the size of the flocks and herds is set by the existence or non-existence of a water supply, not by the feed.

It is true that the grazing is not like that of a wet climate, and that it takes from six to ten acres to keep a sheep or a goat through the year.and perhaps twenty or more for a cow, but the fact remains that with the poor feed and the scanty water there are several million sheep on this reservation, and by the proper development of the water two or three times this number can be kept.

Recognizing these facts, the Indian Service has been endeavoring for some years to increase the water supply of these reservations both by well drilling and spring improvement, both bring-

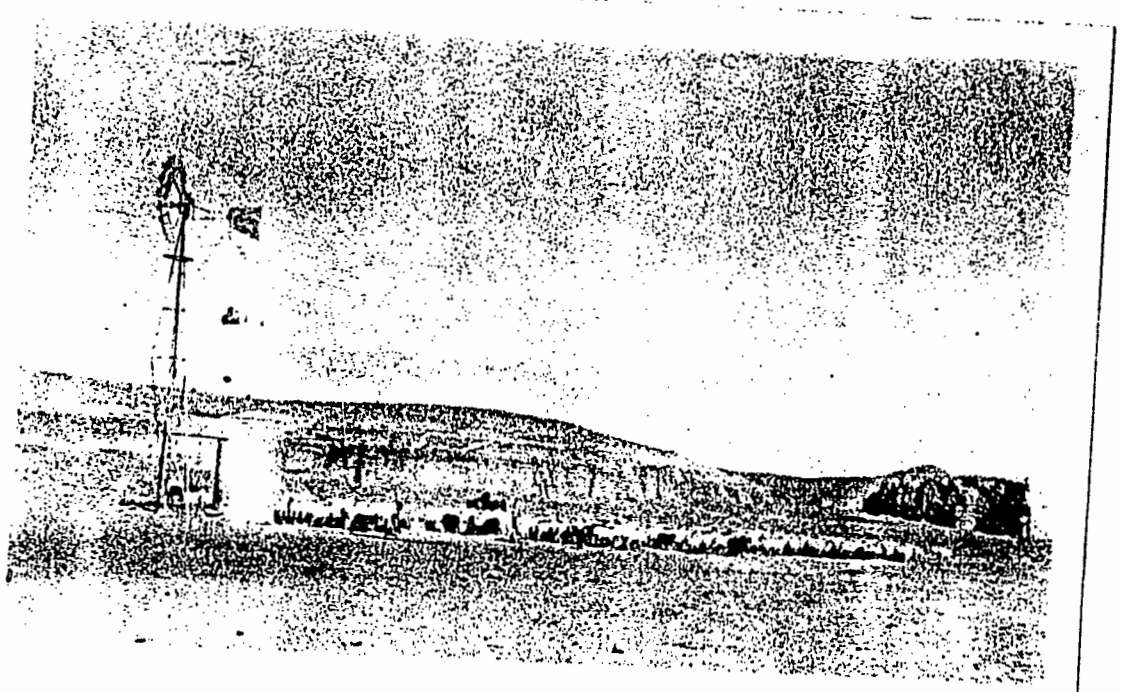
ing in new supplies and conserving any existing source.

The proper supply for a grazing country involves not a few large supplies, but many small ones; not an increase in quantity where water now exists, but a moderate supply at various points where water is not found, and the points where water is needed is where advantage may be taken of the grazing areas of the reservation.

In considering the development of water in new places it must be borne in mind that too great a quantity of water at any one place when there is a scarcity at others will have a tendency to cause that part of the range to be over stocked and as at no place is the grass and natural feed very luxurious more harm than good may be done, by the overgrazing and the trampling out of the grass by the stock.

In this connection it may be pertinent to the subject to quote from Bulletin No. 588 of the Department of Agriculture on "southwestern ranges" under the head of "Water Development."

"The importance of a well-planned water supply for cattle ranges of the Southwest can hardly be over-emphasized. Where watering places are from 6 to 15 miles apart, the range near water is overgrazed and denuded, while that away from water is undergrazed. Loss from starvation increases as the distance from feed and water increases, and under such conditions the



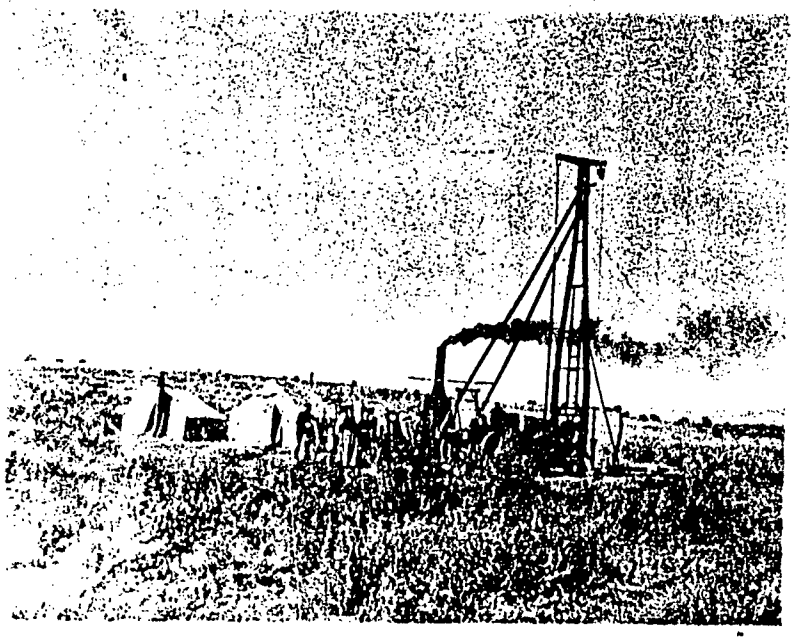
An area of over 40 square miles
is often tributary to a well and
windmill in the Navajo Country.

conversion of grass into meat is generally inefficient. * * * Observations * * * indicate that fairly good utilization of plains and mesa rangecan be secured when the stock do not have to travel more than 2½ miles to water. This would mean permanent watering places 5 miles apart, or one to approximately 13,200 acres. * * * As distances between places increases above 5 miles, grazing becomes perceptibly uneven; with a varying degree of overgrazing around water and undergrazing beyond 2½ miles from water."

Stock raising, especially the raising of sheep, on these reservations has proven the salvation of the Indians. They are natural herdsmen and for a number of years their flocks have increased to about the maximum that the natural water would supply, although the limit of grazing has not nearly been reached. The natural increase of the flocks would reach a maximum point, then there would be a season of drouth and the mortality would be very great, reducing the flocks to that number that could exist on the water supply.

It is several years since this work commenced, and over extensive areas the developed water is the only means of keeping many flocks of sheep and a considerable population. Cut off this supply now and it would mean the loss of many flocks and the ruination of many self-supporting families.

In the Hopi country it has been the endeavor of the Indian Office to bring the people down from



WELL RIG No. 1, and Camp.

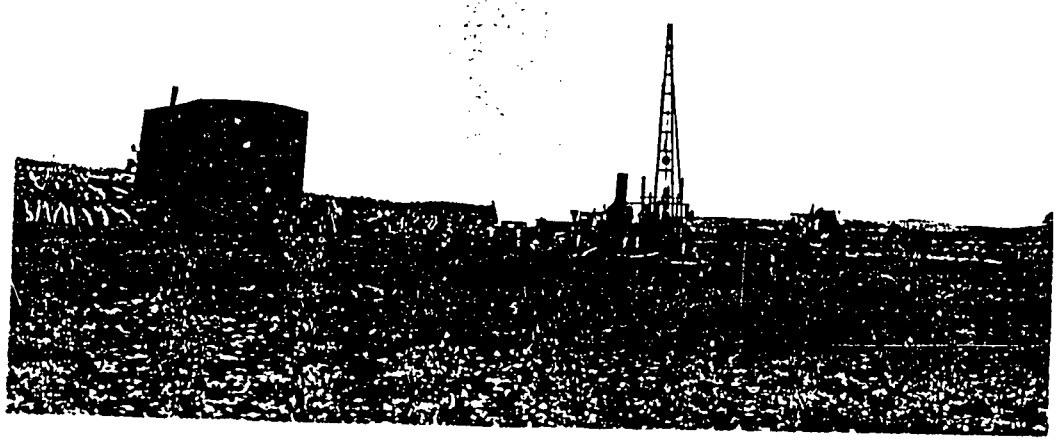
the mesa tops to live in the valleys below. Until now, it has seemed a hopeless endeavor, but with the extending of the grazing areas by the drilling of wells and the development of springs, opening up new feeding places too far from the villages for the daily trip of the flocks from the mesas to the feeding grounds, many of the Indians have moved down and built at the wells and springs, and by relieving the ground around the mesa from a large portion of the flocks those remaining will have a chance to increase. For years, because of the limited area over which they ranged, there had been no increase. They simply existed and held their own. This is now changing for the better.

HISTORY OF THE WELL DRILLING.

Just at the end of the fiscal year 1910 the Department purchased a drilling rig in California and sent it into the Navajo reservation. It was first taken to Leupp, where four 12" wells were put down to furnish water for irrigation of the school farm, and one well for domestic water supply.

After this was done the rig proceeded north and into the Hopi Reservation, drilling as it went. Thirty-four holes were put down, developing 7 good wells.

Prior to commencing this drilling the co-



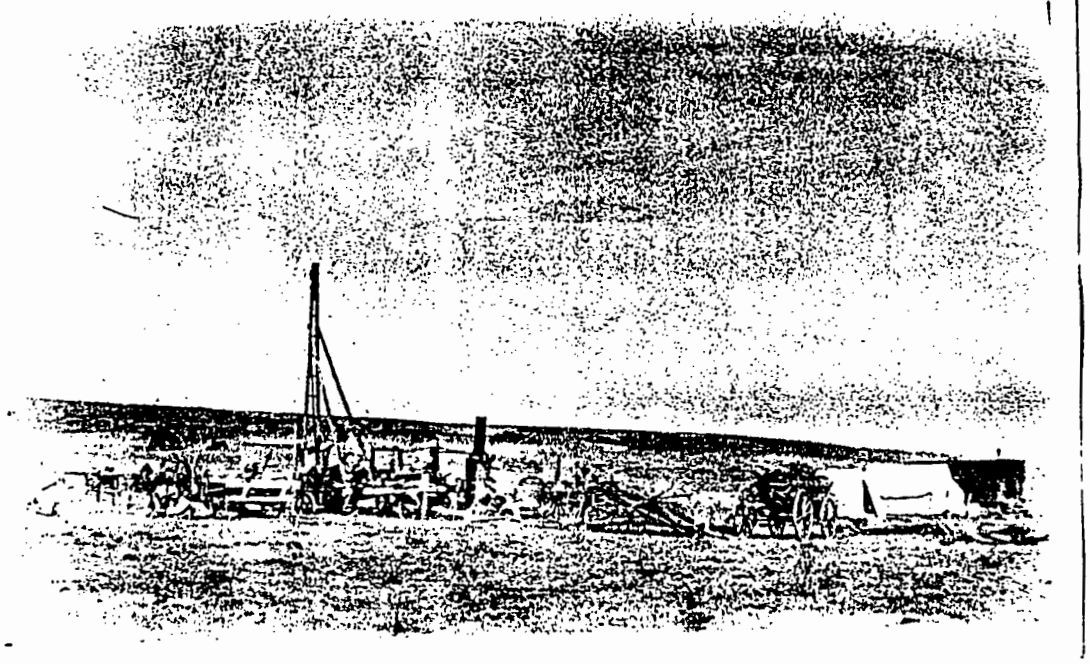
WELL RIG No. 3. Cook house
on wagon.

operation of the U. S. Geological Survey was secured that geological examinations might be made from which to base predictions as to the presence of water in any locality. This work was conducted by Prof. H. E. Gregory, and based upon his reports certain areas were mapped out for drilling.

The examinations showed that there was a possibility of developing artesian water south of the Black Mountain region, and Keams Canyon was selected as a good place in which to try out the prediction.

The rig proceeded there and a deep well was drilled, reaching a depth of 1308 feet without securing any water other than a little surface flow and after submitting the log of the well with samples of material encountered to the geologists it was decided by them that it was probable that water could not be found here, and consequently in no part of the Hopi reservation nor of the Navajo reservation south of the Black Mountain, so while the results were negative, they were of considerable value.

This Rig (known as No. 1), was then moved to a point in the Choiska Valley, New Mexico, about 25 miles north of Gallup and 15 east of Tohatchi, and here the predictions were verified by the striking of artesian water at 1000 feet. The well was continued another 100 feet and a flow of 6500 gal-



WELL RIG No. 4.

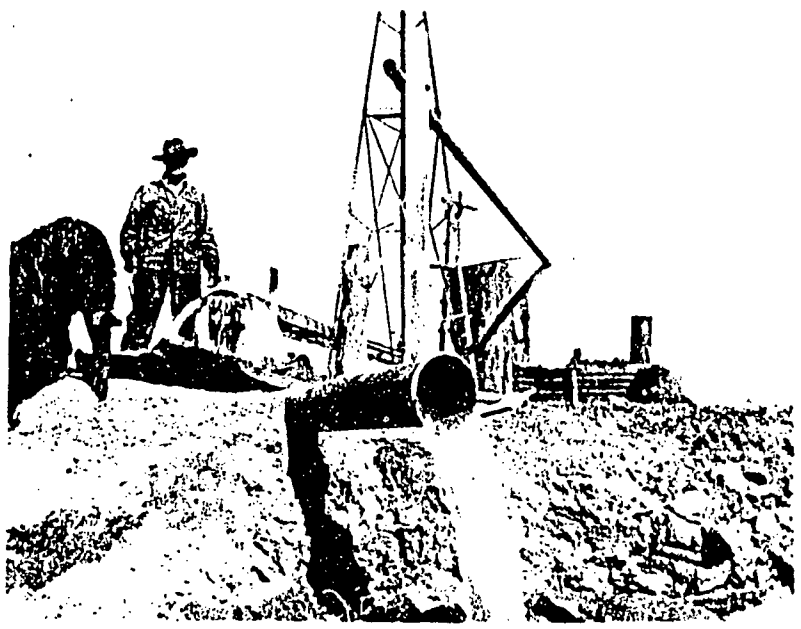
ons an hour resulted.

Over a year was spent on this well owing to difficulties encountered; first large beds of fire clay, which would neither drill nor bale out with the sand baler, and which was finally conquered by hauling in sand, dumping it in with the clay until it was of a consistency that was workable; second, some extremely hard rock was encountered, so hard in fact that in one month of constant drilling, only two feet was made. We were also handicapped by bad water for drilling and camp purposes, and the fact that the best water found was of such nature that it was very bad for boiler use, and not a month went by that it was not necessary to work over the boilers and put in new flues or make other repairs to it. As already stated, in spite of the difficulties encountered the well was a success, in that it demonstrated that artesian water was to be found in Choiska Valley.

The well was finished by capping it, placing a valve to control the flow, and building a corrugated iron house to protect the wellfrom molestation. A small constant flow was allowed to run for stock water.

The rig was moved to various points north and east of this well, going down the valley, and

The flow of an Artesian Well.
(Well No. 113).



seven good artesian wells have been developed there at depths varying from 205 to 500 feet, showing that the dip of the country is such that successful wells may be developed at less depth and at very much less cost than the first one.

In the meantime other drilling was inaugurated and what is known asRig No. 2 was built of scraps and extra parts of Rig No. 1, and during the season of 1912-13 it was successfully operated drilling wells in the Hopi country. At the end of 1913 the rig was in such bad shape that it was not considered worth using for drilling, but during 1915 it was used a part of the year in doing some repair work. By the end of this year it was entirely worn out and of no value. The success of the first wells put down, and the benefits accruing to the Indians was so manifest that money was authorized for two other rigs, numbers 3 and 4, which were built during the summer of 1912, and both rigs have been operated constantly since that time until September 1917, when because of lack of funds one of them was laid up. To June 30, 1917, 226 holes have been drilled in the Navajo-Hopi country, of which 112 are good wells and in working order today. Nine of these wells are artesian flowing wells which need no further attention or maintenance.

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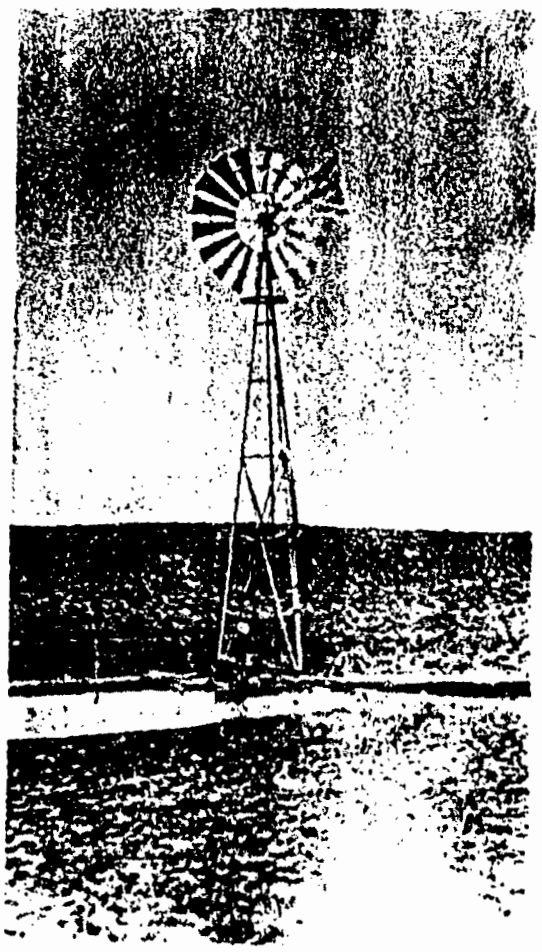

WELL AND WINDMILL.
First development, water stored in hole excavated in the ground.

All of the wells other than the artesian have been equipped with a windmill either eight or ten feet in diameter on a thirty foot tower, and a brass deep well cylinder. Each well is equipped with a tank to hold the water as it is pumped and a string of troughs for the use of the stock.

When we first commenced this development a number of tanks were built of masonry d others of concrete, it being thought that we could utilize the material near at hand and get a good tank cheaper than in any other manner. Practically all of the stone in this section of the country, however, is a soft sandstone, and there is almost an entire absence of any gravel. It was found that both the sandstone and concrete made of the best material that could be found were porous, would absorb water, and as soon as the cold weather came the moisture in the walls would freeze and the walls would be cracked and broken so that by spring they were almost valueless to hold water. Several of the tanks were rebuilt and the greatest care taken in their construction, but the same fate befell them all. It was then decided to put in circular steel tanks and the size seven feet in diameter and eight feet high with a capacity of about 2300 gallons was selected, and they have been

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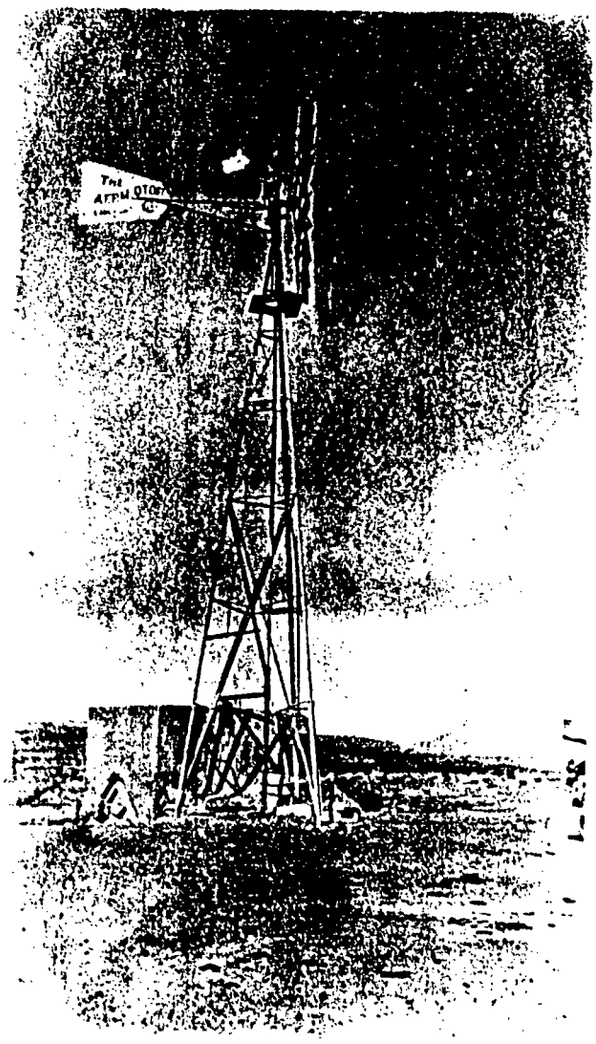
Windmill

Windmill with Stone Tank.



WINDMILL and CONCRETE TANK.

proven absolutely satisfactoryin every way. Tanks are all set on a masonry foundation and are connected with a string of troughs from which the sheep and cattle are watered.

At first these troughs were built of lumber and while the trough was satisfactory they were found to be very expensive. Only the best lumber could be used in their construction, which was quite expensive to obtain, and after being hauled by wagon from the railroad to points where needed 125 to 150 miles from the railroad it was found that a great deal of the lumber was spoiled or warped out of shape before it could be used. A steel trough was then tried out, being sections of corrugated flume made of pure iron heavily galvanized, the only lumber being the frame in which it was set. These have been very satisfactory, the freezing in winter not affecting the troughs and the cost is proving to be less than for the wooden troughs.

OPERATION AND MAINTENANCE.

It has been absolutely necessary for this Service to look after the operation and maintenance of these wells. The windmills must be oiled frequently, although within the last year we have adopted a new kind, known as the auto

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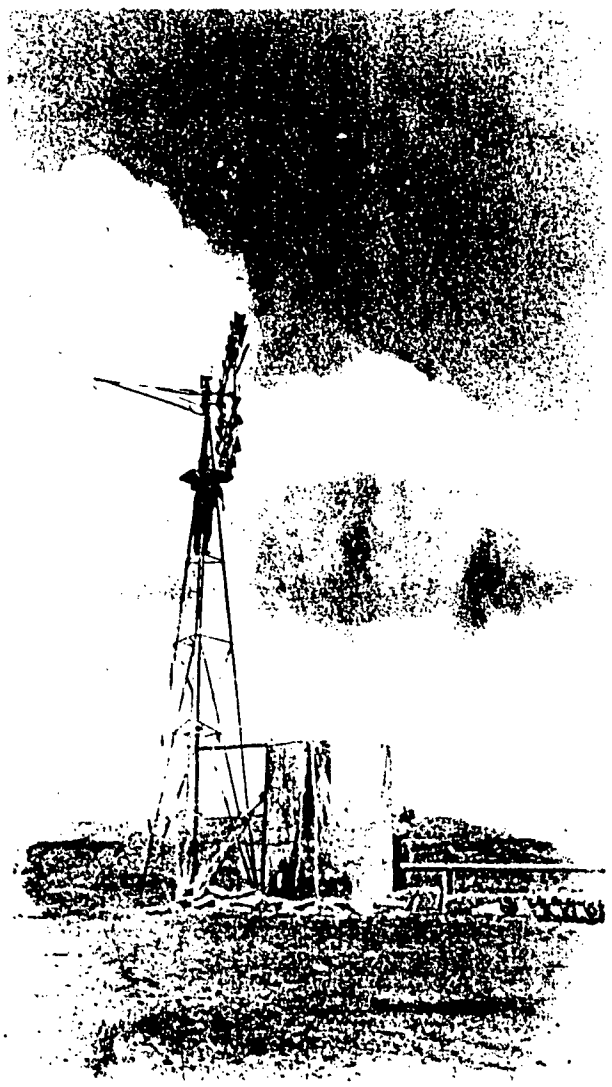
Wilton Newell



Final phase of development.

WINDMILL AND STEEL TANK, 2300 gallons capacity.

oiled mill, in which a reservoir is provided which will hold sufficient oil to run the mill six months or more; but the mills frequently get out of order and usually just at the most important time of the year when the water is needed. Most of the wells are developed in sand, and during all the seasons of the year, but especially such times as the wind does not blow steadily, the fine sand will work into the suction pipe and settle down on the valves and either cut out the leathers by friction, or during times when the wind does not blow, such quantities will accumulate on top of the valves that when the breeze again springs up the valves stick and the pumprod or some other portion is broken.

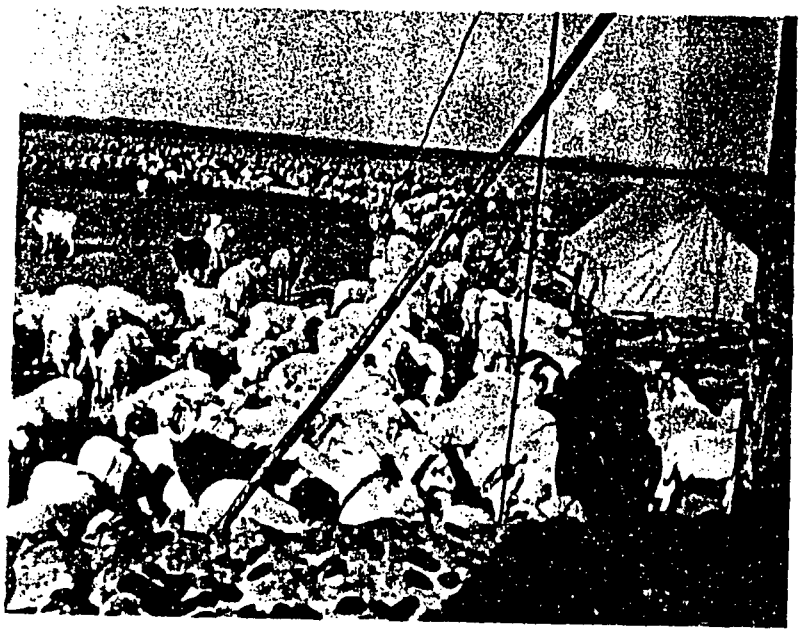
In so many sections not only the flocks and herds but the people themselves are absolutely dependent upon the water of this particular well for all purposes, and the well not pumping for a few days, suffering and considerable loss will ensue. It has therefore been necessary to organize two well patrol outfits, whose sole business it is to ride from well to well with a small repair outfit and keep everything working smoothly. One of these patrols is located at Chin Lee, Arizona, and the other at Polacca. The string

NAVAJO WOMEN bringing in flocks of shhep to water at an artesian well before it is completed.

of wells operated from Chin Lee necessitates a trip of over 500 miles to visit them all, and the other one over 350, and the latter line is increasing all the time by the operations of the well rig in that section. Every well is visited at least once a month and oftener if necessary, and should a well get out of order one of the Indians dependent upon this water for his flock is sure to ride into headquarters, whether it be a few miles or a hundred, with the news, and a special trip is made out to fix the well. A report card is made out for each visit to every well and sent in to this office at the end of the month and a check is kept on this work.

The operation and maintenance and general supervision of the well drilling is under a foreman stationed at Polacca, Arizona, who also has charge of the other water development on these reservations. The well rig crews put down the wells and erect the windmills, while another outfit under Foreman Womack sets up the tanks, puts in the troughs and attends thereafter to the operation and maintenance .

A detailed list of every hole that has been drilled, showing its location, size, depth, equip-



Sheep drinking from the flow
of uncompleted artesian well.

ment, flow of water if good well, etc., has been prepared and is attached to this report in order that full details may be had if desired.

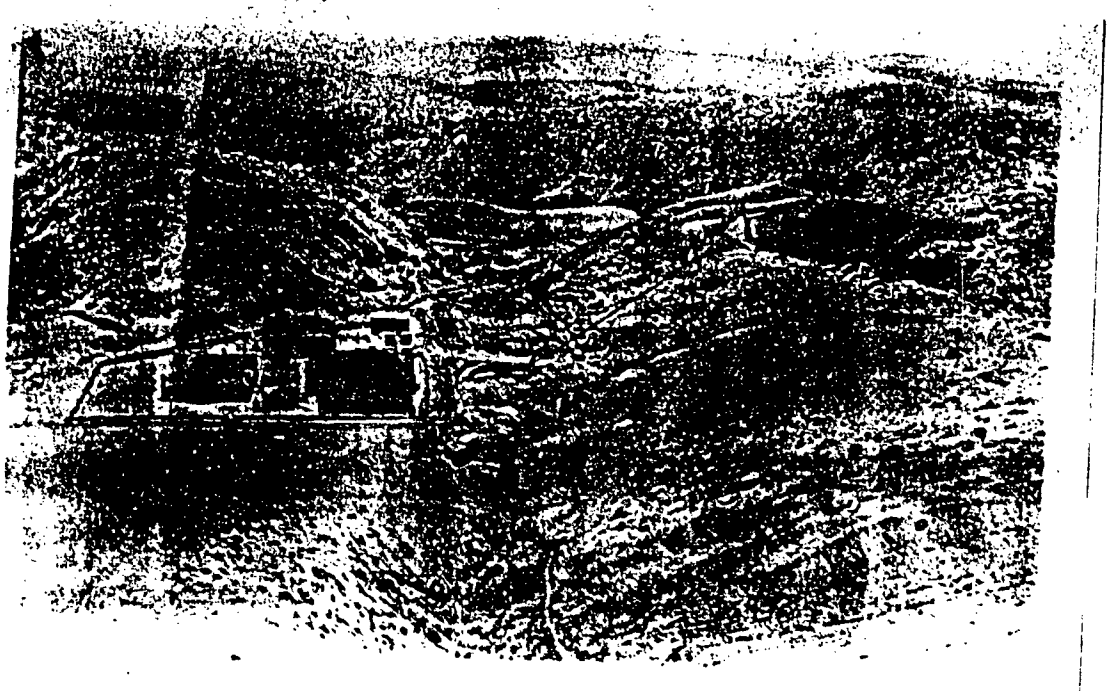
SPRING DEVELOPMENT

Most of the spring development has been within the borders of the Moqui Reservation, but it must be understood that this reservation is occupied by both the Hopi and Navajo Indians and is the most arid part of the country occupied by these Indians.

There have been found and listed eighty-one springs in this section, and a complete detailed list showing the location and sizeof each of these springs as well as the work done in improving and developing them will be found attached to the annual report of this district for 1917.

Of these eighty-one springs seventeen are reported as seeps too small to be developed. An additional number of springs are found along the banks of the Moencopi Wash, and as their united flow is sufficient to keep the wash running a small stream of water, it is not thought worth while to develop them at the present time, inasmuch as that section of the reservation has very little grass and very few inhabitants.

Mrs. Nevell



LOCATION OF THE TOBEVA SPRING
and Day School.

Of the remainder, thirty-six have been developed. Some have only needed a little work but a number have needed considerable in order to develop them, especially those lying near the Hopi villages.

To a person living in a country where there is sufficient water the value of even a very little water in a desert country is not understood. A trickle of a few gallons an hour must often be sufficient for a number of families for their domestic use and their stock, as for instance, in the country lying north of Keams Canon and south of the Black Mesa there is a population of fifty families, each with their flocks of sheep and some horses. They occupy an area of about six hundred square miles and there are but a half dozen springs in this whole district, the largest of which flows only twelve gallons an hour. Some of these springs have been improved and we have put down a number of wells in this section and have improved the condition of the people very materially.

Spring development work, especially around the mesas of the Hopi Indians, has been of inestimable value to the Indians both for their domestic supply and for the stock. At each of the

Alan Newell

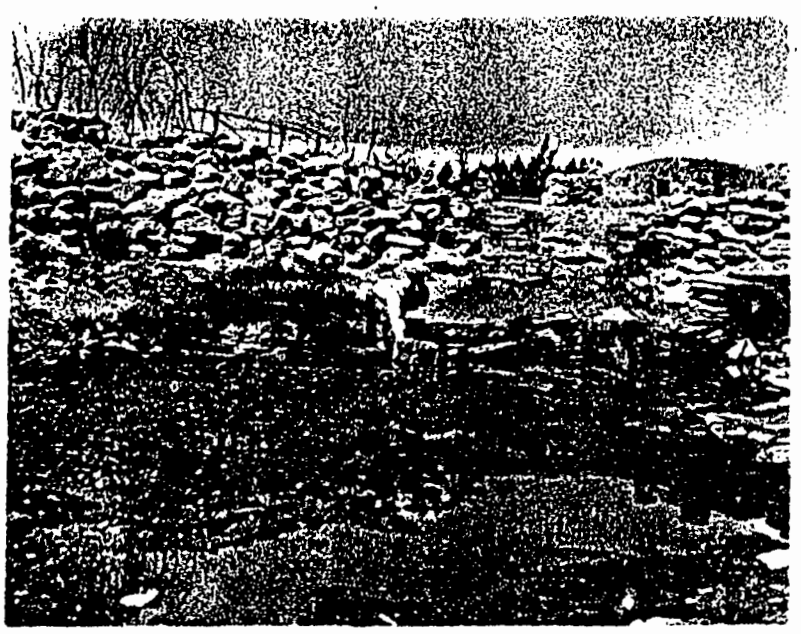
The TOREVA SPRING was a breeding place of disease, full of filth, used as a commom drinking and bathing place by man and brute.

villages the entire water supply has come from one or two sp ings which have been used from time immemorial, and during this entire period have probably never been thoroughly cleaned out. The results has been that there was a vast accumulation of filth in the springs which not only diminished the water supply by sedimenting up the outlet for the water, but the amount of filith made the water almost liquid poison, and only a person enured to its use by heredity and custom could possibly have used it and lived.

At the First Mesa before the principal springs were cleaned out and put in shape there was an epidemic of some enteric trouble in the villages which caused the death of sixty people out of a population of six hundred, and the government physician stated that it was his opinion that the entire trouble lay with the water supply. Since the springs have been put in good shape there has been no more trouble of this kind.

When the water development work was first commenced it met with passive, if not active, opposition on the part of the Indian. They thought that the development of the water by well drilling was the first step of the white man to get

Mrs. Newell



Covered with a thick scum the water was unfit for any use but was the sole water supply for a whole village.

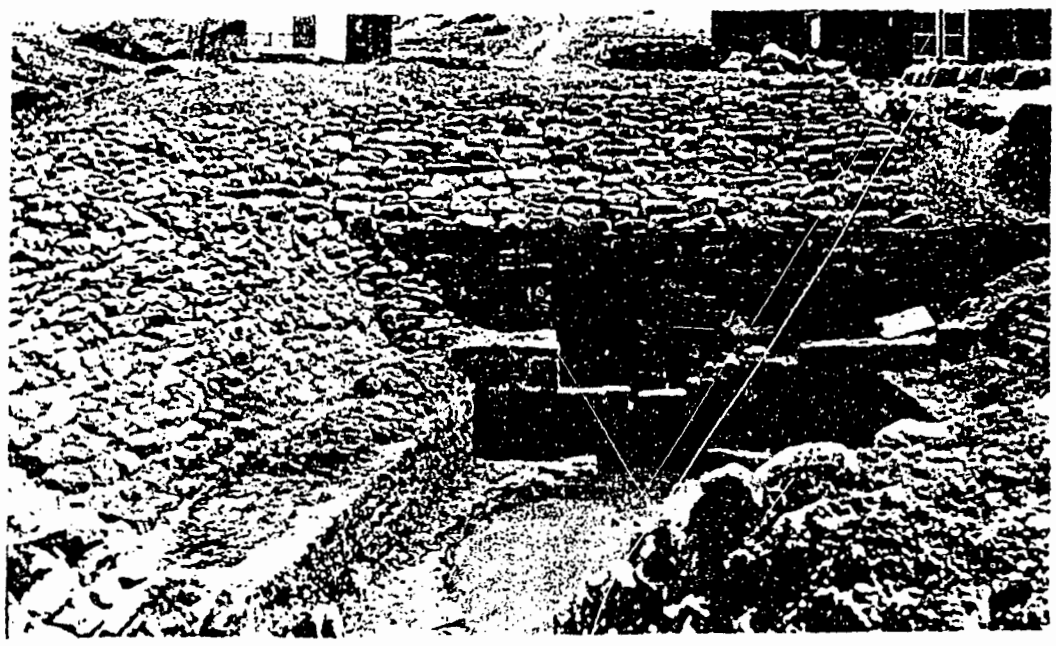
TOREVA SPRING, as it was.
The women of the village carried the water from the spring to the top of the mesa.

Alva Nicholl

a hold on the country for their own uses, and it took considerable work and several years time for the Indians to really understand that the work was being done for them. The Hopis objected to having anything done with their springs for fear that the water gods would be offended and stop the flow of water; but by careful handling of the Indians and the entire situation they too soon became convinced that the development work would not hurt the water supply they already had, but would increase it, and they are now anxious to coOoperate in any way with us. The Navajos co-operate by assisting in the moving of the well rigs and other hauling, as they know the work is for their own benefit, while the Hopis have organized a force to do work in connection with water development in each village and are subject to the call of the foreman in charge of the water development at any time for such work.

It would be interesting to go into details here as to the development of the various springs, but time and space will not allow it. A reference to the list of springs heretofore mentioned will give an outline of the work accomplished at each spring. A description of a few

TOREVA SPRING as it was.
The water comes out from under
the big boulder. This is one
of their sacred springs.

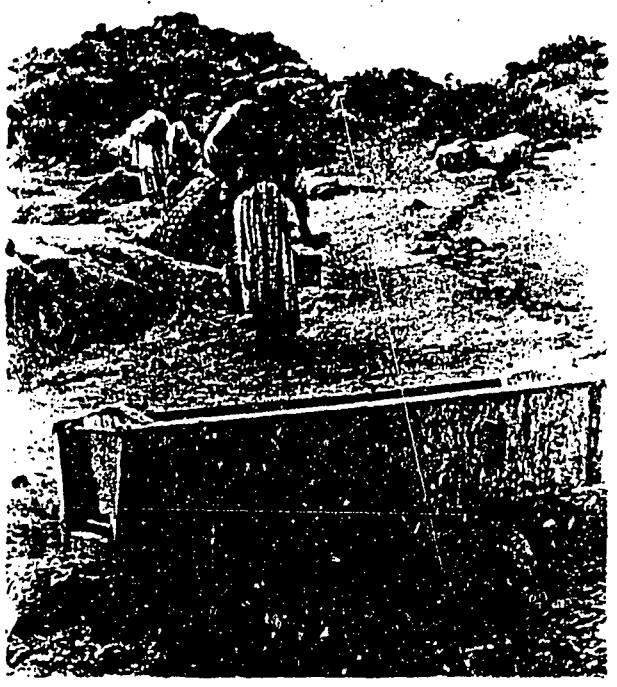


TOREVA SPRING as improved.
The main spring is in the room entered by the door. The overflow comes thro the notch in front of the door and fills the pool below which can be used for any purpose without contaminating the water in the spring.

of the springs will be typical of the work done at most of them and will give a good idea of the work necessary to make the most of the small amount of water found in this region.

The large spring at Mischongnovi at the second mesa is at the Toreva Day School, and was breeding place of sickness, being full of filth and used as a common drinking place by man and brute and as a bathing place by thechildren , dogs and burros. This was cleaned out and put in sanitary shape as may be seen by some of the accompanying "before and after" photographs. The water came out of the ground under the large boulder, which was blasted away, and the outlet located. This was then developed and all of the water came out in an underground room where it could be kept away from the animals and fairly well protected from flying dust and dirt. The overflow was led to the old pool on the outside which can now be used for bathing or any other purpose without defiling the water in the spring proper.

The two main springs at the First Mesa are Toveski Spring on the west side and Ishpi Spring on the east side of the mesa. Both springs were thoroughly cleaned out and walled up, with a flight



At all of the Hopi villages the women carry the water from the springs to the top of the mesa, often a distance of a mile and a climb of 600 feet.

of stone steps leading down to the water. The flow of the latter spring was increased fully 100%. The flight of stairs necessary to reach the water was inclosed and roofed over with solid masonry to prevent the filth from blowing into it.

The Indians now have clean water at these two springs for the first time in generations and the supply has materially increased.

The summer previous to fixing the springs, the supply was so scant that the women would sit around the spring waiting for the water to seep in, that they might dip it up with a cup or gourd and it would often be hours before they would get a load. Since being put in shape there has always been an abundant supply and the amount stored which accumulates over night will almost supply the village during the day.

In another class is the Burro Springs, which lies about eight miles south of the Second Mesa near what is known as the Giant's Chair. There has been a considerable area of wet and boggy land here that has proven a veritable death trap for animals. At the most promising point there was always a pool of standing water. Here an

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THE DAY SCHOOL AT MECIPA
Second Mesa.
The spring is by the man and troughs for stock shown at the left. A village is on top of the bluff.

excavation was made, and a fairly good flow of water was uncovered. The excavation was made about six feet deep and walled with rock. Seven pieces of 8" casing was sunk to a greater depth, the water rising through the casing forming a reservoir about six feet square and six feet deep. The water was piped out some 400 feet to solid ground where troughs were set and the spring and bog were fenced to prevent animals getting into the soft ground and dying. IN excavating for this spring great masses of bones were found consisting of remains of both domestic and wild animals.

Hoana Spring is about 17 miles south of Oraibi and is located in a sand hill. This spring was used by the Indians to water a considerable band of sheep.

The sand was drifting over the spring and it had almost become lost. To develop it, it was necessary to excavate in this loose sand back to solid foundation. The water did not come out at one point, but was a seep along the edge of the solid rock for some distance. A collection box (so called for the want of a better name), was put where the trickling water

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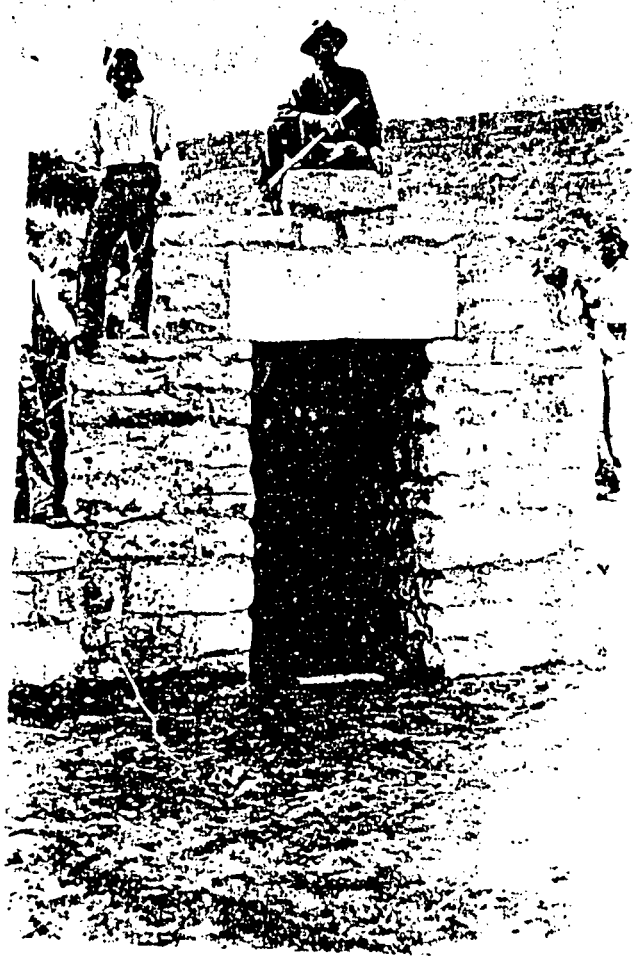
ISHPI SPRING at the First Mesa,
Before improving.
In an open hole, a convenient
receptacle for all the filth
blown from the village dump.

could be collected together, made of stone and cement with a tight cover. A pipe line was laid from this box for a distance of 200 feet until it was clear of the sand dunes, and the water was delivered to a stone tank or reservoir 6 x 6 feet which is entirely covered to keep out the drifting sands. The overflow of this tank is conducted to 24 feet of troughs for the use of the stock. There is another pipe from this reservoir tank, drawing the water from the bottom, which leads for a distance of fifty feet; equipped with a gate valve, so that domestic water can be drawn from the spring to the extent of several hundred gallons without waiting for the trickling spring to slowly fill the bucket. As the Indians haul water from this spring to considerable distancesto their camps, it enables them to fill their barrels without delay. The flow of this spring is 18 gallons an hour.

Most of the springs in this country are developed in sand, usually at the foot of some great sand dune, and the great trouble has been to get the water to separate from the fine sand so it could be carried out to the tank or trough.



ISHPI SPRING, First Mesa,

After developing.

After considerable experiment by Foreman Womack the following plan has been perfected , which works very satisfactorily.

An excavation is made from the point of the seepor spring back into the sand hill, following the course of the water. Into the excavation thus made a pipe, usually perforated for several feet is laid. This is covered with a layer of broken stonegraded to about one inch. On top of this a layer of smaller stone or broken rock is spread, followed by a layer of coarse gravel on top of which is fine gravel, which in turn is covered with torpedo sand and on this a layer of sand finer than that bearing the water. This forms a filter through which the water reaches the pipe while the fine sand is retained. The water is piped out direct to the troughs or in some cases to a small tank and the overflow to the troughs. Reference is made to the accompanying diagram for a better understanding of the method used.

When the spring development work was first commenced, Mr. A. H. Womack was placed in charge of the work and has remained in charge ever since,

THE SPRING THAT SLIPPED OFF THE HILL. The spring came out above the base of this cliff. Wet weather caused a portion of the face of the cliff to fall off and covered the spring. In order to save the spring we were obliged to blast out many tons of rock and re-develop the spring flow.

and for the past two years has also had full charge of overseeing all of the water development including the operation of well rigs.

Having been in charge of this work from its inception, understanding the Indians as he does, and knowing the needs of the country, it is interesting to get the direct idea of the man in the field regarding the work being done, its value to the Indian, and some ideas regarding what should be done. In a report received from Mr. Womack some months ago, he makes the following general statements regarding the water development for these Indians, covering both the well and the spring work:

"The work in the Moqui Reservation is confined to the development of water for domestic and stock use, by developing springs, making surface water reservoirs, drilling wells (50 to 300 feet deep), erecting windmills, tanks, troughs, etc.

Owing to the fact that we have increased the water supply the Moqui Indians have increased the sheep and cattle to such an extent that we cannot keep pace with the demand for more watered range, notwithstanding they have three or four times as much range as they had five years ago. The Indians have become interested in the cattle and sheep business and are making use of all the water that has been developed. Many of them have increased their herds three, and in some cases, four hundred per cent. in the last five years. This progress may be expected to continue if water can be developed in more of the outlying country.

Getting at the main flow of a seep spring coming out of the side of a mesa. This spring was developed by getting all of the water into one place and piping it out to a tank and troughs.

In years past the Indian did not care to have many sheep as he was forced to lose them the first dry year as there were no wells or permanent water, and naturally the sheep would die off to a number that could live on the amount of water remaining. But now, with wells, we have developed water that is not affected by the drouth and they can see where it is possible to raise large numbers. Also we have confined the water in troughs where it can be clean and not so many die from drinking stale water. Many of the Moqui Indians are abandoning the village and moving out to the windmills where there is an abundance of water, living there with their stock insteadof driving them into the village at night.

We have drilled many wells in the part of the Moqui Reservation inhabited by the Navajos and developed six good wells which has developed a large area of excellent grazing country. This will add to the available grazing about thirty per cent. and will take care of thousands of sheep and cattle. The above country was almost without water. If we get a good flow of water in the Cedar Ridge Country, which is the next move with Well Rig No. 4, we will add a large country to the west side of the Moqui Reservation and the east part of the Western Navajo Reservation.

Navajo Reservation.

We have kept in repair all the wells on the Navajo Reservation and maintained a good supply of water. One string of wells on this reservation is 150 miles long and other strings leading off from this string make a distance to travel to take care of them about 350 miles and this is covered once a month for the reason that if one of the wells fails it is necessary to move all the stock to another well as the herds are in most cases so large that they cannot find sufficient water at the springs.

The Indians realize that they have a permanent supply of water and are giving their attention to the stock business and are incfeasing the number in great proportions and are willing to help in any way that they can to get more water.

The stream pumped from one well at Leupp Ariz.

Many of the Indians are building houses at or near the wells and establishing homes as they can depend on the water supply and do not have to move the herds as they did in the past when they were compelled to go great distances to permanent water.

When you realize that one of the wells drilled by Rig No. 4 will flow twice as much water as the combined flow of all the springs in the Navajo and Moqui Reservations you can appreciate what the wells have done to water the reservation and how little permanent water there was on the reservation.

The main drawback is the lack of money to carry on the work on a larger scale; for instance, the country is so large that it is impossible for me personally to supervise work in the remote sections as we do not have enough money to hire men to look after cementing up the springs and fitting in the pipe, etc., it is a waste of material to go and lay out a plan of edevelopment of a spring and have to leave before it is completed as to leave much work as placing a filter, laying pipe, or cementing up the springs in the lands of the Indians, and for that reason the spring work does not go fast as it should. The Indians are increasing the herds so fast that we cannot keep up with them with the water development. What we should have, in my opinion, is a mason that can carry out a plan of development and have him help me do this kind of work that the Indians do not understand. I can get plenty of labor donated if I had time to go to those far away places and stay until a place was finished.

The Indians have seen the benefit of more water and are much encouraged and are making good use of the water, many of the progressive ones are willing to donate money or labor to help the work along. If we can keep up with the present increase of stock, with the water the Indians will make more progress in the stock business the next five years than they have done in the past fifty. As the stock in this country has always been limited to the amount of permanent water, in the past when a drouth would come and the springs dry up the stock was forced to die off to the number that could live on that amount of water.

While the springs are becoming of less importance as compared with the wells, they will furnish a small permanent supply of water and do not require expensive labor. Also people looking at the map would get an idea that if the springs were developed that there would be all the water that the range required. This is

Allan Newell

A MIRACLE on the Desert.

Water from underground in an absolutely dry country!

in no way true, as many of the springs that are marked on the map are mere seeps and do not flow one gallon per hour, and there are others that if developed and conserved will water all the stock that will be able to travel to it.

Also many of the springs are in sandhills and as soon as they flow out of the close or impervious formation they are at once lost by seepage. In some cases the seepage is equal to the flow of the spring and a good spring will only be indicated by a moist place on the sand, and can be developed by excavating back to solid formation and all seepage cut off and piped to a concrete reservoirwhere there is only the evaporation."

COSTS OF THE WORK.

Since the commencement of the well drilling eight years ago there has been expended approximately $140,000. This includes the cost of equipment, supplies and work. To show for this we have 111 good wells, seven of which are artesian, also 114 dry holes - aggregating 14,223 feet of good wells and 11,820 feet of dry holes, a total of 26,043 feet or about five miles scattered over an area as great as the combined area of Connecticut, Massachusetts and Rhode Island; these wells all being equipped with windmills, tanks, and troughs. We have considerable material on hand for future work and three good well drilling outfits.

SHOOTING A WELL.
In some sections the water is found in close grained sand stone which would not give its burden freely. As a remedy the well is shot with with dynamite, the rock shattered and a free flow of water secured.

It is possible that these costs may seem high, but as there are some 35,000 Indians on these two reservations, the cost has only been forty cents per capita per annum. On the

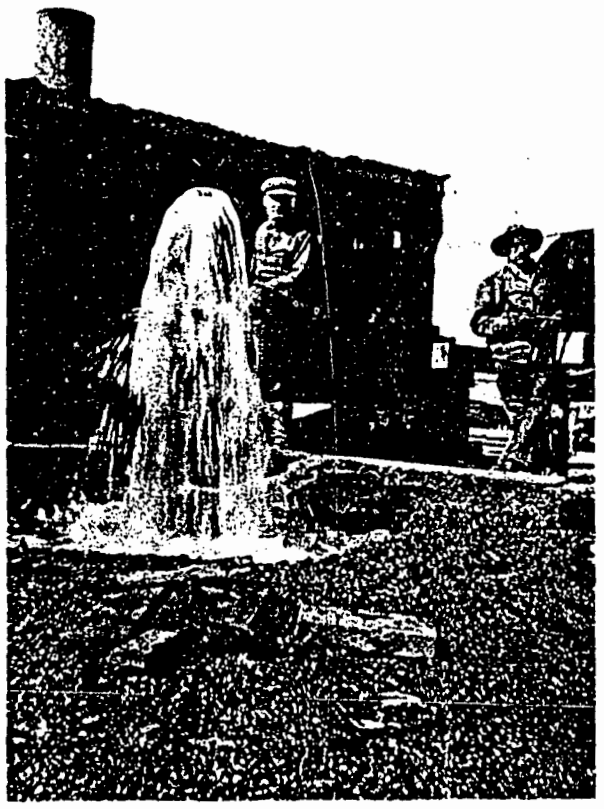
On the spring development there has been expended about $26,000 or about $3,700 a year.

BENEFITS FROM THE WORK.

By the expenditure of this moneywe have increased the watered area of the reservations four or five times. The Indians have received about $22,000 in wages for labor.

The flocks and herds of the Indians have increased fully 200 per cent. in the districts we have covered, and in these days of war and high cost of livingthe value of the increased cost of wool and meat production would not only be a big interest on the investment but go a long ways towards paying the principal.

The health of the Indians in the districts covered has been materially improved. This is especially true of the Hopi Indians where the death rate has been greatly lessened since they have had good water for domestic purposes.



An ARTESIAN WELL flowing free
and throttled down.

After years of effort on the part of the Government to induce the Hopi Indians to come down from the mesa tops and settle on their lands, but without avail, the water development and increase in their flocks and herds has hadnthe desired effect.

We have increased their interest in their flocks and herds, and consequently in the quality of their animals as well as quantity; and last but not least, we have by this expenditure done more towards the civilization of the Indians, along all points, than almost anything else that has ever been done for them.

It is the consensus of opinion of practically everyone who knows of the work being done for the Indians of this region, that greater benefit has come to them from this water development, both in the line of civilization and material prosperity, than any other like sum expended for them, many going to the extent of saying that this applies even to the education of the Indians in the school.

MORE MONEY NEEDED.

The money for the work for this water development has been coming from two funds. For several

DEPARTMENT OF THE INTERIOR.
U. S. Indian Irrigation Service.
District No. 5.

WELL RECORD.

Location ½ mile east of Leupp School — WELL No. 1
Began Well April 6, 1910.
Finished well,
Diameter of well — NAVAJO EXTENSION
Depth of well 90 ft — Reservation.
Surface of ground to water 9 ft when not pumping feet — ARIZONA
Quality of water good
Quantity of water on test run 16.3 minera inches gals per hr.
Kind of casing Size, 12" 80 ft
Screen, kind, length mesh
Windmill, date, size, height tower,
Tank, date, size, kind,
Tank foundation, kind, height,
Troughs, date, kind, length,
Name of driller,
A. F. Hallstrom

REMARKS:

Well for irrigation of School farm.
When pumping water drops to 31' 2" from surface.

Pumping plant erected

LOG.

Depth. From	Depth. to	Formation	Remarks
Surface	6 ft	Dark red adobe	
6 ft	9 ft	Fine sand	
9 ft	30 ft	Fine sand & water	
30 ft	32 ft	Blue clay	
32 ft	66 ft	Fine sand & water	
66 ft	82 ft	Soft tough blue clay	
82 ft	84 ft	Cemented sand rock	
84 ft	90 ft	Decomposed rock	

DEPARTMENT OF THE INTERIOR.
U. S. Indian Irrigation Service.
District No. 5.

WELL RECORD.

Location ¼ mile east of Leupp School
Began Well } Between April 6 & June 28, 1912
Finished well,
Diameter of well 12 in
Depth of well 80 ft (?)
Surface of ground to water 9 ft when not pumping feet
Quality of water
Quantity of water on test run 16.8 miners inches gals per hr.
Kind of casing Size, 80' 12"
Screen, kind, length mesh
Windmill, date, size, height tower,
Tank, date, size, kind,
Tank foundation, kind, height,
Troughs, date, kind, length,
Name of driller, A. F. Hallstrom

WELL No. 2

NAVAJO EXTENSION
Reservation.
ARIZONA

REMARKS:

When pumping water lowers to 28' 5" from surface.

Pumping plant erected

LOG.

Depth. From	Depth. to	Formation	Remarks
Surface	6 ft	Dark red adobe	
6 ft	9 ft	Fine sand	
9 ft	22 ft	Fine sand & water	
22 ft	28 ft	Yellow sandy clay	
28 ft	50 ft	Fine sand & some water	
50 ft	66 ft	Fine sand	
66 ft	80 ft	Soft tough blue clay	
80 ft		Rock	

DEPARTMENT OF THE INTERIOR.
U. S. Indian Irrigation Service.
District No. 5.

WELL RECORD.

Location ¼ mile east of Leupp School
Began Well } Between April 6 & June 28, 1910
Finished well, }
Diameter of well 12 in
Depth of well 80 ft (?)
Surface of ground to water 9' when not pumping feet
Quality of water
Quantity of water on test run 24.4 miners inches gals per hr.
Kind of casing Size, 80' - 12"
Screen, kind, length mesh
Windmill, date, size, height tower,
Tank, date, size, kind,
Tank foundation, kind, height,
Troughs, date, kind, length,
Name of driller, A. F. Hallstrom

WELL No. 5

NAVAJO EXTENSION
Reservation.
ARIZONA

REMARKS:

Water lowers to 29 ft gtom surface when pumping.
Well for irrigatipn of School farm.

Pumping plant erected

LOG.

Depth. From	Depth. to	Formation	Remarks
Surface	6 ft	Surface soil	
6 ft	9 ft	Blue sand	
9 ft	22 ft	Fine sand water bearing	
22 ft	28 ft	Yellow sandy clay	
28 ft	50 ft	Fine sand & gravel Water	
50 ft	60 ft	Fine sand, water bearing	
66 ft	80 ft	Soft tough blue clay	
80 ft		Rock	

DEPARTMENT OF THE INTERIOR.
U. S. Indian Irrigation Service.
District No. 5.

WELL RECORD.

Location ¼ mile east of Leupp School
Began Well } Between April 6 & June 23, 1910
Finished well,
Diameter of well 12 in
Depth of well 77 ft (?)
Surface of ground to water 9' when not pumping feet
Quality of water
Quantity of water on test run 24.4 miners inches gals per hr.
Kind of casing Size, 12"
Screen, kind, length mesh
Windmill, date, size, height tower,
Tank, date, size, kind,
Tank foundation, kind, height,
Troughs, date, kind, length,
Name of driller, A. F. Hallstrom

WELL No. 4

NAVAJO EXTENSION
Reservation.
ARIZONA

REMARKS:

Water lowers to 29' from surface while pumping.
Well for irrigation of School farm.
Pumping plant erected

LOG.

Depth. From	Depth. to	Formation	Remarks
Surface	24 ft	Sandy clay	
24 ft	30 ft	Clay	
30 ft	50 ft	Sand & gravel	
50 ft	64 ft	Fine sand	
64 ft	77 ft	Clay	
77 ft		Rock	

DEPARTMENT OF THE INTERIOR.
U. S. Indian Irrigation Service.
District No. 5.

WELL RECORD.

Location Leupp Indian School
Began Well } between April 6 & June 23, 1910
Finished well,
Diameter of well
Depth of well 58 ft (?)
Surface of ground to water 10' (not pumping) feet
Quality of water
Quantity of water on test run gals per hr.
Kind of casing Size, 58' - 12"
Screen, kind, length mesh
Windmill, date, size, height tower,
Tank, date, size, kind,
Tank foundation, kind, height,
Troughs, date, kind, length,
Name of driller,
A. F. Hallstrom

WELL No. 5

NAVAJO EXTENSION
Reservation.
ARIZONA

REMARKS:

Well for domestic supply at Leupp Indian School.

LOG.

Depth. From	Depth. to	Formation	Remarks
Surface	17 ft	Clay, ~~red adobe & sand~~	
17 ft	25 ft	Clay	
25 ft	29 ft	Fine sand & gravel	
29 ft	31 ft	Clay	
31 ft	51 ft	Fine sand	
51 ft	58 ft	Clay	

DEPARTMENT OF THE INTERIOR.
U. S. Indian Irrigation Service.
District No. 5.

WELL RECORD

Location 8 miles N.E. of Kayenta, Ariz. — WELL No. 358
Began well, Dec. 5, 1916.
Finished well, Jan. 20, 1917.
Diameter of well, 5½ in. — NAVAJO Reservation.
Depth of well, 212 ft
Surface of ground to water 70 feet
Quality of water good
Quantity of water on test run 600 gals per hr.
Kind of casing, black pipe Size, 5½ in.
Screen, kind, Cook length bet. 204' & 212' mesh
Windmill, date, Mar. 10, 1917. size kind
Tank, date, Oct. 1917. size, kind
Tank foundation, kind, height,
Troughs, date, kind, length,
Name of driller,
Ben R. Center

REMARKS:

Pump set up Jan. 16, 1917.
Water lowered eighty ft after pumping one hr.
Good supply of water, quality extra good.

GOOD.

L O G .

Depth. From	to	Formation	Remarks.
Surface	20 ft	Brown clay	
20 ft	30 ft	Yellow sandstone	
30 ft	51 ft	Tough blue clay	
51 ft	60 ft	Gray clay	
60 ft	95 ft	Hard red sandstone	
95 ft	105 ft	Light red sandstone, little water	
105 ft	205 ft	Hard red Sandstone	
205 ft	212 ft	Red sand & gravel, supply of water	

DEPARTMENT OF THE INTERIOR.
U. S. Indian Irrigation Service.
District No. 5.

WELL RECORD

Location Kayenta, Arizona.
Began Well, Feb. 5, 1917.
Finished Well, Apr. 5, 1917.
Diameter of well, 5½ in.
Depth of well, 204 ft.
Surface of ground to water 50 feet
Quality of water good
Quantity of water on test run 300 gals per hr.
Kind of casing, black pipe Size, 3½ in.
Screen, kind, Cook length bet. 196' & 204' mesh
Windmill, date, Apr. 30, 1917. size kind
Tank, date, Oct. 1917. size, kind
Tank foundation, kind, height,
Troughs, date, kind, length,
Name of driller, Ben R. Senter

WELL No. 559
NAVAJO Reservation.

REMARKS:

Pump set up April 4, 1917.
Water lowered 146 ft. after pumping one hr.
Quality of water extra good.

GOOD.

L O G .

Depth. From	Depth. to	Formation	Remarks.
Surface	3 ft	Red soil	
3 ft	5 ft	White sandstone	
5 ft	10 ft	Red sandstone	
10 ft	20 ft	Red clay	
20 ft	25 ft	Red sandstone	
25 ft	40 ft	Red clay	
40 ft	46 ft	Red sandstone	
46 ft	62 ft	Red clay	
62 ft	90 ft	Red sandstone	
90 ft	122 ft	Gray sandstone, little water	
122 ft	186 ft	Light red sandstone	
186 ft	204 ft	Soft red sandstone, good supply of water	

DEPARTMENT OF THE INTERIOR.
U. S. Indian Irrigation Service.
District No. 5.

WELL RECORD

Location 15 miles N.E. of Kayenta.
Began Well, May 10,1917.
Finished Well, Aug. 30,1917.
Diameter of well, 5½ in.
Depth of well, 194 ft
Surface of ground to water feet
Quality of water extra good
Quantity of water on test run 450(by pumping) gals per hr.
Kind of casing, black pipe Size, 5½ in
Screen, kind, length mesh
Windmill, date, size kind
Tank, date, size, kind
Tank foundation, kind, height,
Troughs, date, kind, length,
Name of driller, Ben R. Senter

WELL No. 360

Western Navajo Reservation.

REMARKS:

This is an artesian well.
Well flows about 1000 gallons per day.

GOOD.

L O G .

Depth. From	Depth. to	Formation	Remarks.
Surface	5 ft	Red soil	
5 ft	40 ft	Blue clay	
40 ft	50 ft	Red sandy clay	
50 ft	65 ft	Tough red clay	
65 ft	75 ft	Red sandstone, little water	
75 ft	120 ft	Tough red clay	
120 ft	176 ft	Red sandstone	
176 ft	179 ft	Very hard gray sandstone	
179 ft	186 ft	Porous white sandstone	
186 ft	190 ft	Red clay	
190 ft	194 ft	Porous white sandstone	