Second Conference of Irrigation
and Drainage Engineers - Ext. Station
of the West - Berkeley -
Dec. 1927
M. J. Rohwer
Assoc. Irrig. Engineer,
CALS. Ext., Dept. Sta.
Fort Collins, Colorado.
January 10, 1928.

Professor R. L. Parshall,
State College,
Fort Collins, Colorado.

Dear Professor Parshall:

In reply to your letter of January 3, I have dictated a statement covering our main irrigation and drainage study, from which you can probably obtain the information you desire.

With best wishes, I am

Very truly yours,

W. L. Powers,
Chief in Soils.
Program for Irrigation & Drainage Conference - Utah 1929

Three day session
9 to 12 - 1:30 to 4  Six sessions

Subjects -
Water Requirements of Crops
Distribution, Management & application
Measurement of Water
Evaporation, water & soils
and treatment of
Management of Soils

Drainage of Soils

Rehabilitation of Irrigation Drainage

Agricultural economics

Progress report from Stations

Business meeting and report of Committees.

Extension Relations

Agri. Research by Wash. Office
special evening lecture
1st Day
A.M. { Agricultural Economics

P.M. { Rehabilitation of Irrigation
and Drainage Districts
management of soils
Drainage of soils

2nd Day
A.M. { Progress report from Experiment Stations

P.M. { Business meeting and report
of Committees - Recess

3rd Day
A.M. { Water Requirements of Crops
management and distribution of irrigation water

P.M. { Measurement of Water
Evaporation from various soils

4th Day
{ Inspection of experimental work at Utah Station and excursion

1st Day - any Berkeley office - leader
2nd Day - All States
3rd Day - Am. - Calif. - leader
4th Day - P.M. - Colo. - leader
1st Day

A.M. Berkeley office

pm - Calif.

pm - Idaho

A.M. - All states

pm - Business

2nd Day

A.M. - Utah leader

3rd Day

A.M. - Calif leader

pm. - Colo leader

pm. - Arizona leader
1st

A.M. Agri Economics - Berkeley

A.M. Irrigation Drainage Dist - Oregon

A.M. - All States report

P.M. Treatment of Soils - Calif

P.M. Drainage of Soils - Utah

2nd

A.M. - All States report

P.M. Business - recess

Evening lecture by Washington

A.M. - Water requirements - Arizona

A.M. - Man. Dist. - Idaho

P.M. Evap. from water & soils - Colorado

3rd

P.M. Extension relations - Utah
SUGGESTED PROGRAM, IRRIGATION AND DRAINAGE CONFERENCE, Utah, 1929

FIRST DAY
Morning.-- Agricultural Economics, Berkeley office, leader.
         Discussion, Washington office, California, Oregon
         Irrigation and Drainage Districts, Oregon, leader.
         Discussion, Utah, Berkeley office, Arizona.

Afternoon-- Treatment of Soils, California, leader.
         Discussion, Utah, Oregon and Idaho.
         Drainage of Soils, Utah, leader.
         Discussion, Nevada, New Mexico and Montana.

SECOND DAY
Morning-- Progress report from all Expt. Stations.

Afternoon-- Business, report of committees and recess.

Evening-- Lecture by Washington office representative.

THIRD DAY
Morning-- Water Requirements of Crops, Arizona, leader.
         Discussion, California, Utah and Washington.
         Discussion, Wyoming, Colorado and Nevada.

Afternoon-- Evaporation from Water and Moist Soils, Colorado, leader.
         Discussion, California, Arizona and Utah.
         Relation to Extension Service, Utah, leader.
         Discussion, California, New Mexico, Washington.

FOURTH DAY
Inspection of experimental work at the Utah Station and field excursion.

Sent Jan 25/28 to Berkeley office.
Suggested Program - Irrigation & Drainage Conference - Utah 1929

First Day

Morning - Agricultural Economics - Berkeley office
Leader - Discussion; Wash. office, Calif. Oregon
Morning - Irrigation and Drainage Districts,
Oregon leader - Discussion Utah, Berkeley office, Ariz.
Afternoon - Treatment of Soils - Calif. leader
Discussion Utah, Oregon and Idaho
Afternoon - Drainage of Soils - Utah leader
Discussion Nevada, New Mexico and Mont.

Second Day

Morning - Progress report from all Ext. Stations
Afternoon - Business report of committees
and recess
Evening - Lecture by Washington office representative

Third Day

Morning - Water Requirements of Crops - Ariz.
Leader - Discussion Calif., Utah and Wash.
Morning - Management, Distribution and Application
of Irrigation Water - Idaho leader, Discussion Wyo., Colo. and Nevada.
Afternoon - Evaporation from Water and Moist
Soils - Colorado leader, Discussion Calif.,
Ariz. and Utah
Afternoon - Relation to Extension Service Utah
Leader, Discussion Calif., New Mexico, Wash.

Fourth Day

Inspection of experimental work of the
Day Utah Stations and field excursion
Fort Collins, Colorado

January 19, 1926

Prof. C. E. P. Smith
230- Kellogg Avenue
Palo, Alto, Calif.

Dear Professor Smith:

Your letter was received during my absence and upon returning I find that you have sent Professor Clyde necessary data on Duty of Water and Drainage. I wish to express my thanks to you in this matter.

I have just written Professor Clyde concerning the report on Permanent Organization and will send Professor Powers a copy requesting his signature, this, then, to be returned to Professor Clyde for our official files.

Concerning your request for data on the Improved Venturi Flume, may I advise that I am sending this information to you at Tucson.

Yours very truly

RLP/b

Irrigation Engineer
Dear Professor Parachre,  
Yours of the 3rd at hand. I have just forwarded to Prof. Clyde two write-ups for the report, one on duty of water and one on drainage. The delay was due to an invitation to deliver an address, and I had to get busy and prepare it. The report on technique of up-to-date duty of water research "blew up." I had hoped that Viehmeier and Bartlett would prepare it, but they both dodged it. With regard to the report on permanent organization, it was signed by McLoughlin and myself. Powers was appointed also, and I wish he had signed it. Would it not be well for you to write him and ask a copy of that report and request that he give his permission for you to add his name.  

I enjoyed your illustrated lecture on the flame measuring flames very much. We are going to build one on the University farm near Tucson this year. If you have a blueprint showing dimensions for second object, I wish you would send it, addressed to me at Tucson.  

Very cordially,  

G. E. P. Smith
Fort Collins, Colorado  

January 19, 1926

Prof. George D. Clyde

Logan, Utah.

Dear Professor Clyde:

I have just received two letters from Major Stout, of Berkeley, submitting statement as to California Cooperative Irrigation Investigations in the Sacramento-San Joaquin Delta, also the proposed investigation of Irrigation by Pumping and of the drainage of irrigated lands by the same means. Major Stout informs me that these outlines have been forwarded to you.

I am enclosing a statement covering the main irrigation and drainage studies in Oregon by Dr. Powers. I have not had time to read this matter, but assume it to be what is needed for our report.

In a letter from Professor C. E. P. Smith, I note that he has forwarded to you two write-ups for our report, one on Duty of Water and one on Drainage. I trust these have been received.

Also, I am enclosing letter from Professor Weir concerning the point relative to the use of alkaline water for irrigation. I believe that you will be able to extract from his letter the features necessary for the conference report.

Professor Smith mentions in his letter the following: "With regard to the report on permanent organization, it was signed by Mr. McLaughlin and myself. Powers was appointed also and I wish he had signed it. Would it not be well for you to write him and have a copy of that report and request that he give his permission to you to add his name?" I shall search thru my files and no doubt I have a copy of the report of this conference committee, which I will forward to Dr. Powers requesting his signature, and have this returned to you for your file. I concur with Professor Smith that this should be done.

As far as I am aware at this time, this practically clears up the remaining features of the report of the recent conference. When you have been able to complete this matter, I would appreciate very much reviewing the copy before final issue. I recall having
discussed with you at Berkeley the matter of issuing the report and suggested that the station here put this out in mimeograph form. If this is still agreeable with you, I think it will be possible for us to do this. Would you not let me have your estimate about the number of copies needed for distribution? Just now I think it would be well to send a copy to all the delegates present, directors of all the experiment stations concerned, with a reserve of possible twenty-five copies for others who might be interested in this conference.

Yours very truly

Irrigation Engineer

RLP/b
2 encls.
Montana - Murdock v.
Arizona - Smith v.
Oregon - Powers
Utah - Clyde
Colorado - Pashall

Dr. Jutiæn

Technically

Lack of information on aquifer reserves - general data

Latitude - longer sunshine

Does anyone know about Alaskan aquifer? Tomorrow

Lunch.

Why this practice

(See 1925 Schedule)
Duty of Water - Beckett - Orchard adsorption extraction effect of soil moisture by tree appears to be independent of percent of moisture, straight line variation.

[Graph showing moisture extraction over time with labeled axes: Acme Inches, MJJASON, Field Crop, Depth, Moisture Content, Time, Moisture.]

Huberty
Duty of Water - what is this based upon
Soil & Water curves - how to apply to another type of soil
Why would you expect a smooth curve
Consumptive use of water - how do you interpret correlate
Irrigation efficiency 88%
Volume of tree, weight or leaf area - space column
How to measure small furrow flow
How to determine the moisture extraction
Ewing notion of efficiency

Diurnal curves of ground water table interesting - 3 in. due cottonwood
Atmospheric black & white be considered

Do not fully appreciate your problems
land worse than river - fat scientists no organize corn off program
Permanent irrigation Jones

Ecologist
Mr. Parrish:

What was the fate of the report of the conference two years ago? Presumably transmitted, presumably reported by Director Gilette to the Land Grant College Committee, and then what? Did they ever make it or pay any attention to it?

Report of corn, in duty of water summary.

Soil about Sang. Ill. Am. Ser. of CE.

Response

Soil temp., variation in deep soil.

Copy of Hodgson's paper.

Station Work and material for Extension Workers.

Transpiration & evap.

Use & trans.

Use a "Evap."
Duty of Water: - Obligation, service, tax, ratio.

New term "consumptive use" defined as the "permanent water loss incident to irrigation of large tracts of land." By a river system, outflow from the inflow.

Review scope of our field of activity.
Need of concentration of study on what problem.
Forecast the needs 25 years hence.
Is productivity in step with population?
Is population a criterion, or is productivity a matter of profits based on better business methods. Is it money that makes the mare go.

Our Sept 1925 conference. Outlines the results of sound reasoning. Believe much was accomplished.
Loss due to no coordination of organizations.
Present meeting - definiteness of purpose to be stressed. Results must be attained.
Delegate from distant points.
Suggest a permanent organization.
Entomology Club, agronomist.
Correct to state that the engineer problem are as numerous and varied as other lines of endeavor.
A Brief Statement of Conditions.

by

C.V.P. Stout,
Division of Agricultural Engineering,
Bureau of Public Roads,
U. S. Department of Agriculture.

The Division of Agricultural Engineering of the U. S. Department of Agriculture, the California Agricultural Experiment Station, and the Divisions of Engineering and Irrigation and of Water Rights of the State of California have been engaged for the last four seasons in a cooperative investigation directed to determine the consumptive use of water in the Sacramento-San Joaquin Delta. The region under investigation comprises about a half-million acres, and presents many unique features. The deltaic channels of the rivers form a network which cuts it up into a large number of islands, which have been reclaimed, by the interposition of levees, from the conditions of swamp and overflow. The land surface is in general at lower elevation than that of the surface of the water in the surrounding channels, and water for irrigation is admitted through culverts under the levees, through siphons over their tops, and to some extent by pumping. The irrigation of the peat lands, and to a considerable extent that of sedimentary lands also, is accomplished by subbing from small machine-made trenches, called "spud ditches" which grid the fields and which are constructed anew each year. The four-foot ditches, so called, convey the water from the outlet end of the culvert, siphon or pump-discharge to the spud ditches.
The prevailing practice, on the peat lands especially, is to apply an excess of water in irrigation, withdraw it from the lands by drainage and restore it to the channels by pumping.

The lands are classified roughly, in the proportion of about three to four, as peat and sedimentary. The peat ranges in depth from a mere surface covering to beds fifty feet or more in depth.

The Delta contains the great asparagus district of the world, between fifty and sixty thousand acres being devoted to that crop. Beans, celery, potatoes, sugar beets, onions, corn and grain are also raised on a large scale. The sedimentary lands contain some important fruit districts. Alfalfa is grown on the sedimentary lands but not on the peat.

The technique of procedure in the investigation lies to a considerable extent along established lines. There are, however, a number of problems for whose solution it is required that methods be modified or that new methods be developed. The following paragraphs set forth some of the schemes of attack:
DESIGN AND OPERATION OF TANKS.

by

Lloyd N. Brown
In Resident Charge of Cooperative Investigations on Peat Lands.

Two different sizes of tanks have been used. The reason for this is that the area of soil surface for each plant in the tank is designed to be approximately equal to that occupied by a plant in the field. The small tanks are about twenty-three inches in diameter, the large ones about forty-two inches. Both sizes are five feet deep. The methods of installation of the two sizes do not differ except in magnitude of undertaking. The following discussion concerns the small tanks installed in peat:

The tanks are of the usual double type used for work of this nature. The outer tank is water tight but the inner tank is perforated on the sides near the bottom and on the bottom. A welded collar of angle iron is riveted around the top of the inner tank, and since the outside diameter of the outer tank is a little less than the outside diameter of the collar, the inner tank is suspended in the outer tank when they are telescoped. The outer tank is just enough larger than the inner tank to afford clearance between the bottoms and leave an annular space of about two inches between the tanks.

It was desired to fill the inner tank with soil in condition as nearly as practicable the same as when in place in the field.
The chief feature to this end is a removable bottom with two steel bars riveted on it and projecting about an inch into the annular space. The bottom is held in place by means of four rods which pass through holes in the ends of the steel bars and extend upward through the annular space and through holes in the angle at the top of the tank. The top angle had three other holes bored through its horizontal leg, two on a diameter of the tank and a third halfway between but on the same circumference. These holes were tapped with three-quarter inch pipe threads. Screw eyes properly threaded could then be screwed into the diametrically opposed holes, and by means of a tripod and tackle the tanks could be lifted when filled.

To fill a tank the bottom was removed and the tank placed upright in the location where it was desired to have it ultimately. The tank could then be sunk into the peat by having it sufficiently weighted. This was accomplished by making a platform that would rest on the top of the tank. Two holes were bored through this platform so that the above mentioned screw eyes could be shoveled through the holes and screwed into the diametrically opposed holes in the angle, thus making the tank and platform rigid. It was then merely a matter of turning the tank and platform, weighted with a few sacks of earth, back and forth a few times to sink the tank to its entire depth into the peat. In a few cases the peat would be somewhat compacted when forced into the tank but never in excess of three or four inches and often not at all. After the tank had been imbedded in the peat in this manner a
hole was dug around it, and the bottom forced under and bolted on as previously described. The filled tank was then lifted out of the hole by means of tripod and tackle; the outer tank, tested to see that it was water tight, was placed under it and the inner tank was then lowered into place. The excavated material was backfilled around the tank. The connection between the angle iron of the inner tank and the top of the outer tank was made tight by means of friction tape and asphalt paint.

When the small tanks were installed in a heavier soil, in Reclamation District No. 999, it was necessary to put about 4,400 pounds of sacked earth on the platform to force them down. With the platform loaded in this manner it was not feasible to turn it through a small arc so a slight teetering motion was resorted to.

The larger tanks were installed where the peat was about three and one-half feet deep, underlain with a sandy clay. It required about three tons of weight to force them down to the required depth. The bottom was forced under the tank and into place by means of a jack-screw. The bottom had three small angles riveted on it and was suspended from the top by six bolts.

After the tanks were in place all operations affecting the water supply control and measurement were carried on through holes in the top angle. Plugs were kept in these holes to prevent evaporation losses. The first year the small tanks were in operation, float gauges composed
of test tubes and rods were used to determine the elevation of the water in the annular space. During the last two years an electric gauge has been in process of evolution. This gauge is now composed of a square tube graduated to feet and hundredths which runs through a frame on which is mounted a vernier so that readings may be taken to thousandths of a foot. When the rod is lowered into the annular space to the water level an electrical contact is made between two points which causes a bell to ring. Readings with this instrument are very accurate and may be checked precisely by several observations.

A number of difficulties have been encountered in the work with tanks in the peat soil: Probably the greatest problem is the control of nematodes. This pest has already caused considerable inconvenience and promises to continue as a chief source of worry. Several bacterial, fungus, and insect diseases also interfere. Corn has been planted no less than five times due to depredations of pheasants. The presence of alkali has added somewhat to the troubles.
THE TECHNIQUE OF DETERMINING THE CONSUMPTIVE USE OF WATER
ON 23,500 ACRES OF SEDIMENTARY LANDS OF THE SACRA-
MENTO–SAN JOAQUIN DELTA IN CALIFORNIA.

By

Frank Davis,
Division of Irrigation Investigations and Practice,
California Agricultural Experiment Station.

I. To determine the amount of water withdrawn from the
supplying channels it was necessary to determine the rate of dis-
charge and to compute the total delivery of some 30 pumping plants
ranging in size from 4 to 22 inches, a 60-inch siphon and a gravity
inlet. As the water surface in the supplying channels is affected
by tide, the rate of discharge of each plant at intervals through a
complete tidal cycle was measured. For pumping plants where condi-
tions were suitable the discharge was measured over a weir. Where
sufficient head was not available, a submerged orifice was used. In
cases where the pump discharged into a concrete pipe line the color
method was employed, a solution of potassium permanganate being best
suited for the use in the turbid water. In some cases the Collins
Flow Indicator, an adaptation of the Pitot tube, was used. With
each series of measurements, the power input, head and other relevant
facts were noted.

The rate of discharge of the 60-inch siphon was measured with
the Collins Flow Indicator, checked against rod float gagings in the
canal into which the siphon discharges. This siphon presented a
special case because of its size and the conditions under which it
operates, namely: the vacuum is at times allowed to fall below the point where it is sufficient to keep the siphon completely filled at the summit. This required a number of measurements with different vacuums as well as with the varying head. When the siphon is completely filled the discharge is a function of the head or difference in elevation of the water surfaces at the intake and discharge. An analytic approach to the problem of discharge when the siphon was not completely filled did not give a workable result. From the measurements with the siphon not filled, together with the physical features of the siphon, an empirical expression was deduced for the relation between the ratio of discharges when filled and not filled and the elevation of the water surface at the intake plus the water vacuum at the summit. To insure the siphon being full, this sum is equal to or greater than 26.0 feet, the elevation of a point 6 feet above that of the bottom of the siphon at the summit. From the above it is noted that the discharge with partial vacuum is a function of the head, the vacuum and the elevation of the water at the intake.

The gravity inlet was a culvert placed under the levee between two large borrow pits. On the discharge end of this culvert is a "Y" spillway of the same size as the culvert, placed with one leg in the line of the culvert and the other leg at an angle of about 30 degrees, with and vertically above the culvert. There are gates on the intake end and on the horizontal leg of the "Y." There is a flow through the
culvert when the gate on the intake is open, the gate in the "Y" closed and the elevation of the water at the intake greater than the elevation of the bottom of the opening on the inclined leg of the "Y". The gate opening at the intake varied. The rate of flow for various gate openings and heads was determined by timing a color solution of potassium permanganate through the culvert. The rate of flow is a function of the gate opening and the head. The equation for rate of flow for each gate opening with various heads was computed analytically. From this equation an expression for rate of flow for each gate opening was computed and adjusted to the observed values.

The total discharges in each case were computed from the time rate of discharge and the total time as recorded by the operator, or for electrically operated pumps, as obtained from the power company.

II. Another increment to the consumptive use is the water made available as the ground water table drops during the irrigation season. The extent of the drop was ascertained from a record of the water table elevations in wells of sufficient number and at such locations as to give an average water table in the district. This record, supplemented by soil moisture determinations and volume weight determinations, was used to compute the magnitude of the increment. Another increment, which may be positive or negative, results from the under ground movement of water from or to the supplying channels. This movement was studied by various means, including Slichter's method, the effect of tidal action in the supplying channels on the water table adjacent
to the levees, vertical probes to determine underground hydraulic
gradients, and the subsoil in the district as shown by the logs of
drilled and driven wells.

III. The tanks used in Reclamation District No. 999 are of
the same size and type as the smaller ones used in the peat soils.
The tanks and the field immediately adjacent were planted at the
same time to the same crop, plants being given as nearly as possi-
bly the same growing space as in the field. From the planting of
the crop until harvest, the water table in the annular space was
maintained as nearly as practicable at the depth below the soil
surface indicated by an index well placed in the field. The water
added to the annular space to maintain the proper depth was measured
by a calibrated measure. The amount of water added, the increase
or decrease in the amount of water in the annular space, and
observations on growth of the plants were noted at 3 or 4 day
intervals. The depth to water in the annular space was accurately
measured by the specially constructed micro-hydro-gage hereinfor-
described. Soil moisture increment or decrement was computed from
samples taken at intervals during the growing season. At harvest
the crop was taken from the tank and weighed.
NOTES ON WORK IN COLORADO
(To be included in Report of Conference, Berkeley, Dec. 28-30, 1927)
R. L. Parshall

At the Colorado Experiment Station is maintained a battery of 18 buried metal tanks for the purpose of studying the evaporation loss from moist soil surfaces and a free water surface. All tanks are provided with an individual automatic water feed which keeps the water table at a definite fixed depth below the soil surface. Six of these tanks have the water table at one inch below the surface. Of this series, two are medium and coarse clean river sand, two are very fine river sand containing a fair proportion of silt, one of heavy black adobe soil having a large percentage of alkali, and the remaining one of fairly heavy clay loam soil. In another series of five tanks, the water table is held at six inches below the soil surface. These soils are of the same kind as found in the 1-inch series. In the third series the water table is at 12 inches below the surface, with similar soils. Two of the 18 tanks have a free water surface, in duplicate, under similar conditions.

The surface of all soils has been kept free from all plant growth and in an undisturbed condition. Movable covers are provided for the tanks to prevent moistening by rain. Soil and water temperatures are recorded, also wind in miles per hour.

Observations were formerly taken twice each day, morning and evening, in the attempt to show the relation between the day and night rates of evaporation loss. The results so far have not been consistent enough to establish this relation.

During the year 1927 the apparatus was improved and the time of observation changed to about midnight, for the reason of more uniform temperatures
affecting the Mariotte feed regulation.

The results of the past season show that for the water table at 1 inch the coarse and medium river sand lost about 10 percent more water by evaporation than from the free water surface. The fine river sand being about equal to the free water surface, while the heavy adobe soil was 15 percent less and the clay loam soil about 10 percent less. For the 6-inch depth to the water table, the fine and medium river sands, as well as the loam soil, all agreed closely with the loss from the free water surface. The heavy adobe and coarse river sand were approximately 30 percent less. With the water table at 12 inches, the fine river sand shows a loss equal to that from the free water, loam soil about 20 percent less, medium river sand 40 percent less, and the coarse sand and heavy adobe soil about 70 percent less.

During 1926, tanks 1, 2, 3 and 4 contained a fine river sand with an admixture of silt. These samples were very similar. The results are as shown where the loss from the free water surface is taken as 100 percent.

<table>
<thead>
<tr>
<th>Tanks</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss in pct.</td>
<td>102</td>
<td>96</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

For the purpose of studying the relation of the loss by evaporation from large and small water surfaces, such as tanks 3 feet square, buried flush with the ground surface, a standard U.S. Weather Bureau pan 4 feet in diameter and 10 inches deep, set above the ground surface and fully exposed, and a floating pan 3 feet square, there has been provided at the Colorado Expt. Station a copper lined basin \( \frac{3}{4} \) feet deep, 86 feet in diameter with side slopes 1 to 1. This basin or reservoir has the top edge flush with the ground surface. The floating pan is placed near the center of this basin, while the U.S. standard pan and small buried pan are located about 6 feet back from the rim of this circular reservoir. Air and water temperatures
are taken at the center, mid-radius and edge of circular reservoir. These temperatures are also observed in the floating and land pans. Vapor pressures are determined by an Assmann psychrometer. Wind velocities over the reservoir and near the land pans are observed by three standard Robinson anemometers. The drop in the water surfaces in all tanks is determined by hook gages reading to 0.001 of an inch. One gage is used for each of the smaller tanks. For the reservoir, four gages are mounted around the circumference of the basin at the NE, SE, SW and NW points. Special hook gage wells are provided for all gages.

It is found that the relation existing between the evaporation loss from the small pans and the reservoir is not constant but depends upon the advance and recession of the temperatures of the season. During the season 1928, where the loss from the large reservoir is taken as 100 percent, Mr. Rohwer has found that the floating pan lost 127 percent, the 2-foot square buried tank 116 percent, and the U. S. standard 131 percent as a mean of about 6½ months, April to October.

From the standpoint of better use of water in irrigation practice, there has been perfected at the Colorado Experiment Station a measuring device known as the improved Venturi flume. Laboratory and field tests indicate that this flume is a practical device and is meeting conditions in the field where the ordinary weir or rating flume has been found to be unsuited. The improved Venturi flume has been calibrated for the smallest size, 6-inch throat, for discharges of 0.06 to 2.5 second-feet, and for the 10 and 12-foot size for discharges up to 200 second-feet. There has recently been completed in the Holbrook Canal, near Rocky Ford,
Colorado, a 20-foot flume which is designed to carry more than 1000 second-feet. At this time only two flow tests have been made on this structure, however, the indications are quite encouraging as to the utility of this large flume.

The Lake Canal, near Fort Collins, is completely equipped with the improved Venturi flume. There are in use two large flumes, one with a 12-foot crest and the other having an 8-foot crest. To distribute the water to the users along the canal, there are approximately 60 small re-inforced concrete structures, of these more than 75 percent being of the 1-foot size, and the remainder 2-foot and 3-foot sizes. The experience with this installation of flumes, which replaced the rectangular weir, indicates a marked improvement in the distribution.

Success is being attained in the Arkansas Valley in Colorado, where the large sized flumes are used to measure the diversion by canals and ditches from the river. Because of the accumulations of sand and silt in the channel and the filling in over the floor of the rating flume, past experience shows this type of measuring device to be wholly inadequate and at times grossly in error. Tests on a 10-foot improved Venturi flume in the Las Animas Consolidated Ditch, near Las Animas, Colo., show the measured discharge by current meter gagings to agree remarkably well with that computed by the standard free-flow discharge formula. Tests in flows from 80 to 130 second-feet show a maximum deviation of about 2 percent. For a discharge of about 12 second-feet, with a head of approximately 0.5 foot the agreement was not so good. Three observations on these small discharges show a mean deviation of 5.4 percent. The current meter gagings were made within the converging section of the structure where the depth of water was about 6 inches. Best current meter results cannot be obtained for the shallow depths.
Memorandum of Irrigation and Drainage Conference
Berkeley, December, 1927

As a result of the meeting of irrigation and drainage investigators held at Berkeley in September, 1925, a call for a similar conference of these workers from the various western experiment stations was issued, to be held again at Berkeley, December 28-30, 1927.

The work of the first conference developed a very comprehensive outline of the various relations existing in the field of research of the irrigation and drainage investigator. So complete is this outline that, when reviewed after two years of seasoning, it stands without question as a basic guide in the correlation of the relations covering the complete gamut in the study of irrigation and drainage problems.

The second conference of these investigators was primarily for the purpose of organization in view of the splendid work accomplished in 1925, and further because of the need of reviewing, in conference, the work in irrigation and drainage carried by the men from the several western experiment stations and the U. S. Dept. of Agriculture, all dealing with more or less common problems in this field of research. Another very decided advantage to be gained in the organization of such a group of workers is the personal contact in such a conference. Much good is derived in the more complete and better understanding of the problems involved when reviewed by the leaders in these various special lines of activity. Suggestions and criticisms arising from discussion are thought to be a distinct benefit to those carrying on their research work. Pertinent and useful information coming from such a conference is a wonderful asset to the experimenter in broadening his viewpoint in relation to his studies.

There general topics were discussed at this last conference, namely: Duty of Water, Pumping for Irrigation and Drainage, and Information on the subject of Irrigation and Drainage for use by Extension men. These subjects proved
to be of great interest at this meeting, especially the topic Duty of Water. It appears that the former ideas underlying this subject may be replaced by a new conception, as evidenced by very recent work done by the investigators of California. The duty of water studies based on the ratio of water used to yield of crop has long been recognized to involve factors which are difficult, if not impossible from the standpoint of correlation. The recent studies with orchards promise success in establishing the relation of use of water by the trees to the growing season. It may be shown later that the use of water by the crop is independent of the type of soil, and should this prove to be true it will be recognized that an outstanding achievement has been accomplished.

Pumping for irrigation and drainage was given considerable attention. The Division of Agricultural Engineering, U. S. Dept. of Agriculture, submitted a most careful and comprehensive project outline covering this subject. It was reported that the subject of drainage reclamation by pumping is being generally accepted as a practical and economic means of solving this problem. The subject of drainage investigations invites extended study, because it is believed at this time to be more economic to accomplish reclamation of seeped areas than to develop new lands by means of an extensive irrigation system.

The discussion of Experiment Station work in irrigation and drainage as being useful to the Extension Service brought out forcibly the California plan of disseminating this information. A short summary of the results of experimentation, presented in an elementary form easily understood and void of technical matter, has been found to be effective. The mere distribution of circulars and bulletins to farmers without personal contact by the Extension Service, does not seem to fully accomplish the purpose.
INTRODUCTION

The conference of September, 1925, at which a very complete and comprehensive outline of the field of research in irrigation and drainage was worked out, also took occasion to recommend that a future conference of irrigation and drainage investigators of the eleven western states be called, and to include interested research agencies not directly connected with the state experiment stations.

In view of the splendid work done at the first conference held at Berkeley in 1925, steps were taken to bring about this second meeting for the purpose of following up the work already accomplished, and last but not least, the opportunity of discussing the desirability of permanent organization. The many advantages gained by such an association of scientific investigators was soon apparent, and by unanimous action a permanent group organization was effected.

The importance of a general conference in the study of many of the problems relating to irrigation and drainage is generally recognized as a distinct advantage to those who are actively pursuing a study which is being carried on at other experiment stations. Methods of attack, success or failure in manipulation of apparatus, and new ideas or information arising from discussion of the subject, all very greatly aid in the progress of the work done by the individual experimenter. General discussion of minor phases will sometimes bring to light an explanation of the trend of results which seem to be contrary to expectation. Time and money will be saved in some instances by the advantage of knowledge gained through the work and experience of others engaged in the same or similar field of research. The personal contact and association of the delegates at a general conference of this kind is one of great importance.
and permits each to better appreciate the problems undertaken by others. Conferences of this nature will be an inspiration and of inestimable value to the investigator in the field of irrigation and drainage research.

The appreciation of the value of such conferences resulted in the proposal that meetings be held every second year at such place as would be decided by the Conference, and there review the progress and findings of the several phases of investigations in irrigation and drainage as carried on at the experiment stations of the western states, it being tentatively agreed that the next meeting of this conference be held at Logan, Utah, sometime during the summer of 1929.
Duty of Water

Beckett
Huberty
Stout
Brown
Davis
Hodgson
Smith
Murdock

Dr. Laughton
Powers
Weir
Murdock

Brown

Write to
Dr. Powell about
500 words - sunny
work - In & Drainage
Oregons
Smith - 500 words
same thing

Dr. Laughton dir. in
Stout in Drug &
Drainage
Report
of the
Second Conference of Irrigation and Drainage Investigators
of the
Experiment Stations of the Western States
and the
Division of Agricultural Engineering, Irrigation Investigations,
United States Department of Agriculture

Held at Berkeley, California, Dec. 28, 29, and 30
1927.
January 14, 1928

Directors of Experiment Stations,

Western Division, Association of Land-Grant Colleges.

Gentlemen:

There is herewith transmitted a report of the Second Conference of Irrigation Workers in the Western States, held at Berkeley, California, December 28, 29, 30, 1927, addressed through the respective Directors to the Irrigation sections of the Experiment Stations.

Six states and one federal agency were regularly represented at the Conference, Arizona, California, Colorado, Montana, Oregon, Utah, and U.S.D.A. Division of Agricultural Engineering, Irrigation Investigations.

A permanent organization of Workers in Irrigation and Drainage Research in the Western States was effected with Mr. W. W. McLaughlin as Chairman and Dr. O. W. Israelsen as Secretary for the next two years.

The conference was conducted as a round table discussion, the subjects being confined to the following topics: (1) Duty of Water, (2) Drainage, and (3) What information on Irrigation and Drainage is available for use of Extension workers?

The conference adjourned with the firm conviction that an exchange of ideas, a comparison of experimental technique at regular intervals, is extremely valuable and should be encouraged.

Respectfully,

R. L. Parshall, Chairman,
G. D. Clyde, Secretary.
INTRODUCTION

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CONFERECE OF IRRIGATION WORKERS OF THE WESTERN STATES

Berkeley, California, December 28-30, 1927

Minutes

Morning Session, December 28, 1927, 9:00 A.M. - General Business.

Present:

R. L. Parshall, Colorado Agricultural College and U.S.D.A.
G. E. P. Smith, Arizona Experiment Station
H. E. Murdock, Montana Experiment Station
O. V. P. Stout, U.S.D.A.
J. B. Brown, California Extension Service
F. J. Weihmeyer, California Experiment Station
F. C. Scohey, U. S. D. A.
E. N. Bryan, California State Department of Public Works
W. W. McLaughlin, U.S.D.A.
Martin R. Huberty, California State Experiment Station
C. F. Dunshee, California Experiment Station
Frank Davis, California Experiment Station
G. H. Russell, Federal Land Bank, Berkeley
G. D. Clyde, Utah Experiment Station
Senator Brown, Oregon
W. L. Powers, Oregon Experiment Station
Frank Adams, California Experiment Station
Lloyd Brown, U. S. D. A.
S. H. Beckett, California Experiment Station
Macy Lapham, U. S. Bureau of Soils
P. A. Ewing, U. S. D. A.

Professor Frank Adams called the meeting to order. Moved that Mr. Parshall of Colorado be elected chairman. Seconded and carried. G. D. Clyde of Utah, elected secretary.

Mr. G. E. P. Smith, Arizona, requested statement of purpose of organization. Mr. Smith moved that the chair appoint a committee of three on organization to consider all phases of organization of irrigation workers. A preliminary report to be ready at 8 o'clock Thursday evening when it will be discussed as a special order of business. Motion seconded by Mr. Murdock and passed. Committee: Professor Smith, Dr. Powers, and Mr. McLaughlin.

Dr. Powers moved that all privileges of the conference be extended to Senator Sam H. Brown. Seconded by Mr. Adams. This motion was changed to
include Mr. E. N. Bryan, Division of Water Rights and Mr. Russel of the Federal Land Bank. Passed.

Chairman Parshall brought up the question as to who should be eligible for membership. This question to be considered by Committee on Organization.

Mr. Frank Adams, on behalf of the California members, invited the visiting workers to a dinner at the Faculty Club at 6 o'clock Wednesday night. Accepted.

It was announced that Dean Merrill would speak at 1:30 P.M.

Meeting turned to a general discussion of topics assigned to the conference. Chairman Parshall outlined three subjects which are proposed for discussion:

1. Duty of Water
2. Drainage of Irrigated Lands
3. What information on irrigation and drainage is available for use of Extension workers.

As no papers were called for, this will be a round table discussion covering the above topics. What are the future needs in irrigation research? Should review scope of activity at various stations.

For the benefit of those who were not in attendance at the last conference, the chairman reviewed the work of the last conference. The chairman proposed that "Duty of Water" be discussed at afternoon meeting.

Mr. J. B. Brown asked that the outline of the last conference be placed on the board. This was done.

Meeting adjourned, 12:00 o'clock.

Afternoon Session. December 28, 1927, 1:30 P.M.

Present: Mr. Parshall, Mr. Smith, Mr. Murdock, Mr. Stout, Mr. J. B. Brown, Mr. Vichmeyer, Mr. Scobey, Mr. Bryan, Mr. McLaughlin, Mr. Hubert, Mr. Dunshee, Mr. Davis, Mr. Clyde, Mr. Powers, Mr. Adams, Mr. L.N. Brown, Mr. Beckett, Mr. Lapham, Mr. Ewing.
An address of welcome was given by Dean E. D. Merrill of the California College of Agriculture. Reply by Chairman Parshall.
Subject for discussion: Duty of Water.

Mr. Adams: Mr. Beckett and Mr. Huberty of the California Station have been doing work on duty of water and they are prepared to outline methods used in their recent studies.

Mr. Beckett briefly outlined his work in southern California, and at the end of the discussion submitted in writing an abstract of his work which is made a part of this report.

DUTY OF WATER INVESTIGATIONS IN SOUTHERN CALIFORNIA

S. H. Beckett

Following the conference held in Berkeley, September, 1925, the irrigation projects of the California Experiment Station were grouped under the proper headings of the outline adopted at the meeting. In addition to this certain phases of the projects were modified to more nearly conform with the general plan as outlined. In planning the duty of water investigations in southern California, this outline as adopted in 1925 was kept in mind with the idea that the work should come under the general heading "Plant and Irrigation Relationships" and the sub-head "The quantity of water required per acre for economic irrigation."

The area under investigation in southern California was one of high land values and of very limited water supply. In general the soils were residual in character and of comparatively shallow depth. Because of the very favorable climatic conditions it is assumed that these lands will ultimately be planted to citrus and semi-tropical fruits (avocados) on the favorable soil
types, with grapes on the shallower and poorer soils. The investigations were therefore limited to a study of the quantity of water required per acre for the economic irrigation of the above crops.

The investigations started in the fall of 1925, consisted in the selection of eight typical groves and vineyards in Vista, Escondido and Fallbrook sections of northern San Diego County. On each of these areas plots of one-quarter acre area were selected and by means of measurement of water applied and intensive soil sampling it was hoped to determine the following:

1. The quantity of water required to produce a satisfactory winter cover crop.

2. The seasonal quantity of water in acre inches per acre taken from the soil by the various groves in maintaining normal growth.

3. The depth of soil from which this water was taken.

4. The quantity of water which it is necessary to apply to meet these needs as determined in 2.

Soil samples were taken to the full depth of moisture penetration at two-week intervals and at eight permanently established points of each plot throughout the season.

Analysis of the first year’s work showed that owing to variation in soils found on the one-quarter acre plots certain inconsistencies appeared in the results and that but one of the groves dropped below the "wilting point" at some time during the season resulting in a break in the "transpiration curve" and a noticeable suffering of the trees.

During 1927 the two vineyards under observation in 1926 were eliminated and the work confined to seven citrus and one avocado grove. The plots were reduced to one-fortieth of an acre in size and the number of sampling holes increased to 30 per plot, these holes being regularly spaced with respect to the location of the trees and furrows used in irrigation. In all soil sampling the top 4 inches of soil was discarded and all samples were taken at
one foot intervals in depth.

Water applied to the plots was measured volumetrically as closely as possible and run off, when occurring, was also measured. At the end of the 1927 season when the soil moisture losses were reduced to acre-inches of water it was found that for each plot a uniform seasonal transpiration curve was obtained. It was also observed that a marked consistency existed throughout the season in the rate at which moisture was taken from the various depths of soil into which the root systems of the trees extended.

Mr. Beckett: This moisture extraction does not include all the water necessary to produce the crop because it requires a certain amount of water to get the water over the land. The rate of the total moisture extraction to the total applied is the efficiency of irrigation factor.

Professor Veihmeyer: As long as the moisture in the soil is not reduced to the wilting point you can not influence the plant growth by manipulating the available amounts of water. Unfavorable conditions may be introduced by too frequent application, but these conditions may be due to unfavorable oxygen supply, leaching, etc.

Professor Smith: Assuming you have different orchards of the same variety on different soil types, but the same number of trees per acre and trees of the same age and vegetative condition, do you find the trees taking out the same amounts of water?

Professor Beckett: Yes, if conditions of experiments are such that there is no loss downward.

Continuing the discussion of effects of climatic factors especially light:

Professor Smith: Outlined results of experiments on transpiration from cottonwood and mesquite forests. Root systems extended down to ground water table.
Automatic gages placed on wells and fluctuation of ground water noted. There was a marked fluctuation between night and day. The curves showed a depression in ground water level due to use by plants. Maximum June use shows daily fall of range about three inches. Days with high clouds gave same results as sunny days but on rainy days there was very little change in water surface between night and day and the general inclination of the curve was upward. Believes effect of light has been over estimated and that important factors are temperature and vapor pressure.

At this point the question was raised as to how much the rainfall on the valley floor contributed to the ground water table. It was stated that the Division of Agricultural Engineering, U.S.D.A. under Mr. McLaughlin, and the Division of Water Rights of the California State Department of Public Works were now cooperating on this problem in southern California.

Mr. Huberty outlined the work being done by him along similar lines in the Sacramento Valley. A summary by Mr. Huberty of the procedure followed in these experiments follows:

BRIEF ABSTRACT OF WORK DONE IN SACRAMENTO VALLEY

Martin Huberty

The experiments to determine the use of water by shallow-rooted orchard crops on shallow residual soils irrigated by the furrow method has been outlined by Mr. Beckett. I have been making duty-of-water studies with deciduous trees on deep alluvial soil of the Sacramento Valley. The procedure followed in this work is as follows:

1. Select uniform orchards growing on uniform topography in areas of low water table. From these tracts select an area of about one acre for detailed studies. These small areas are selected on uniformity of crop,
topography and soil type and upon the ease of water measurement. The uniformity of soil is determined by sampling to a depth of 9 feet. Within this area several trees are selected and the ground about these trees is leveled by hand.

2. At the beginning of the growing season eight holes to a depth of 9 feet are taken around each of the "key trees" in the following manner:

3. Sampling is continued at about ten days to two weeks intervals throughout the growing season.

4. When the soil moisture approaches the wilting point apply, by the single tree basin method, sufficient water to adequately irrigate but yet not have any water pass below a depth of nine feet.

5. Make volume, weight, and moisture equivalent determinations for each tract of land.

The results so far seem to indicate that mature deciduous trees growing in the Sacramento Valley, with the water table at a depth of twenty feet or more, require from 12 to 18 inches of irrigation water.

Mr. Adams: Major Stout has been conducting work in peat lands. Mr. Beckett, Mr. Taylor, and Mr. Blaney have been working in southern California. Mr. Huberty has been working in the Sacramento Valley. All of these men have been working on the same general problem. We would like to hear from Major Stout.

Major Stout stated the objective in these experiments was to determine the amount of water to be accounted for by the delta. After making a brief statement of conditions involved Major Stout turned the time over to Mr. Lloyd N. Brown, who had immediate charge of the investigations on the peat lands and to Mr. Frank Davis who was handling the experiments on the sedimentary lands. A brief outline of conditions involved and the method of attack used in these experiments follows.
CALIFORNIA COOPERATIVE IRRIGATION INVESTIGATIONS
IN THE SACRAMENTO–SAN JOAQUIN DELTA

A Brief Statement of Conditions

O.V.P. Stout

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The Division of Agricultural Engineering of the U. S. Department of Agriculture, the California Agricultural Experiment Station, and the Divisions of Engineering and Irrigation and of Water Rights of the State of California have been engaged for the last four seasons in a cooperative investigation directed to determine the consumptive use of water in the Sacramento–San Joaquin Delta. The region under investigation comprises about a half-million acres, and presents many unique features. The deltaic channels of the rivers form a network which cuts it up into a large number of islands, which have been reclaimed, by the interposition of levees, from the conditions of swamp and overflow. The land surface is in general at lower elevation than that of the surface of the water in the surrounding channels, and water for irrigation is admitted through culverts under the levees, through siphons over their tops, and to some extent by pumping. The irrigation of the peat lands, and to a considerable extent that of sedimentary lands also, is accomplished by subbing from small machine-made trenches, called “spud ditches” which gird the fields and which are constructed anew each year. The four-foot ditches, so called, convey the water from the outlet end of the culvert, siphon or pump-discharge to the spud ditches.

The prevailing practice, on the peat lands especially, is to apply an excess of water in irrigation, withdraw it from the lands by drainage and restore it to the channels by pumping.

The lands are classified roughly, in the proportion of about three to four, as peat and sedimentary. The peat ranges in depth from a mere surface
covering to beds fifty feet or more in depth.

The Delta contains the great asparagus district of the world, between fifty and sixty thousand acres being devoted to that crop. Beans, celery, potatoes, sugar beets, onions, corn and grain are also raised on a large scale. The sedimentary lands contain some important fruit districts. Alfalfa is grown on the sedimentary lands but not on the peat.

The technique of procedure in the investigation lies to a considerable extent along established lines. There are, however, a number of problems for whose solution it is required that methods be modified or that new methods be developed. The following paragraphs set forth some of the schemes of attack:

DESIGN AND OPERATION OF TANKS

Lloyd N. Brown
In Resident Charge of Cooperative Investigations on Peat Lands

Two different sizes of tanks have been used. The reason for this is that the area of soil surface for each plant in the tank is designed to be approximately equal to that occupied by a plant in the field. The small tanks are about twenty-three inches in diameter, the large ones about forty-two inches. Both sizes are five feet deep. The methods of installation of the two sizes do not differ except in magnitude of undertaking. The following discussion concerns the small tanks installed in peat:

The tanks are of the usual double type used for work of this nature. The outer tank is water tight but the inner tank is perforated on the sides near the bottom and on the bottom. A welded collar of angle iron is riveted around the top of the inner tank, and since the outside diameter of the outer tank is a little less than the outside diameter of the collar, the inner tank is suspended in the outer tank when they are telescoped. The outer tank is just
enough larger than the inner tank to afford clearance between the bottoms and leave an annular space of about two inches between the tanks.

It was desired to fill the inner tank with soil in condition as nearly as practicable the same as when in place in the field. The chief feature to this end is a removable bottom with two steel bars riveted on it and projecting about an inch into the annular space and through holes in the angle at the top of the tank. The top angle had three other holes bored through its horizontal leg, two on a diameter of the tank and a third halfway between but on the same circumference. These holes were tapped with three-quarter inch pipe threads. Screw eyes properly threaded could then be screwed into the diametrically opposed holes, and by means of a tripod and tackle the tanks could be lifted when filled.

To fill a tank the bottom was removed and the tank placed upright in the location where it was desired to have it ultimately. The tank could then be sunk into the peat by having it sufficiently weighted. This was accomplished by making a platform that would rest on the top of the tank. Two holes were bored through this platform so that the above mentioned screw eyes could be shoved through the holes and screwed into the diametrically opposed holes in the angle, thus making the tank and platform rigid. It was then merely a matter of turning the tank and platform, weighted with a few sacks of earth, back and forth a few times to sink the tank to its entire depth into the peat. In a few cases the peat would be somewhat compacted when forced into the tank but never in excess of three or four inches and often not at all. After the tank had been imbedded in the peat in this manner a hole was dug around it, and the bottom forged under and bolted on as previously described. The filled tank was then lifted out of the hole by means of tripod and tackle; the outer tank, tested to see that it was water tight, was placed under it
and the inner tank was then lowered into place. The excavated material was backfilled around the tank. The connection between the angle iron of the inner tank and the top of the outer tank was made tight by means of friction tape and asphalt paint.

When the small tanks were installed in a heavier soil, in Reclamation District No. 999, it was necessary to put about 4,400 pounds of sacked earth on the platform to force them down. With the platform loaded in this manner it was not feasible to turn it through a small arc so a slight teetering motion was resorted to.

The larger tanks were installed where the peat was about three and one-half feet deep, underlain with a sandy clay. It required about three tons of weight to force them down to the required depth. The bottom was forced under the tank and into place by means of a jackscrew. The bottom had three small angles riveted on it and was suspended from the top by six bolts.

After the tanks were in place all operations affecting the water supply control and measurement were carried on through holes in the top angle. Plugs were kept in these holes to prevent evaporation losses. The first year the small tanks were in operation, float gauges composed of test tubes and rods were used to determine the elevation of the water in the annular space. During the last two years an electric gauge has been in process of evolution. This gauge is now composed of a square tube graduated to feet and hundredths which runs through a frame on which is mounted a vernier so that readings may be taken to a thousandths of a foot. When the rod is lowered into the annular space to the water level an electrical contact is made between two points which causes a bell to ring. Readings with this instrument are very accurate and may be checked precisely by several observations.

A number of difficulties have been encountered in the work with tanks
in the peat soil: Probably the greatest problem is the control of nematodes. This pest has already caused considerable inconvenience and promises to continue as a chief source of worry. Several bacterial, fungus, and insect diseases also interfere. Corn has been planted no less than five times due to depredations of pheasants. The presence of alkali has added somewhat to the troubles.

THE TECHNIQUE OF DETERMINING THE CONSUMPTIVE USE OF WATER ON 23,500 ACRES OF SEDIMENTARY LANDS OF THE SACRAMENTO-SAN JOAQUIN DELTA IN CALIFORNIA.

Frank Davis

Division of Irrigation Investigations and Practice, California Agricultural Experiment Station

1. To determine the amount of water withdrawn from the supplying channels it was necessary to determine the rates of discharge and to compute the total delivery of some 30 pumping plants ranging in size from 4 to 22 inches, a 60-inch siphon and a gravity inlet. As the water surface in the supplying channels is affected by tide, the rate of discharge of each plant at intervals through a complete tidal cycle was measured. For pumping plants where conditions were suitable the discharge was measured over a weir. Where sufficient head was not available, a submerged orifice was used. In cases where the pump discharged into a concrete pipe line the color method was employed, a solution of potassium permanganate being best suited for the use in the turbid water. In some cases the Collins Flow Indicator, an adaptation of the Pitot tube, was used. With each series of measurements, the power input, head, and other relevant facts were noted.

The rate of discharge of the 60-inch siphon was measured with the Collins Flow Indicator, checked against rod float gagings in the canal into which the siphon discharges. This siphon presented a special case because of
its size and the conditions under which it operates, namely: - the vacuum is at
times allowed to fall below the point where it is sufficient to keep the siphon
completely filled at the summit. This required a number of measurements with
different vacuums as well as with the varying head. When the siphon is complete-
ly filled the discharge is a function of the head or difference in elevation of
the water surfaces at the intake and discharge. An analytic approach to the
problem of discharge when the siphon was not completely filled did not give a
workable result. From the measurements with the siphon not filled, together
with the physical features of the siphon, an empirical expression was deduced
for the relation between the ratio of discharges when filled and not filled and
the elevation of the water surface at the intake plus the water vacuum at the
summit. To insure the siphon being full, this sum is equal to or greater than
26.0 feet, the elevation of a point six feet above that of the bottom of the
siphon at the summit. From the above it is noted that the discharge with
partial vacuum is a function of the head, the vacuum and the elevation of the
water at the intake.

The gravity inlet was a culvert placed under the levee between two
large borrow pits. On the discharge end of this culvert is a "Y" spillway of
the same size as the culvert, placed with one leg in the line of the culvert
and the other leg at an angle of about 30 degrees, with and vertically above the
culvert. There are gates on the intake end and on the horizontal leg of the
"Y." There is a flow through the culvert when the gate on the intake is open,
the gate in the "Y" closed and the elevation of the water at the intake greater
than the elevation of the bottom of the opening on the inclined leg of the "Y."
The gate opening at the intake varied. The rate of flow for various gate
openings and heads was determined by timing a color solution of potassium
permanganate through the culvert. The rate of flow is a function of the gate
opening and the head. The equation for rate of flow for each gate opening with
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d

ual heads was computed analytically. From this equation an expression for rate of flow for each gate opening was computed and adjusted to the observed values.

The total discharges in each case were computed from the time rate of discharge and the total time as recorded by the operator, or for electrically operated pumps, as obtained from the power company.

II. Another increment to the consumptive use is the water made available as the ground water table drops during the irrigation season. The extent of the drop was ascertained from a record of the water table elevations in wells of sufficient number and at such locations as to give an average water table in the district. This record, supplemented by soil moisture determinations and volume weight determinations, was used to compute the magnitude of the increment. Another increment, which may be positive or negative, results from the under ground movement of water from or to the supplying channels. This movement was studied by various means, including Slichter's method, the effect of tidal action in the supplying channels on the water table adjacent to the levees, vertical probes to determine underground hydraulic gradients, and the subsoil in the district as shown by the logs of drilled and driven wells.

III. The tanks used in Reclamation District No. 999 are of the same size and type as the smaller ones used in the peat soils. The tanks and the field immediately adjacent were planted at the same time to the same crop, plants being given as nearly as possible the same growing space as in the field. From the planting of the crop until harvest, the water table in the annular space was maintained as nearly as practicable at the depth below the soil surface indicated by an index well placed in the field. The water added to the annular space to maintain the proper depth was measured by a calibrated measure. The amount of water added, the increase or decrease in the amount of water in the annular space, and observations on growth of the plants were noted at three- or four-day
intervals. The depth to water in the annular space was accurately measured by the specially constructed micro-hydro-gage herein described. Soil moisture increment or decrement was computed from samples taken at intervals during the growing season. At harvest the crop was taken from the tank and weighed.

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In addition to the above outline Mr. Davis stated that the difficult thing to determine is the lateral and vertical inflow to the area from underground sources. Beginning at a point just inside the levees, wells were driven at various intervals to a distance of 900 feet from the levees. These wells showed fluctuations corresponding to the tides in the channel, but they were dampened out as the distance from the channels increased. A gravel stratum was found under the area at 35 to 40 feet below the surface. It is believed to be demonstrated that water is coming into the area by vertical seepage from these strata. Three years' records indicated a use of about 1-3/4 acre-feet during a single irrigation season.

Professor Smith: Believes the lines of flow are widely dispersed. A very slow rate of upward flow over a large area would yield large quantities of water while if it were moving laterally through a smaller area, it would require a much higher rate of flow. The upward flow would account for the apparently low water requirements.

Referring to the response of the wells in this area to the fluctuation of the tides, in Arizona in sections where there is a thick bed of unconsolidated gravel, a disturbance in ground water conditions is felt almost instantaneously over wide areas. In one case the starting of a pumping plant affected in less than one minute the ground water levels at points 1/2 mile away.

Mr. Parshall announced that duty of water discussion would be continued at 9 A. M. Thursday morning, December 29.

Meeting adjourned.
Morning Session. December 29, 1927.

General Discussion - Duty of Water

Meeting called to order by Chairman Parshall at 9:30 A. M.


Dr. Fortier was introduced to the conference and asked to discuss Duty of Water.

Dr. Fortier called attention to the fact that Duty of Water is the basis of the definition and allocation of water rights and therefore a very important question. He told of his present work on the water requirements of western lands as based upon existing records. Dr. Fortier deplored the lack of organized data on the agricultural resources of the several states and even the U. S. Department of Agriculture.

Professor Murdock of Montana stated that they are doing their duty of water work on Furnell funds. A brief statement of the work being done in Montana is as follows:

BRIEF OUTLINE OF DUTY OF WATER INVESTIGATIONS IN MONTANA

H. E. Murdock

- - -

Experiments first started six or eight years ago on measuring water used by farmers in their regular irrigation. Work was later confined to a rented farm near Valier where more factors could be controlled. An 80-acre farm was used, of which about 10 acres is in pasture, 30 acres in alfalfa, and 40 acres used for a series of rotation experiments. A three-year rotation consisting of 1 year cash crop, 1 year cultivated crop and 1 year enriching crop. The crops first used were wheat, corn, clover, and timothy.

The corn and red clover have not yet shown to be very well adapted to the conditions on the farm, so substitutions of potatoes and peas for the
cultivated crop and yellow sweet clover for the enriching crop were made. Only one cycle has been completed, but some information on the farmer’s problems has already been obtained.

The plots were so arranged that each crop would be growing each year. Series of plots were arranged so that each crop would have one, two, and three irrigations. Large plots running from three to over four acres were used in order to approach actual farm conditions as nearly as possible and thus eliminate some of the objections met in the use of very small experimental plots.

The alfalfa was divided into plots to get one, two, three, and five irrigations. A depth of five inches was aimed at for each irrigation.

We have problems that are peculiar to that section of the country, and factors enter into the investigations over which we have little or no control. For example, the second year after the rotations were established there was so much rainfall early in the season that the first irrigation was eliminated. And the last year there was so much rain throughout the entire season that no irrigation was given to the rotation and only one given to the alfalfa. The yield results this year also are not uniformly consistent with former results.

Crops grow more rapidly in northern latitudes than in the south. Long days of sunshine and long hours of dawn and twilight in the growing season, thus permitting the absorption of large amounts of heat units, are responsible at least in part for this condition.

Professor Smith of Arizona stated that little duty of water work had been done by the Arizona Station because by agreement with the Division of Agricultural Engineering, U.S.D.A. the Arizona Station was to confine itself to ground water studies and the U.S.D.A. would handle the duty of water investigations. At the present time, however, experiments on duty of water on lettuce and citrus fruits are being conducted jointly by the Irrigation and Horticulture
Departments of the Arizona Station. A brief statement of the work at the Arizona Station by Professor Smith follows:

DUTY OF WATER INVESTIGATIONS IN ARIZONA

G. E. P. Smith

The Irrigation Investigations Office of the U. S. Department of Agriculture began studies of duty of water in the Salt River Valley of Arizona in 1911. In order to avoid expensive duplication of effort, an agreement was made whereby duty-of-water investigations was reserved to that organization, while the subject of ground waters and their utilization was reserved to the Irrigation Department of the University of Arizona. The results of those early studies were prepared for publication in 1920, but the publication was not consummated until a month ago. It appears as Bulletin 120 of the Arizona Agricultural Experiment Station.

Since 1920 our duty of water work has been fragmentary until two years ago, when two projects were initiated, one on lettuce irrigation and the other on irrigation of citrus orchards. The former is carried on at Mesa in the Salt River Valley. The differential treatment of the different plots last winter was not reflected in the crop of lettuce taken off. This year there are quadruplicate plots: (a) to be kept at or close to water-holding capacity, 19 per cent; (b) to be dried down to wilting point, 12 per cent, then irrigated; (c) to be irrigated frequently up to the bunching stage, then no further irrigation unless soil reaches wilting stage, which is unlikely; (d) dry until bunching stage, then to be kept at field capacity. Presumably, the last-named treatment will encourage deep rooting.

The citrus irrigation work is being carried out on the Yuma Mesa, which is considered to be a frost-free area. We have 12 acres of newly-set
grapefruit, divided into three blocks of six plots each. Each plot is 88 ft. by 300 ft., and has four rows of 13 trees. Since the trees were botted when transplanted, and the roots would be in or near the boll last summer, very little science could be applied in differential treatment. However, the first plot of each block was irrigated weekly, the second plots biweekly, and the others every four weeks. Those trees irrigated every four weeks made the least growth, but perhaps, by means of greater root extension they may make more hardy and longer-lived trees. Let me say that this study has been undertaken because of very serious troubles in mature orchards of both Yuma and Salt River Valleys.

The plan for the coming year is to irrigate two plots of each block when the moisture has fallen to the wilting point, giving one of the pair a heavy irrigation and the other a light irrigation; to irrigate two plots when the moisture is at wilting point plus 15 or 20 per cent, and the third pair of plots when moisture is down to wilting point plus 30 or 40 per cent. You will appreciate our difficulties when I say that the Yuma Mesa soil has wilting point of three to five per cent and field capacity of five to nine per cent.

Both studies are in cooperation with the Horticultural Department, and plant relations as to health and vigor, growth, and production will be noted and recorded. As to the irrigation study, in both cases it is not so much the quantity of irrigation applied as it is the quality and character of the irrigation practice.

The feature of importance is the maintenance of a Class A evaporation station in the vicinity of each study. We believe that use and demand for water, as to quantity, primarily on transpiration, is roughly proportional therefore to evaporation rate, and the keeping of cooperative records by standard methods, in many localities will make it possible to approximate the duty of water in many places after it has been studied and determined in one place.
Some fragmentary work on alfalfa about 1908 indicated that uniformity of distribution is a factor of great importance in duty of water. Data obtained subsequently has emphasized that observation and we are planning to make a special study of uniformity of distribution. The "lands" for this purpose have been graded with different slopes and seeded already.

Professor Clyde of Utah reported the status of duty of water investigations in Utah.

DUTY OF WATER INVESTIGATIONS IN UTAH

G. D. Clyde

At the present time, outside of some irrigation practice experiments, there are no duty-of-water projects active at the Utah Station.

The duty-of-water investigations that have been carried on were for the purpose of determining the amount of water necessary to produce a crop. This was really the determination of the net duty. The experiments were usually so arranged that there was no surface runoff. If surface runoff did occur, it was measured and deducted from the amount applied. The amount of water used was that absorbed by the soil.

Experiments to determine the relation of yield to amount of water applied were carried on at the Central Experiment Station (Greenville), Logan, Utah, for 17 years. The results of these experiments have been published in Utah Experiment Station Bulletin 173 by F. S. Harris. These experiments established the well-known water yield curve which shows that in general the yield increases with increase in water applied up to a certain point and then decreases. These experiments indicated that for the given conditions sugar-beets yielded best when given 15 to 30 inches of water; potatoes 20 to 25 inches; corn, 15 to 25 inches; oats, 15 to 30 inches; and wheat about 15 inches. Alfalfa yields increased with water applied up to 50 inches but smaller quantities of water were much more efficient per acre-inch of water.
Similar experiments were conducted in the Sevier Valley, central Utah 1914-21, (Utah Station Bulletin No. 182, by O. W. Israelsen and L. M. Winsor) and in Cedar Valley, 1916-21, southern Utah (Utah Station Bulletin No. 181 by Arthur Fife). The Sevier Valley work suggests that for the conditions under which the experiments were carried out, sugar-beets give the best results on 27-33 inches, potatoes on 21-27 inches, and alfalfa on 30 to 36 inches of water. In Cedar Valley, where a uniform distribution was practically unfavorable, it was found that considerably more water was required to produce a crop.

It must be remembered that these experiments indicate only the water absorbed by the soil and do not include transportation losses and surface runoff. In determining the proper amount of water to allot to a particular tract in an adjudication of waters, these factors must be considered and will probably cause a variation in amount greater than that caused by the crop requirements.

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Mr. Parshall stated that Colorado was working along lines of economic use of water, was studying better methods of the measurement of irrigation water and also the evaporation from free water surface and moist soils. A brief statement of work along these lines being done by Colorado follows:

NOTES ON WORK IN COLORADO

R. L. Parshall

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At the Colorado Experiment Station is maintained a battery of 18 buried metal tanks for the purpose of studying the evaporation loss from moist soil surfaces and a free water surface. All tanks are provided with an individual automatic water feed which keeps the water table at a definite fixed depth below the surface. Of this series, two are medium and coarse clean river sand, two are very fine river sand containing a fair proportion of silt, one of heavy
black adobe soil having a large percentage of alkali, and the remaining one of fairly heavy clay loam soil all with water table at one inch. In another series of five tanks, the water table is held at six inches below the soil surface. These soils are of the same kind as found in the 1-inch series. In the third series the water table is held at twelve inches below the soil surface. These soils are of the same kind as found in the 1-inch series. Two of the 18 tanks have a free water surface, in duplicate, under similar conditions.

The surface of all soils has been kept free from all plant growth and in an undisturbed condition. Movable covers are provided for the tanks to prevent moistening by rain. Soil and water temperatures are recorded, also wind in miles per hour.

Observations were formerly taken twice each day, morning and evening, in the attempt to show the relation between the day and night rates of evaporation loss. The results so far have not been consistent enough to establish this relation.

During the year 1927 the apparatus was improved and the time of observation changed to about midnight, for the reason of more uniform temperatures affecting the Mariotte feed regulation.

The results of the past season show that for the water table at one inch the coarse and medium river sand lost about 10 per cent more water by evaporation than from the free water surface, the fine river sand being about equal to the free water surface, while the heavy adobe soil was 15 percent less, and the clay loam soil about 10 per cent less. For the 6-inch depth to the water table, the fine and medium river sands, as well as the loam soil, all agreed closely with the loss from the free water surface. The heavy adobe and coarse river sand were approximately 30 per cent less. With the water table at 12 inches, the fine river sand shows a loss equal to that from the free water,
loam soil about 20 per cent less, medium river sand 40 per cent less, and the
course sand and heavy adobe soil about 70 per cent less.

During 1926, tanks 1, 2, 3, and 4 contained a fine river sand with an
admixture of silt. These samples were very similar. The results are as shown
where the loss from the free water surface is taken as 100 per cent.

<table>
<thead>
<tr>
<th>Tanks</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss in %</td>
<td>102</td>
<td>96</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

For the purpose of studying the relation of the loss by evaporation
from large and small water surfaces, such as tanks three feet square, buried
flush with the ground surface, a standard U. S. Weather Bureau pan four feet in
diameter and 10 inches deep, set above the ground surface and fully exposed,
and a floating pan three feet square, there has been provided at the Colorado
Experiment Station a copper-lined basin six and one-half feet deep and 85 feet
in diameter with side slopes 1 to 1. This basin or reservoir has the top edge
flush with the ground surface. The floating pan is placed near the center of this
basin, while the U. S. standard pan and small buried pan are located about six
feet back from the rim of this circular reservoir. Air and water temperatures
are taken at the center, mid-radius and edge of circular reservoir. These
temperatures are also observed in the floating and land pans. Vapor pressures
are determined by an Assmann psychrometer. Wind velocities over the reservoir
and near the land pans are observed by three standard Robinson anemometers.
The drop in the water surfaces in all tanks is determined by hook gages reading
to 0.001 of an inch. One gage is used for each of the smaller tanks. For the
reservoir, four gages are mounted around the circumference of the basin at
the NE, SE, SW, and NW points. Special hook gage wells are provided for all
gages.

It is found that the relation existing between the evaporation loss
from the small pans and the reservoir is not constant but depends upon the
advance and recession of the temperatures of the season. During the season 1926, where the loss from the large reservoir is taken as 100 per cent, Mr. Rohwer has found that the floating pan lost 127 per cent, the 2-foot square buried tank 116 per cent, and the U. S. standard 131 per cent as a mean of about 6½ months, April to October.

From the standpoint of better use of water in irrigation practice, there has been perfected at the Colorado Experiment Station a measuring device known as the improved Venturi flume. Laboratory and field tests indicate that this flume is a practical device and is meeting conditions in the field where the ordinary weir or rating flume has been found to be unsuited. The improved Venturi flume has been calibrated for the smallest size, 6-inch throat, for discharges of 0.05 to 2.5 second-feet, and for the 10- and 12-foot size for discharges up to 200 second-feet. There has recently been completed in the Holbrook Canal, near Rocky Ford, Colorado, a 20-foot flume which is designed to carry more than 1000 second-feet. At this time only two flow tests have been made on this structure; however, the indications are quite encouraging as to the utility of this large flume.

The Lake Canal, near Fort Collins, is completely equipped with the improved Venturi flume. There are in use two large flumes, one with a 12-foot crest and the other having an 8-foot crest. To distribute the water to the users along the canal, there are approximately 60 small reinforced concrete structures, of these more than 75 per cent being of the 1-foot size and the remainder 2-foot and 3-foot sizes. The experience with this installation of flumes, which replaced the rectangular weir, indicates a marked improvement in the distribution.

Success is being attained in the Arkansas Valley in Colorado, where the large-sized flumes are used to measure the diversion by canals and ditches from the river. Because of the accumulations of sand and silt in the channel
and the filling in over the floor of an ordinary rating flume, past experience shows this type of measuring device to be wholly inadequate and at times grossly in error. Tests on a 10-foot improved Venturi flume in the Las Animas Consolidated Ditch, near Las Animas, Colorado, show the measured discharge by current meter gagings to agree remarkably well with that computed by the standard free-flow discharge formula. Tests in flows from 50 to 130 second-feet show a maximum deviation of about two per cent. For a discharge of about 12 second-feet, with a head of approximately 0.5 foot, the agreement was not so good. Three observations on these small discharges show a mean deviation of 5.4 per cent. The current meter gagings were made within the converging section of the structure where the depth of water was about six inches. Best current meter results cannot be obtained for the shallow depths.

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Mr. McLaughlin: The Committee on Organization is ready to report. The report was read and copies distributed for study. Action on the report was deferred until the evening meeting.

Adjourned.
Afternoon Session, December 29, 1927.

Meeting called to order by Chairman Parshall at 1:30 P.M.

Dr. Powers of Oregon briefly reviewed the work of the Oregon Station on duty of water. Dr. Powers stated that they found by rotating and manuring they could cut the water cost of crops in two. A brief statement of the work of the Oregon Station by Professor Powers follows:

THE SOIL SOLUTION AND IRRIGATION REQUIREMENTS OF PLANTS

W. L. Powers

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In the initial experiment station bulletins by the speaker fifteen years ago it was pointed out that several years of irrigation increased the soil organic matter content by from one-half to one percent. It was also pointed out that the returns per unit water with potatoes were far more when grown on irrigated alfalfa sod land than on dry-farmed alfalfa sod land. This led to the arrangement of an experiment to measure the value of rotation and manure in connection with supplemental irrigation. Ground that for three years gave an average yield of 12 bushels of beans an acre has been included in this trial the past 14 years, with the following results — beans grown continuously gave an average yield of nine bushels an acre; beans grown in rotation with clover and barnyard manure each rotation 20 bushels average. Yields with continuous gave an average yield of nine bushels an acre; beans grown in rotation with clover and barnyard manure each rotation 20 bushels average. Yields with continuous cropping have decreased to six bushels, while yields with rotation and manure have increased to 29.95 bushels for the past season. The water requirement has been cut in two, and profit an acre-inch doubled by these soil-building treatments.

The past 20 years we have endeavored to determine the water require-
hort and irrigation requirement of staple crops grown under good, modern methods of farming, including rotation and the use of barnyard manure. Based on the water requirement of the plats which each year have given the maximum net profit it appears that the crop-producing power of water for alfalfa for the conditions is five inches to the ton of hay and that four inches are required for each 100 bushels of potatoes; three bushels of wheat are produced with one inch of water consumed. It is believed that the figure for alfalfa would not change one-half inch if the experiments were continued indefinitely. Water variation trials of similar character have been conducted at Harney Branch Experiment Station for ten years, and at Umatilla Experiment Station for some 15 years. Although there is some waste on the sandy land at Umatilla Station, and large yields are secured on the fertile soil at Harney Station, yet Eastern Oregon figures obtained under arid conditions, and even those of other stations in the arid region, correlate fairly well with the figures given.

Sulphur has been very effective in increasing yields and the efficiency per inch of water under Northwest conditions. In developing a formula for a permanent irrigation agriculture crop rotation with legumes, the use of barnyard manure, and perhaps some mineral applications will be required. Maintaining a high state of fertility is the most important step in securing efficient use of water. Making conditions favorable for nitrification and biological activity is an important condition toward supplying a "rich" soil solution.

Before we can establish a permanent irrigation agriculture we must make irrigation farming profitable. If our young reclamation projects with partly improved farms could be refinanced with a supplemental federal reclamation fund negotiated on the rigid appraisal basis along the line of the "fact finder's" plan, it would extend agricultural relief needed, clear the slate of the financial difficulty confronting these projects; simplify the settlement problem; hasten
the time when further reclamation would become timely; and would bring about a condition where the farmers could give more serious attention to economic duty of water and permanent irrigation agriculture.

As this concluded the discussion on Duty of Water, the chairman opened the discussion on the subject of Drainage and called on Mr. McLaughlin to lead.

Mr. McLaughlin: Not a great deal being done in drainage research at this time. The U.S.D.A. Division of Agricultural Engineering has two projects active at the present time.

1. Work in Idaho on alkali in which they are studying the effect of chemicals and different cropping systems both with and without applications of manure.

2. Drainage by means of pumping. The studies in Idaho indicate that sweet clover sown on well rotted manure gives the best results. Much better results than application of chemicals. Slick spots are giving considerable trouble. These spots seem to be caused by or are associated with a perched water table. Blasting holes through the hard layer under the hardpan has not proved sufficient as the holes rapidly seal up. The water table can be held five to seven feet deep with open drains, but this is not deep enough. Lowering the water table by pumping has been tried in Idaho and apparently is very successful.

Major Stout of the Division of Agricultural Engineering, U.S. Department of Agriculture, was asked to discuss the proposed work in irrigation research by his division. After the discussion it was requested by Professor Smith that this outline be included in the minutes. This request was granted and the outline follows:
A PROPOSED INVESTIGATION OF IRRIGATION BY PUMPING, AND OF THE DRAINAGE OF IRRIGATED LANDS BY THE SAME MEANS

O. V. P. Stout

The United States Department of Agriculture, operating through the Division of Agricultural Engineering, Bureau of Public Roads, is engaged in a comprehensive survey of irrigation by pumping in this country. It is submitted that this survey should be followed by a detailed investigation of irrigation by pumping, and of the drainage of irrigated lands by the same means; the investigation to be undertaken on the basis of cooperative effort of the various agencies which are interested in the subject and which are equipped for the purpose or can aid in some way in its support. An examination of the field to be covered leads to the conclusion that it offers a manifest opportunity to serve agriculture on a large scale and in an effective way. When the subject facts have been collected and analyzed, and an adequate study of principles and their application has been made, the assembled result should constitute a reliable guide covering the features peculiar to the establishment and practice of irrigation and the drainage of irrigated lands by pumping.

A great many western farms, already under irrigation from gravity supplies, are limited in the varieties of crops grown and in the yields and consequent returns of those crops, because there is a shortage in the water supply after the spring runoff is over. A relatively small additional supply for use in summer and fall permits greater crop diversity, augments the yields and frequently improves the quality of the product, thus increasing returns at least expense.

The agriculture of non-irrigated farms throughout a large portion of the West is likewise limited by shortage of moisture to the growing of a few kinds of crops, which suffer recurrent failures. The provision of water for the irrigation of portions of such farms makes it possible to introduce additional
desirable crops. The farmer is at the same time enabled to produce a material part of the family food supply, an item which in years of extreme drought becomes of vital importance in the region in which the conditions noted prevail.

Providing a supplemental supply to irrigated farms, or a complete supply to portions of non-irrigated farms is a question of the economics of engineering and agriculture. A well-considered and comprehensive answer is necessary in order to determine what course it is profitable for the farmer to follow. The investigation must therefore include an effective consideration of the problems of organization and economic adjustment.

It is now generally conceded that drainage becomes sooner or later a necessity in nearly every irrigation enterprise. Drainage by deep well pumping is a recent development to meet this need. It is known that it is not applicable to all situations, and while a considerable amount of knowledge has been gained, based on the experience thus far, further observation and study are needed in order that engineers and irrigators may have the information to serve as a basis of confident procedure in variant cases. The subjects of pumping for irrigation and for drainage are so closely related and the mechanical equipment so similar that it is undoubtedly economical to study them together rather than separately.

A proper and adequate carrying out of the investigation will affect a vast number of existing and future pumping enterprises of the relatively small individual type, a good many partnership undertakings, and a smaller number of those which serve communities or districts. An essential feature of the program is that this general proportion be observed in allocating the work to be done.

Any adequate study and investigation of the field of pumping for irrigation is therefore an undertaking of some magnitude and must be planned to extend over a period of years. The physical and mechanical problems encountered must be solved by technical methods, both in the laboratory and on the ground, the practical application of the ultimate results being kept constantly and
prominently in mind.

The detailed study is proposed to cover the following five general lines:

I. Providing a water supply.
II. Waters requiring removal by pumping.
III. Pumping equipment and power for irrigation and drainage.
IV. Economics of irrigation by pumping.
V. Economics of drainage by pumping.

Under "I" will be made detailed studies of the technique of the location and development of various sources of water supplies for pumping. The consideration will include both ground and surface waters. The entire process of making ground water available to the pump must receive attention, with a view to increasing knowledge and improving practice wherever possible, to the end that the best results in any case may be assured. This will call for the engineering and economic investigation of the methods of sinking all kinds of wells, the kinds of lining or casing which are or may be used, the effectiveness and durability of screens made of various materials and in various patterns, the relations of these methods and devices to the physical conditions encountered, and their influence on the decision as to the necessity or propriety of additional wells, or the substitution of tunnels or galleries for wells, or their combination with wells, most advantageous methods of availing pumping projects of artesian waters, and so on. Well sinking and tunnel and gallery construction are normally attended by numerous minor troubles and occasional emergencies of larger order. Study of the history and of the possibilities along this line must be made, prevention being aimed at first, and where this may not be assuredly possible, at remedy or correction. Finally, examination will be made of the testing and developing of wells as now practiced and as practice may be improved in the direction of economy and dependability, together with investigation and research relating to the natural principles involved.
The availability of surface water for pumping presents a larger field for study than may at first appear. There is frequent occasion to consider the conditions and principles which determine whether a development for irrigation shall be by gravity or by pumping; and if by pumping, the extent to which and the manner in which economies may be effected and general adaptability to the scheme as a whole enhanced by the construction of dams, basins, channels and the like, to make the water more readily available to the pumps and to allow the pumps to be located to the best advantage relative to the land to be irrigated.

The phase of the investigation outlined under "II" relates similarly to the drainage waters whose removal by pumping may be considered. Many of the facts ascertained and principles established in the investigation of waters for irrigation will be directly applicable to pumping for drainage. In addition to these, there are other questions peculiar to the drainage phase of the investigation, some of which are outlined under "II."

Under "III," the third line of study, directed to the investigation of pumping equipment and power, there will be investigated the mechanical features involved in the raising of water for both irrigation and drainage, chiefly from the standpoint of adaptability and use of existing equipment rather than making a main point of the improvement of design. This will include in this way the consideration of the pump and appurtenances, the sources of power and the means of development and transmission, and their proper assemblage, use and care. The various types of pumping machinery and the various kinds of power will be considered in relation to their adaptability to the conditions of use, as determined from collection and analysis of the data concerning engineering, agricultural and economic conditions. Serious and consistent endeavor will be made to reach in this work results of the most definite and specific character which the nature of the problems will permit. The features and characteristics of equipment called for by specific sets of conditions will be determined and reported,
and the types of equipment which embody suitable and best features and characteristics will be pointed out. The common troubles of pumps and associated machinery and equipment will be determined, and the best known or discoverable means of preventing or overcoming them described. Attention will be given similarly to special troubles also, such as those encountered when the pumped water induces acid reactions, or contains much sand. A practical study will be made to lead to the preparation of a reliable guide to the selection of the most appropriate kind of power for pumping for irrigation or for drainage, when more than one kind is available. This study will involve the collection and analysis of data concerning the magnitude and time distribution of the demand for power for pumping, together with rate schedules, fuel costs, cost of attendance, possible supplementary uses of power, and other related items. The form of presentation of the results of this study will include, in addition to an exposition of the general governing principles, an extended and detailed consideration of a large number of typical sets of conditions, with definite conclusions and the reasons therefor.

The line of study designated as "IV - Economics of Pumping for Irrigation" will have assigned to it the pertinent economic phases which have been treated incompletely or not at all under "I" and "III." The field for this study is extensive and embraces the fundamental points involved in the process of deciding the primary question "to pump or not to pump." It is imperative to the rounding out of this project that the application of the principles of the economics of production to the question of whether to pump or not to pump be invoked. Therefore, the data collected under "I" and "III" of this project, together with those representing the sum or essence of available, dependable and pertinent information concerning methods, costs, criteria and results of irrigation considered as an agricultural operation, must be assembled, arranged and analyzed in their interrelations. The reasoning and conclusions
in all of this must be made clear, and as elsewhere throughout the project the obligation to be definite must be recognized. The general conclusions must be supplemented and illustrated by the detailed consideration of typical instances, covering, as nearly completely as practicable, the range of conditions and combinations of conditions found within the territory of the project.

It is proposed to make similar studies as outlined under "V" in the vicinity of pumping plants installed for drainage purposes or for a combination of irrigation and drainage purposes.

Finally, while it is not within the province of this investigation to undertake the development of economic principles, it will undertake to apply to the specific field considered the principles which have been developed by economists and made available for perfecting engineering and agricultural practice.

The diagram herewith is submitted as covering in outline the field of the proposed investigation. It is believed that the primary headings are sufficiently comprehensive, and that, on the other hand, the proper limitations of their application in the present connection are indicated in the foregoing paragraphs and in the extension of the outline. The secondary, tertiary, and quaternary headings become in their order increasingly subject to addition, extension, and other form of revision.

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Mr. Parshall briefly reviewed the drainage work in Colorado. In the area around Grand Junction the results of under drains were negative but in the San Luis Valley a drain placed along the east side of a 40,000-acre tract was effective for four or five miles from the drain.

Professor Weir: California has much land drained by pumps. There are 600 to 700 drainage pumping plants in Sacramento Valley. In general, the land under
Outline for Proposed Investigation of Irrigation by Pumping, and of Drainage of Irrigated Lands by the same Means.

I. Providing a Water Supply.

A. Ground Water
   1. Wells
      (a) Types and equipment.
      (b) Methods of sinking.
      (c) Water yield; developing and testing.
   2. Prospecting and location
   3. Replenishment.

B. Surface Water
   1. Streams, canals, springs.
   2. Lakes, sloughs, ponds.

C. Developed Water
   1. Tunnels, galleries.
   2. Underflow dams.
   3. Drains.

(A. Origin, Movement, Character and Position.
   1. Ground Water. (a) Conditions favoring drainage by pumping.
   2. Surface Water.

B. Final Disposal.
   1. Conveyance and application to land.
   2. Other uses.
   3. As waste waters.

C. Estimation of Amount.
   1. Least amount required to be removed.
      (a) Land conditions which govern.
      (b) Crop conditions which govern.
   2. Greatest amount which may be removed.
      (a) Land conditions which govern.
      (b) Crop conditions which govern.
III. Pumping Equipment and Power for Irrigation and Drainage.

(A. Selection as affected by:  (1. Conditions encountered ((a)
 (2. Types of pump ((a) and kinds of ((b) power available. ((c)
 (3. Initial and probable annual cost.

B. Installation and Testing.

C. Operation and Maintenance.

IV. Economics of Irrigation by Pumping

A. The Agricultural Program as affected by:  (1. Relationship ((a) In point of seasonal distribution.
 (b) In point of total supply. ((b)

B. The Individual vs. the Community Plant.

C. Pumped Water in Distribution.

D. Pumped Water for Small Areas on Dry Farms and the Range.

E. Cost and Returns in Farming.
V. Economics of Drainage by Pumping.

(A) The Agricultural Program as affected by:

1. Cost and results of pumping.
   (a) Compared with no drainage.
   (b) Compared with drainage by other means.
   (c) Complete and partial drainage compared.

2. Availability of drainage water for irrigation.

(B) The Individual vs. the Community Plant.

(C) Cost and Returns in Farming.
these pumps has been successfully drained. The discharges of wells vary from 700 to 1500 g.p.m. and the drainage water is usually used for irrigation. On the Turlock district it is said that the water from their drainage wells is much cheaper than their gravity water.

Water containing alkali may be used for irrigation without serious effect provided sufficient water is used to always wet the soil below the root zone of plants. It appears that where sufficient water is used to cause free drainage, the amount of alkali remaining in the soil does not materially increase with continued irrigation; at least it does not increase in proportion to the amount of alkali in the irrigation water. If this is the case, and I believe it to be true within reasonable limits, it may not be objectionable to use somewhat alkaline water for an indefinite period. This, of course, assumes that such secondary complications as a rise in the water table will not occur. With the use of excessive amounts of water, this, of course, is always a possibility.

In some southern California walnut groves quite serious injury has been caused by the use of slightly alkaline water where only sufficient has been used to wet the soil to a depth of about 4 feet. We have suggested as a possible remedy the wetting of these soils to a depth of 15 or more feet at intervals. In some cases it is not possible to do this because of the scarcity of water, in which case it will be necessary to seek a purer supply of water.

On the other hand, quite alkaline waters are being used in the Salt River Valley of Arizona without serious effect. Here each irrigation wets the soil to the water table. Water which is so salty that it is quite disagreeable to the taste has been used to leach alkali from the land in parts of the Salt River Valley.

Conditions in the Imperial Valley are different and pumping there would probably not be very successful.
There are about 70,000 to 80,000 acres being drained in the Imperial Valley by means of open drains 14 - 16 feet deep. These drains have not been very successful, the total drainage runoff being rather low.

Professor Adams: Referring to the outline submitted by Messrs. McLaughlin and Stout, the project is too broad. It could be handled better if it were broken up into several projects. Some of it seems to be based on the premise that we are just starting out, whereas, much of the outlined work has already been done.

Dr. Fortier: Mr. McLaughlin and associates have given this project much thought and upon careful reading it will appear in a better light.

Mr. McLaughlin: Major portion of inquiries are about pumping for irrigation. The outline is a statement of a continuous project to be taken up by units.

Professor Smith: I would call that a super-project. It is all right but the title. I wish to suggest the following title, "An Analysis of the Field of Investigation of Pumping for Irrigation and Drainage." Seconded by Mr. Smith. Passed.

Dr. Fortier suggested that the stations represented here and others make similar outlines and give the U.S.D.A. the benefit of their deliberations.

Professor Smith: I take it that the inclusion of this outline in the minutes signifies that this body approves it, or essentially so.

Dr. Fortier: Could we not assign to various experiment stations in the West the various tasks of preparing comprehensive outlines covering the five general fields of irrigation and drainage research?

It was called to Dr. Fortier's attention that that was the plan of the conference two years ago and if a permanent organization were effected it would probably be put into effect.

Professor Adams: Moved that the outline drawn up by this conference two years ago be altered to fit the outline on irrigation and drainage pumping submitted by Mr. McLaughlin and associates. Seconded.
After some discussion this motion was withdrawn before coming to a vote.

Professor Weir reviewed briefly alkali studies and also his work on the subsidence of peat lands. A brief statement by Professor Weir covering this work follows:

**ABSTRACT OF DRAINAGE INVESTIGATIONS IN CALIFORNIA**

W. W. Weir

Drainage investigations in California in which the Experiment Station has been particularly interested have been:

1. **The development of pumping.** This type of drainage has won wide favor in many portions of the state, particularly in the San Joaquin Valley. Some work has been done on the effect of pumps on the ground water table and on the relative efficiency of this type of drainage compared with open ditch or tile. All these studies show a decided advantage in pumping. Water is almost always used for irrigation. Recent work tends to broaden the field of possible adaptation.

2. **Alkali Reclamation.** Alkali reclamation has been very successful under controlled conditions, as at Kearney Park, but we have not met with similar success under practical field conditions. A greater measure of success has been obtained in Imperial Valley where rice has been introduced as a possible cash crop. Rice also gives some indication of actually aiding reclamation. This is still a debatable question and has not been tried under strictly controlled conditions.

Recent work on the shape of the water table on tile-drained land indicates very strongly that the water table takes a very flat curve regardless of the distance between drains or the type of soil. Studies on the movement of alkali under controlled conditions in the laboratory indicate some results
inconsistent with previously conceived ideas. These studies are, however, not complete enough nor have the results been studied fully enough to justify a conclusion.

Professor Smith: Pumping from wells for drainage was probably first practiced in Arizona. Where this practice is followed the country is underlain by a thick layer of extremely porous gravel. Wells having a capacity of 6000 g.p.m. with a draw down of 10 - 12 feet are common. Screens are not used in the wells. A stove pipe casing is put down and perforated. The driller must test the well before leaving. The pumped water is used over again for irrigation. Some of it is highly alkaline and its continued use will no doubt cause injury. A new power contract has been developed wherein the district rather than the individual is charged for the peak load. This plan permits large pumping plants operating for short periods to eliminate the expensive peak demand charge. Of course, all of the plants in the district cannot operate at once.

A brief statement of drainage by pumping in Arizona by Professor Smith follows:

DRAINAGE OF IRRIGATED LAND IN SALT RIVER VALLEY

G. E. P. Smith

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Ordinary methods of drainage, by open trenches, failed to afford relief, on account of tightness of soil - adobe and caliche - the influence of drainage ditches was confined to a very narrow ribbon of land. Alternatives were lining of irrigation canals and pumping from wells for drainage. Although the latter method was novel, yet the Water User's Association had an abundance of cheap power, and that method was adopted. Over a part of the valley where wells encounter thick beds of porous gravel, wells at one-mile intervals give adequate control of groundwater; elsewhere the intervals are less. The upper
strata, although relatively impervious, permit slow movement downward, and the underlying unconsolidated gravel acts as a collector and transmits the water to the wells. Because of the low rainfall and shortage of water the past few years, practically all of the pumped water has been discharged into irrigation canals, diluted, and used for irrigation, though some of it is quite heavily charged with salts. It has been found, however, that the well water, heavily charged with calcium salts is more effective in leaching salt from the land than is the river water. Many of the wells are of extraordinary capacity - over 5000 gallons a minute. The lifts are low. The criteria for this type of drainage are underlying porous strata, and cheap power, though drainage can be effected in less porous material by closer spacing of wells.

The Yuma Valley irrigation project is drained by a system of drainage canals, and in the Upper Gila Valley are several small drainage projects, in which clay tile pipe lines are used. In the latter, the largest item of cost was the long freight haul from Los Angeles.

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Professor Murdock briefly reviewed the drainage work in Montana, a statement of which follows:

OUTLINE OF DRAINAGE INVESTIGATIONS IN MONTANA

H. E. Murdock

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Manuscripts have been prepared on seepage and drainage problems of the Gallatin Valley and on the general drainage problems of the state. Data were secured on the water table fluctuations throughout the year. In the Gallatin Valley it was found to fluctuate from only a few inches up to 15 or 20 feet. In places where the water table was at or very near the surface the fluctuation was smallest.
The high point of the water table at the upper end of the valley was reached during the early part of June, while at the lower end of the valley the highest point was not reached until October or November. There are several spring creeks that drain out of the swamps at the lower end of the valley, and the discharge of these was 50 percent greater at the time of the high water table than at low water table. The slope of the land in the swamps is over 1 foot per hundred. The subsoil is open gravel overlaid with but a foot to three feet of top soil. The conditions are such that even with this heavy grade the water cannot get away fast enough through the subsoil to prevent water logging of the land.

A few experimental drains have been installed at various points throughout the valley and the county digs large drain ditches along the roads. The railroad company has also dug a large drainage channel along the right of way diagonally across the swamp. These drains show what can be accomplished.

We have also done a little work on pumping for drainage and believe conditions are favorable for such a method of reclaiming lands in many localities throughout the state.

Mr. W. L. Powers submitted a brief review of drainage work in Oregon which follows:

IRRIGATION AND DRAINAGE INVESTIGATIONS IN OREGON

By

W. L. Powers, Oregon Exp. Station

Three drainage experiment fields have been maintained in this state. At the home station the drainage and improvement of so-called "white land," or Dayton silty clay loam, has been under way since 1914. The most efficient and economic methods of tiling and improving this soil are reported in Experiment Station circular #83, issued June, 1927. The main experiment field is being
taken over for campus purposes, which will close this phase of the study.

Drainage and improvement of tideland are under study at the branch experiment station near Astoria, where the outflow and water table conditions are under study, as affected by tile lines placed at different distances, and different depths in the land. A preliminary report was made in Oregon Station bulletin #157.

Alkali land reclamation investigations are centered at Vale, on leased land. The effect of sulphur and sulphate in various combinations, and the various alkali resistant pasture mixtures, are under study on land that was provided with deep drainage, and has been copiously irrigated since 1921. A preliminary report of the first four years' work is given in Station bulletin #210. Analyses of carefully selected composite samples from each plat, are made periodically, soil horizons making it desirable to sample to a depth of 5 inches; 5 to 20 inches, and 20 to 40 inches, which is the practice there. Getting uncleared greasewood land into pasture mixtures, by seeding resistant grasses and clovers, and providing copious irrigation has been the most promising of economic returns in those trials. A total application of 1500 pounds of sulphur over 5 year periods, together with light annual manuring, has practically reclaimed plat C, which produced 2 tons of rye hay this last year, has produced a heavy growth of sweet clover, and now has a nearly perfect stand of alfalfa.

This soil is a heavy clay loam, with a high percentage of colloids, including soluble silica and other colloidal material. The land originally had a pH value of 10.4 and 2/3 of one per cent salt, including about .3% replaceable sodium and one .1% replaceable calcium. The total sodium salts amount to about 2,000 pounds in the plowed surface of an acre. From 1/3 to 2/3 of the initial alkali content has been eliminated by the most promising treatments for the surface 20 inches of soil.
In connection with field work, studies have been made of the colloids separated from Dayton silty clay loam, and from the Malheur clay loam, the effect of various electrolytes on permeability has also been studied, using 4 gallon jars, and measuring the hourly rate of percolation, and the effect of repeated wetting and drying upon it. Part of these studies are reported in Soil Science, June, 1927.

Composition of percolates from drainage bins or lysimeters, and the amount of percolation with different treatments, has been studied for four years, and reported by Higby in Soil Science, July, 1927.

Irrigation studies at the home station include the water cost of crops from plats in water variation trials. The data for plats giving the maximum net profit an acre, has been averaged. As a first 20 year average, the crop producing power of water for alfalfa hay appears to be about 5 inches per ton, for potatoes 25 bushels per inch, for wheat 3 bushels an inch; and for beets $\frac{1}{2}$ inch per ton. By using rotation and manure in connection with supplemental irrigation, the water cost has been cut in two, the profit an acre inch has been doubled, and the yield has been more than doubled as a 14 year average. The duty of water based on water requirement above indicated, is for good modern methods of farming. Similar experiments are underway and of 15 years duration at the Umatilla Branch Station, and 10 years duration at the Harney Branch Station.

In cooperation with the Federal Office of Agricultural Engineering, economic method of applying water has been studied in Rogue River Valley during two years. Field water capacity has been studied by use of 6 inch cylinders, 1 foot long, and checked by means of applying water to diked areas of virgin soil. Penetration of water has been studied by means of systematic soil moisture determinations.
One-fourth mile has been found to be a suitable length of run in orchards on Medford clay adobe soil with flat topography, a half inch stream has been sufficient in irrigating some of these heavy soils per furrow. Barnyard and green manure crops, namely White sweet clover, and Hungarian vetch, have increased the permeability or storage of moisture nearly 50%, and increased the size and yield of fruit.

On coarse, granitic soils, near Grants Pass, belonging to Siskiyou series, an irrigating head of 2½ to 3 second feet is desirable. With strips 2 rods wide and 220 feet long it is possible to irrigate according to the water capacity of the soil, which has a depth of about 4 feet, and a usable water capacity of about 1½ inch per foot. The value of soil building treatment needs further study, especially in connection with the quality of pears produced.

In cooperation with the Federal Office of Agricultural Engineering, preliminary irrigation and drainage studies were made in Grande Ronde Valley the past season, including the distribution and concentration of alkali, the water table and seepage conditions, and their relation to cropping or vegetation, as well as the effect and probable value of proposed supplemental irrigation.

Much of the station time of our staff members has been given to feasibility, soil and economic surveys of irrigation projects started during the optimistic or high price period, incident to the war. Base maps of the scale of 1 inch to 400 feet, or a little over 1 square foot to the square mile, have been used, in classifying and eliminating land. The Morgan reaction outfit for determining the concentration of alkali has been used, substituting a spot plate, and in some cases other indicators. Little attention has been given to total salts, more attention being given to the concentration of black alkali.
As a result of recommendations in connection with these feasibility reports a considerable amount of progress has been made in improvements of our water laws. Most of the recommendations in the Ochoco feasibility report were enacted by the 1927 Oregon Legislature. Two important principles were recognized: The one, recovery of irrigation charges on the basis of benefits, or ability to pay; the other, the change from general liability to individual liability, to encourage payment.

Meeting adjourned until 7:45 P.M.

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Evening Session. December 29, 1927.

Special Order of Business -- Organization

Meeting called to order by Chairman Parshall at 8:00 P.M.


States and Federal agencies represented: Arizona, California, Colorado, Montana, Utah, U.S.D.A. Division of Agricultural Engineering.

Mr. J. B. Brown: What effort is being made to coordinate the work and workers in irrigation research in the western states?

The session was turned into a discussion on organization. Professor Smith moved that a committee be appointed to report on the Coordination of Work in Duty-of-Water Investigations. Seconded by Mr. McLaughlin. Passed.

Committee: Beckett, Chairman, Veikmeyer, Adams, and Smith.

Reading of Report of Committee on organization called for. After Secretary read the report which follows, it was moved by W. W. McLaughlin that the Report of the Committee be adopted. Seconded by Frank Adams.

A standing vote was called for by the chair. One vote allowed each
state or Federal agency represented. Result of voting:

Arizona  Aye
California Aye
Colorado  Aye
Montana  Aye
Utah    Aye
U.S.D.A. Aye

The motion passed and the report of the Committee accepted.

REPORT OF COMMITTEE ON PERMANENT ORGANIZATION AT SECOND
CONFERENCE OF IRRIGATION AND DRAINAGE RESEARCH AND
INVESTIGATIONAL WORKERS

Your Committee is of the opinion that conferences such as the one
held in September, 1925, and the present conference of December, 1927, are of
great value to those attending them, and therefore to the institutions repre-


dented by the delegates. These conferences afford opportunity for contact of
individual workers in the same line of investigation, and an exchange of in-
formation and opinions and of technique used in research work that will
ultimately bring about a measure of coordination that will be for the betterment
and ultimate value of work undertaken. These meetings also afford an oppor-
tunity for focusing upon difficult problems the attention of investigators from
various parts of the West, and in many instances suggestions are made which
permit a more ready solution of problems under study.

It is believed that these meetings will be of value to the Association
of Land Grant Colleges by putting before it in definite form the irrigation and
drainage problems upon which the different institutions are working and the
methods adopted in this work; they should also be a ready means of ascertaining
the important problems upon which work has not been or is not now being done.
Your Committee therefore recommends:

(1) That a conference of workers in irrigation and drainage investigations and research be held biennially.

(2) That membership in this conference include those engaged in irrigation and drainage investigations and research in land grant colleges or other educational institutions of the eleven western states, and in the Division of Agricultural Engineering of the U. S. Department of Agriculture.

(3) That a member of the State Relations Service of the U. S. Department of Agriculture be accorded honorary membership and extended an invitation to participate in our conferences.

(4) That the Committee on Irrigation and Drainage Research of the Association of Land Grant Colleges be continued in order that the conference may have a central body to which it can report and from which it may receive suggestion and direction.

(5) That a president and secretary be elected at the close of each meeting of the conference, these officers to be responsible for the program and for the conduct of the next conference.

Respectfully submitted,

W. W. McLaughlin
G. E. P. Smith

The question of election of officers and committees was raised but deferred until Friday session.

Meeting adjourned to listen to an illustrated lecture on the Venturi flume by R. L. Parshall and an illustrated lecture on Palestine by Frank Adams.
Morning Session. December 30, 1927.

**General Business**

Meeting called to order at 10:00 A.M.


Chairman: "Nominations are in order for Chairman for the next two years."

Professor Adams nominated Professor Smith, Arizona, seconded by Professor Murdock. Professor Smith protests. Professor Adams refused to withdraw his nomination. Professor Smith nominates McLaughlin, seconded by J. B. Brown. Moved by Professor Smith and seconded by Mr. Murdock that nominations close.

Discussion: Question raised as to desirability of having a Chairman from Experiment Station or from U.S.D.A. Division of Agricultural Engineering. Professors Murdock and Clyde object to man outside of Experiment Stations. Professor Adams moves to lay election of Chairman on the table temporarily to permit us to hear from Director Cocheran. Director Cocheran discussed the relationship of Experiment Station research to Extension Service. At conclusion of this discussion the election of a chairman was again brought up. McLaughlin suggested that someone from the Experiment Stations be elected chairman. After a lengthy discussion without progress a vote was called for by chairman -- secret ballot. Four states and U. S. D. A. voting. Mr. Murdock, Montana, had to leave before vote was called.

Results of voting were four for McLaughlin and one for Smith. Professor Adams changed his vote and made the election of McLaughlin unanimous.

Chairman: "Nominations are in order for secretary."

Professor Smith nominated Professor Israelsen, Utah. Seconded by Clyde. It was moved by Professor Adams that the Secretary cast the ballot for Professor Israelsen. Seconded and passed. Question of place of next meeting
Professor Beckett: Committee on Coordination is prepared to report.

Chairman: We will hear this report.

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REPORT OF COMMITTEE ON THE COORDINATION OF WORK IN DUTY OF WATER INVESTIGATIONS

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The Committee appointed to report on the Coordination of work in Duty of Water Investigations at the several experiment stations reports as follows:

The Committee recommends the placing in effect of paragraphs 5 and 9 as contained in the outline as adopted at the meeting of September, 1925.

Paragraph 5 states that the chairman appoint a chairman to lead in the coordination and cooperation of each major division of the 1925 report.

Paragraph 9 states "Recognizing the importance of proper methods and standards in conducting and interpreting research in irrigation and drainage, we recommend the appointment of a standing committee on 'experimental methods and standards' to be composed of three representatives from the western experiment stations and one representative from each cooperating Federal agency."

Respectfully submitted,

G. E. P. Smith
Frank Adams
S. H. Beckett

Professor Adams moved adoption of Report. Seconded and carried.

Professor Smith moved that we, the outside members of this conference, do hereby express our deep appreciation for the splendid dinner given us by the California members of this delegation. Seconded by Clyde. Passed.
Professor Adams moved the California members of this conference 
express appreciation for the privilege of holding this conference on our 
campus and that the California delegation extend a standing invitation to come 
again. Seconded and passed.

Meeting adjourned until 1:30 P. M.

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Afternoon Session. December 30, 1927

Discussion of Extension Work in Irrigation

Meeting called to order at 2:00 P. M.

Present: Lloyd Brown, Parshall, J. B. Brown, Weir, Smith, Fortier, Davis, 
Huberty, Clyde, Adams, Hodgeson, Stout, McLaughlin.

Professor R. W. Hodgeson, California, was asked to discuss briefly 
the principles of root growth of citrus trees when the moisture content gets 
Hodgeson down to the wilting point. Professor discussed a paper written by him on some 
fundamental principles in irrigation dealing with the Irrigation of Citrus and 
Avocado Trees.

J. B. Brown, California, Extension specialist in Irrigation presented 
a paper on Extension work in Irrigation.

EXTENSION WORK IN IRRIGATION

J. B. Brown, 
Extension Specialist in Irrigation

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The primary object of extension work in agriculture is to demonstrate 
 improved practices and to induce farmers to adopt those practices. In irri-
ation work there are certain fundamentals that we, as investigators and teachers, 
recognize as desirable practices to extend. The great question is how to 
present the knowledge that is in existence in such a manner that the results
obtained are worthy of the effort and money expended. Can we adhere to the first ideas of agricultural extension that knowledge of improved practices was to be extended through personal visits, or must we attempt to work through organizations or by other means of instruction by which larger groups may be reached? Finally, our problem in extension comes down to inducing the farmer to put into actual practice the things that have been taught to him. Stated in another way, "The end and aim of all extension work is to get the farmer to do the things you think he ought to do because he thinks he ought to do it."

Coming to the work of irrigation specialist with no background in teaching and with experience largely in the engineering phases of irrigation work, it was but natural that at first there was considerable groping for a starting point. There was and is considerable published matter which gives good information on irrigation practices and methods, but in a state with such a diversity of methods and practices as exist in California no simple method could be adopted for a concentrated program. In order to develop a general program for irrigation work throughout the state, it was necessary to base instruction on the soil moisture demonstration, i.e., the behavior of irrigation water in various types of soil, the amounts of water required to wet those soils and the study of moisture conditions by means of a soil auger. Such a program can be adapted to any locality and the necessary variations of local practices to secure better soil moisture conditions may be pointed out at local meetings.

The goals of the present irrigation practice project are

1. To demonstrate the economic value of proper soil moisture conditions for various crops on various soils by irrigation practices involving time, amount and method of application.

2. To demonstrate the methods and uses of soil examinations with regard to modification of irrigation practices, with consequent improvement of crop conditions and yields.
3. To secure the cooperation of agencies supplying water to farmers in adjusting delivery schedules to the end that water may be conserved and that lands may be properly irrigated.

Work under this project has been carried on for about five years. The majority of demonstration meetings in the counties have been conducted by the specialist. Necessarily the specialist can not conduct many meetings. The average number in any one year is about 75 with a total attendance of around 2500 persons. During the past year a total of 198 demonstration, farm bureau center, and other meetings were held at which irrigation was discussed. The total attendance was more than 5,000. The specialist held 54 of these meetings, attendance about 1200. The above statements show that county agricultural agents are conducting more meetings on their own responsibility and thereby adding considerably to the volume of the work.

But something more is required than just getting these people to attend meetings. How are we to get them to adopt and use these better practices? In a new community or where irrigation is just starting it is comparatively easy for the county agent to aid materially in spreading the right sort of information because men new to irrigation practices are constantly coming to his office for information. In a community where irrigation has been practiced for a long time, it is very difficult to induce farmers to change a practice especially if it involves any additional labor or expense even if it can be shown that this expense or labor will be justified by increased returns.

There is, of course, a large field involving technical information that must be handled by technically trained men. This consulting work on pipe lines, pumps, measuring devices, and structures will always have to be handled by personal visit.

Can research work by the agencies represented here be so coordinated
that such work will fit into the extension program? The matter of uniform methods of duty of water determinations is one phase that seems to offer promise. Another suggestion is in the matter of publications. This has more to do with methods of instruction but nevertheless it is closely connected with research work. For many years we have had University and Farmers' Bulletins but these publications are not fulfilling the purpose that it was thought they would when first issued. They are read by few compared to the large number it was hoped would be reached. The professional engineer and agriculturist secures and reads these publications and they are exceedingly valuable to him, but it is questionable whether the average farmer makes any extensive use of these bulletins. The farmer desires short, specific, and elementary information on a single subject. As an instance, a three-page mimeographed circular on irrigation practice was handed out at a series of meetings in Merced County last year. About 60 copies were given out at two meetings, but farmers kept coming into the county agent's office for additional copies to such an extent that three editions of this circular, totaling more than 300 copies, had to be issued. Three other counties copied this circular and one county issued 400 copies of a circular of its own embodying the same information. Altogether, more than 1000 copies were distributed.

The suggestion is made that there is a field for such publications as these. In the Agricultural Extension Service there is now in existence a series known as Extension Service Leaflets. They cover a variety of subjects. Some such series of publications would be useful in extending the information developed by your research agencies. The subject matter should be authoritative and representative of good practice and would serve as a set of notes for material delivered at a lecture or field meeting.

The following is a list of subjects which might be covered by circulars. Some of these have been completed by members of the Irrigation
Division and by myself.

1. Units of Water Measurement - Completed J.B.B.
2. Irrigation by Means of Level Checks.
3. The Border Method of Irrigation - Completed J.B.B.
4. The Furrow Method of Irrigation.
5. Irrigation by Overhead Sprinkling - U.C.Bul. 4 - Ext. Ser.
6. The Effectiveness of Irrigation by Overhead Sprinkling -
   Published in California Citrograph, Feb. 1927. Nos. 5 and 6
   above are by Prof. H. A. Wadsworth.
7. Contouring and Terracing. A bulletin is now in process of publica-
   tion on the subject of Irrigation by Contour Furrows. A number
   of short articles have been written on contouring and terracing
   which could readily be combined into a single circular.
7a. The contour check method of orchard irrigation - Completed J.B.B.
8. How soils are wetted and behavior of water in soil.
9. What becomes of irrigation water?
10. Pumping for irrigation. Circular should cover certain economic
    data as lift, proper relation to area to be irrigated and
    explanation of power bills.

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Chairman: Mr. Brown, how do you get the data from the research workers over
   to the farmers?

Professor Brown answered by outlining six essentials of a good
extension project:

1. Show practices have real value.
2. Simple subject.
3. General interest.
4. Active participation by County Agent or Home Demonstration Agent.

5. Definite measure of results.

6. Permit use of project leaders in carrying to consumer.

Mr. Brown thinks leaflets, mimeographed sheets, and summaries are better than bulletins for getting information to farmers.

Professor Beckett: "Extension Service workers should take experimental data that are furnished and boil it down into the type of publication that the service needs."

Dr. Fortier: Farmers' Bulletins partly fill gap between strict research and farmer but not enough.

Professor Smith: There are two cases:

1. Where state has full-time extension specialist.

2. Where state has no regular specialist.

Summaries of bulletins are usually readable and should be drawn upon by Extension people who want only the kernel.

The general opinion of the conference seems to be that there must be a re-writing of bulletins by the Extension Specialist before it can be of great value to the farmer.

Conference adjourned, 5:00 P.M.

George D. Clyde, Secretary.
Conference Report - Mailed April 4, 1928 to

A. W. Smederna
B. H. Crocheron
R. W. Trullinger
S. H. W. Crow
F. Garcia - Hri. New Mel
J. B. Sinfelt - Hri. Mont
J. A. Hill - Alir. Wyo
Wm Peterson - Alir. Utah
J. J. Jardine - Alir. Oregon
E. J. Sadding - Alir. Idahio
E. D. Merrill - Alir. Calif
J. H. Thormer - Alir. Ariz
E. P. Gillette - Alir. Wyo
Dr. O. A. Long
Rodd McCann
A. J. Mitchelson
Edward Hyatt Jr.
L. G. Carpenter
W. W. Weir
A. W. Hodgson
W. A. Hutchins
Mr. Fortier
P. A. Ewing
Macy Lapham
S. H. Beckett
Lloyd Brown
Frank Adams
W. L. Powers
C. W. Isrealson
Frank Davis
C. J. Dunshee
Martin Hubert
W. W. McLaughlin
E. H. Bryan
Fred C Scobey
F. J. Wiehmayer
J. B. Brown
Major Stout
H. E. Murdock
G. E. P. Smith
April 18th
Senator Sam H. Brown
Pres. H. L. Kent, New Mexico Aggies
G. H. Russell, Fed Land Bank, Berkeley