SB 191

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BULLETIN OF THE UNIVERSITY OF TEXAS, NO. 16.
ISSUED SEMI-MONTHLY.

RICE IRRIGATION IN TEXAS.

ENTERED IN THE
POSTOFFICE AT AUSTIN AS MAIL MATTER
OF THE SECOND-CLASS.

AUSTIN, TEXAS:
VON BOECKMANN, SCHUTZE & CO., STATE PRINTERS,
1902.

MATAGORDA PUMPING PLANT.

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Thomas G. Gayles
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MADE IN U.S.A.

LETTER OF TRANSMITTAL.

Wm. L. Prather, President of The University of Texas.

SIR: I herewith transmit to you a report on the subject of Rice Irrigation in Texas. The report was prepared under the auspices and direction of the Hydrographic Division of the U. S. Geological Survey, and it is a part of a report on Irrigation Systems in Texas, which is now going through the government press at Washington and will be issued as Water Supply Paper No. 71 by the U. S. Geological Survey. This report was prepared by me while acting as resident hydrographer for Texas, and its publication here is with the consent of the Survey. It is just to remark that all the expense of the investigation was borne by the United States government.

Respectfully yours,

THOMAS U. TAYLOR,

Professor of Civil Engineering.

Austin, Texas, October 15, 1902.

ACKNOWLEDGMENTS.

In the preparation of this paper I have received valuable assistance from Dr. S. W. Sholars, of Orange, Texas; J. E. Broussard, Beaumont, Texas; Willard S. Lovell, Labelle, Texas (on Taylor's Bayou); Stonewall Tompkins & Co., Mechanical Engineers, Houston, Texas; W. T. Meriwether, Civil Engineer, Eagle Lake, Texas; J. L. Ladd, Editor of the *Matagorda Tribune*; Charles Peterson, Garwood, Texas; and to many other friends in the rice belt of Texas.

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RICE IRRIGATION IN TEXAS.

The rice belt of Texas (Fig. 1) extends from the Sabine to the Rio Grande, and includes at present two well-developed zones (Beaumont and Colorado valley) and several detached areas that are sure, with good management, to be the forerunners of extended systems in the respective localities. In the Beaumont section, the land is a flat prairie which heretofore cut very little figure as an industrial factor. It is very flat, some of which having a slope of only 1 in 5000, and generally requires small

FIG. 1.—Texas Rice Belt.

levees and small lifts at the pumps. This flat section extends all along the coast region from the Sabine to the Rio Grande. The 250-foot contour above sea level is from 50 to 125 miles from the gulf, while the strip twenty to thirty miles wide along the shore rises only a few feet above the sea level. But in addition to this coastal belt the rice section has, since 1897, been rapidly spreading along and back from the coast, until it has reached the Rio Grande to the west, and to Cuero, Columbus, and to Washington county on the north. In the flat sections the water is often obtained from bayous frequently impregnated with salt sea water

to such an extent that injury to the rice occurs. Rice must have an abundant supply of fresh water, and a soil that is rich enough to nourish the rice, and compact enough to hold the water. It is being successfully grown in Texas wherever the above factors are grouped; and money and brains are grouping them with a twentieth century effectiveness. No longer is the rice belt restricted to the old bayou country, but along the Brazos, Colorado, Guadalupe and Rio Grande, over 100 miles from the coast, a high grade of rice is grown. In addition to this the irrigation of rice from wells will certainly prove of greater benefit to the Texas farmers than all of the big plants combined. This latter method is in its infancy, but it is certain to be the chief factor in rice production in Texas. The plant of Hudson & Ayers, two miles east of Eagle Lake, is but the pioneer of many others in Texas, where the farmer can, with a small outlay, convert his flat lands into a successful rice farm. A well 12 feet in diameter, 34 feet deep (7 feet of water), an engine to supply power, a centrifugal pump, an open box for a flume, a canal easily constructed,—total first cost \$2,200—constituted the equipment. With this 125 acres of excellent rice were raised in 1900.

The rice land is laid off in sections, or "cuts," so that the extreme difference of elevation should not exceed 4 inches. The size of these cuts varies with the character of the topography. A cut is surrounded by levees or dykes to hold the water. It may be that a hillock or a hole will occur in a cut, but this can be ignored as rice producers, till time and the plow, will level the one or fill the other. The water is pumped to the land by steam, gasoline or water power, by far the greatest part of the work in Texas being done by steam. From the best evidence obtainable in western Louisiana and East Texas, it seems to be the consensus of opinion that it requires 9 gallons of water per minute for each acre of rice, or 1 second-foot of water to each 50 acres of rice, although some companies estimate $7\frac{1}{2}$ gallons to each acre per minute. In the Beaumont section the rainfall often reduces the pumping considerably. During 1900, a wet year, some pumps were operated only 4 days. But a dry season will require the pumps to furnish all of the 9 gallons per minute for each acre, and it is not good engineering to allow less than 9 gallons per minute, or 12,960 gallons per 24 hours per acre. If x is the number of acres to be irrigated and y the lift in feet, the weight of water to be supplied per second is, allowing 9 gallons per minute per acre, $1.25x$ pounds, and the work done each second in pumping this amount $1.25xy$ foot-pounds. The theoretic horse power required would, therefore, be

$$\text{Horse power} = xy \div 440.$$

Thus for $x=1000$ acres and for a lift of $y=22$ feet, an engine exerting 50 absolute horse power would be required. The estimated or nominal horse powers of engines will have to be tested or reduced by a substantial fraction if disappointment is not desired. The diagram shown in Fig. 2 will (by a single glance) give the horse power required. Given the lift and the number of acres to be irrigated to find the horse power of engine: Find the lift on the sloping lines (say 40 feet) and following this line to the vertical line through the number of acres to be irrigated (say 550); follow the horizontal line to the left and read off the horse power required (in this case 50). This, for a good engine, should be made 75, and if based on the claims of agents should be increased still more.

For some plants, owing to the contour of the ground, more than one lift has to be erected—that is, more than one pumping station has to be constructed. The pumping capacity of each station is the same if there is no acreage under the first lift, but the machinery in one may be heavier than in the others, depending on the height of the lift.

From the pumps, the water is led by means of flumes to the canals, and is distributed from the main canal to the laterals, from which it is distributed over the land. The main canals are usually very wide, for in most cases they are intended to be wide enough to act as partial reservoirs. The canals are constructed by the "Humper" (a single man with a wheel barrow and pick and shovel), as shown in Fig. A, Plate 1, by the plow and scraper, or by the modern steam grader which lifts the earth by

FIG. 2.—Horse Power Diagram.

an endless belt and deposits it on the canal embankment. The motive power is generally supplied by steam, as shown in Fig. B, Plate 1.

The first rice raised in Texas, by irrigation, was produced in 1862, in Jasper county, by the father of Dr. S. W. Sholars, of Orange, Texas. The land was situated on a clear flowing stream. It was covered at first with thick underbrush, which was cleared away. The land was broken by single teams, the rice sowed broadcast, and when up several inches was flooded from the stream. A small dam provided with a gate deflected the water on to the land, the depth of water in the field being regulated by the gate. The manner of flooding was similar to that practiced today. The rice was harvested with reap hooks, was threshed by crude methods, and was milled by the original method of removing the upper stone of a grist mill and substituting therefor a section of log whose under surface was sufficiently rough to remove the husk from the rough rice and produce a clean product. After the husk had been removed, the section of

log which had replaced the upper stone was taken off, the stone replaced, and the clean rice was then reduced to flour.

The first modern experiments with rice in Texas began in 1888. In these experiments the farmers depended upon rainfall to furnish the water, but this trusting to Providence in the matter of rice cultivation did not pay, and to insure success, pump irrigation was resorted to. This has proved satisfactory, regardless of rainfall. The culture of rice by this method began about 1893. Prior to this it had only been grown in a small way, in ponds and marshes for home use. The method of growing rice on a large scale by irrigation and with improved machinery is comparatively new and peculiar to the Southwest, unlike Georgia and the Carolinas, where rice is still grown in the old way, the rice being planted in rows, the field flooded and the water drawn off several times during the growing season. Rice is here sowed on comparatively high land, with drills or broadcast, cut with self-binders, threshed (Plate II, Fig. A) from the shock, or stacked to suit the convenience of the farmer. The same kind of machinery is used in raising, harvesting and threshing rice that is used with other small grain; the only difference being that rice lands are flooded after the rice is up to the height of 3 to 6 inches, and that the "rough" rice from the thresher is milled and made "clean" in a mill similar to Fig. B, Plate II. The practice in Texas is to sow the rice any time from April 15th to June 15th, and to keep it flooded from 80 to 110 days, 90 days being the average. The water kills the grass and weeds and causes the rice to grow rapidly. Ten days to two weeks before the rice is ripe and ready to harvest, the levees on the lower side are cut and the water is drawn off by means of the ditches made in throwing up the levees. This drainage for some plants requires more engineering skill in the arrangement of the levees than is required in making them fulfill all the requirements for feeding the land with water.

After the rice is threshed it is taken to the rice mill, where it is "milled." The process consists in taking off the husk from the rice grains, and it is thus converted from "rough" into "clean" rice. A bushel and a quarter to $1\frac{3}{4}$ bushels are sown per acre. The land is plowed and harrowed and prepared as it should be for wheat. On the large canals traction engines are used to pull a gang or disc plow and the land is thus plowed by steam power. Fig. A, Plate III, shows three steam plow outfits of Sam A. Robertson on the Colorado Canal Company's farm near Bay City. One traction engine with its plows running night and day can break 50 acres in 24 hours. The outfit or equipment will vary with the acreage. After the rice is planted and the water is turned on, eternal vigilance is necessary to keep canals and ditches in order, to prevent breaks, with a consequent waste of water and drowning out part of the crop. It is by no means an easy crop to manage. The work from the first day's flooding till harvesting is a muddy history of patience. Just before the crop ripens the water is drawn off to allow the ground to harden enough to bear the binder. If the rains set in at this critical moment, it entails an additional amount of expense and worry in saving the crop. In this respect the rice farmers away from the coast and further west have an immense advantage. The rainfall yields a reluctant aid during the flooding period and does not jeopardize the crop during the time of harvest. While the cost of pumping will be more in the western part of the rice belt, the surety of an undamaged product will overbalance the additional cost.

In Texas at present two kinds of rice are raised, the Japan and Honduras. The latter is longer in grain and generally commands a better price, while the former is hardier, can stand dry weather better, and is more prolific in its yield. In general, 44 pounds are allowed per bushel. 162 pounds per barrel, while the sack is a rather variable quantity, but is usually estimated at 180 pounds.

There are two general rice sections in Texas, one known as the Beaumont section (including the counties of Jefferson, Orange, Liberty and Chambers) and the Colorado River Valley Section, extending from Columbus, Texas, to the coast. While rice is raised in other sections of the State, these sections raise 75 per cent. of all the rice grown in Texas.

BEAUMONT SECTION.

JEFFERSON COUNTY.

Of all the counties of Texas where the people have tried rice growing by means of irrigation, Jefferson county undoubtedly stands first in extent of acreage and universal success. Rice has here been grown about as long as it has in any county in the State, and in addition the people seem to have shown more energy in trying to make it profitable, and in increasing the acreage. The recent increase in the number and capacity of the rice canals in Matagorda county has rendered it second only to Jefferson county in the acreage planted.

The various rice farms and plantations lie in two general districts, one in the valleys of Taylor and Hillebrandt bayous above their junction in the southern part of the county; the other along the valleys of the Neches and the Pine Island bayou, northwest of Beaumont. There are 7 rice growing companies, known as the Beaumont Company, the McFadden & Wiess, the Port Arthur, the Jefferson County Rice Company, the Southern Rice & Trust Company, the Gulf Rice Growing Company, and the Southwestern Company. The last three rice companies are small in comparison with the others, and their acreage is less than some individual planters.

What follows is a general description of the plants, and, when possible, the idea of growers will be given in reference to the time of sowing, disposal of the straw, nature of the land over the whole farms, and similar convictions drawn from experience.

Taylor's Bayou.

Mr. Geo. Gill's farm is situated on Taylor's bayou. The soil on it is clay with no sand, and is very hard to plow. He uses the drill and also sows broadcast, but recommends the former method. There are two complete pumping plants on this farm. A 9000-gallon per minute Ivens pump is used at one plant, with a life of 12½ feet. A Skinner engine, and 80-horse power boiler, made by the Columbia Boiler Works, are used. At the other plant a 12,500 minute-gallon Menge pump is used with a lift of 3 feet. A Taylor compound engine is used here, with a boiler of the same steaming capacity and make as above. The flume is 6 feet wide, 2 feet deep and 24 feet long. The main canal leading away is 60 feet wide and 3 miles long, with several laterals. The total cost of this equipment was about \$5,000. Acreage in 1902 was 1500.

Mr. J. G. Garland's farm lies along Taylor's bayou, about 20 miles southwest from Beaumont. The soil on this farm is of a very sticky nature, although it works very well when dry. Mr. Garland sows either with a drill or broadcast along in the season from March 20th to about June 10th, and uses the ordinary binder in reaping. Irrigation is begun about the 20th of May on the first rice sown, and is continued until almost time of harvesting. There is in use one pump of the Menge pattern, which has a capacity of 15,000 gallons per minute (33 second-feet) with a lift of 8 feet. A 75-horse power Skinner engine drives the pump by means of rope transmission. The water flows from the delivery pipe into a flume 10 feet wide, 2 feet deep, and 12 feet long, then into canal 50 feet wide and 1 mile long. There are two laterals—one-half and three-fourths of a mile long, respectively. The total cost of this plant was about \$2,700. With this equipment Mr. Garland irrigated about 750 acres in 1902.

The farm of Mr. J. C. Ward is situated on Taylor's bayou, from which the water is pumped for irrigating. The soil here is generally sandy, with a good clay foundation close to the top of the ground. Irrigation is begun about the first of June, though this depends upon the weather. His average yield has been 10 barrels or 35 bushels per acre, and he has received for this \$3.00 per barrel. There are two complete pumping plants on this farm. The pump at the larger station is of the Menge type, with a capacity of 12,000 gallons per minute (27 second-feet). A 100-horse power Atlas engine is installed with only an 80-horse power Atlas boiler. At the other plant, there is a 8300-minute-gallon Menge pump, an engine of local make, with only a 30-horse power boiler. The lift in each case is 9 feet. The larger plant cost \$5,000, while that of the smaller was only \$1,500. The flume is 60 feet long, 12 feet wide, and 4 feet deep. The main canal is from 60 to 40 feet wide and 2 miles long, with several large laterals branching off. This plant is operated during 1902 by the Bigham Bros.

The farm of the Jefferson Rice Company is situated on the south side of Taylor's bayou, 17 miles from Beaumont. Two pumps, one Morris 22-inch and one Ivens 15-inch, with respective capacities of 20,000 and 7500 minute-gallons, raise the water from the bayou against a lift of fifteen feet. The engines are of the Erie make, and have a capacity of 150-horse power and 50-horse power, respectively. The boiler is of the same make and has a steaming capacity of 200-horse power. The flume is 12 feet wide, 3 feet deep, and 120 feet long, and empties into a canal 100 feet wide. Twenty-three hundred acres are being irrigated this year. The smaller pump was installed in 1896, and the larger (150-horse power) in 1898. The highest point on the farm is at the pump plant, and this enables them to flood the whole tract without additional lifts by pumping. To insure a full supply, a reservoir covering 500 acres has been constructed, with an average depth of 4 feet, with a capacity of 2000 acre-feet or 323,000 cubic yards.

J. H. Hoopes' farm lies in the lowlands made by Taylor and Hillebrand bayous. Some of the soil is black waxy, some black loam and some is sandy, all having a clay subsoil. The yield has been some 8 to 12 sacks per acre. A Menge pump, with a capacity of 16,600 gallons per minute furnishes the water. This pump works against an average lift of 10 feet, varying with high or low water. One Erie engine of 60-horse power is used, with an Erie boiler of the same steaming capacity. The flume is 32

feet long, 9 feet wide, and 1 foot deep, and lined with galvanized iron, which is an exception to the ordinary construction of flumes in this district. The main canal is 100 feet wide and 1 mile in length. Six hundred acres were planted in 1902.

Mr. Ed. Moore's farm is located on Taylor's bayou near that of the preceding. The soil on it is a mixture of clay and loam. His yield last year was below the average, being only from 6 to 8 sacks per acre. He uses an Ivens centrifugal pump with a capacity of 3000 gallons per minute, with a lift of 17 feet. One engine of the Cleveland make of 60-horse power runs the pump, and the steam is supplied by a 75-horse power boiler. The flume is 200 feet long, 3 feet wide and 1 foot deep. The canal is from 15 to 20 feet wide and 2 miles in length. Fifty acres are being watered this season.

The plant of the Southern Rice Company is situated on Hillebrandt's bayou, about 12 miles south from Beaumont. The plant is equipped with Iven's pumps with 22-inch suction pipes and 21-inch discharge, operated by a Chandler & Taylor 100-horse power engine which, with the lift of 13 feet, is estimated to have a capacity of 15,000 gallons per minute (33 second-feet). With an engine efficiency of 75 per cent., 71-horse power will do this work. The water is delivered by the pumps into a flume 150 feet long, 8.5 feet wide and 4 feet deep. The main canal is $1\frac{1}{2}$ miles long, 75 feet wide and delivers water into laterals 12 feet wide. The soil is black with a clay subsoil. Water was rented in 1899 when 200 acres of rice were sowed, yielding 2000 sacks which sold for \$2.70 per barrel. The amount sowed in 1902 was 900 acres.

The Plant of the Lovell Brothers (Willard G. Lovell, manager) is located on the banks of Taylor's bayou, and consists of an Iven's pump with 21-inch suction pipe and an 18-inch discharge which, under a maximum lift of 18 feet, is estimated to have a capacity of 18,000 gallons per minute (40 second-feet). The plant is run by a Houston, Stanwood & Gamble engine of 100-horse power. With an engine efficiency of 75 per cent., a 100-horse power can pump only 275 second-gallons or 16,500 minute-gallons. The flume is 146 feet long, 10 feet wide by 3 feet deep; the length of main canal is 3.5 miles, width 50 feet; 1 mile of laterals are 20 feet wide, $1\frac{1}{2}$ miles 15 feet wide, $\frac{1}{2}$ mile 10 feet wide. In 1902, 760 acres were planted.

The farm of the Gulf Rice Company is 10 miles south of Beaumont on Hillebrandt bayou. The lift is about 12 feet, and the water is pumped by a 90-horse power engine. The soil is a brown clay, 300 acres of which were irrigated in 1902.

The plant of C. A. Pace has one Morris pump, with 15-inch suction and 12-inch discharge, operated by a 25-horse power Westinghouse Junior engine, which has a maximum capacity against the lift of $12\frac{1}{2}$ feet, of 10,000 minute-gallons (22.2 second-feet). The water is conveyed by the discharge pipe to a flume 28 feet long, 4 feet long by 2 feet deep, which in turn delivers the water into the canal, the length of which is 1 mile and width 60 feet. The soil is clay and black loam, with a clay subsoil, 500 acres of which were irrigated in 1902. The yield in 1900 was 3400 sacks, commanding \$3.00 per sack. The whole plant cost \$25,000. Previous to 1899 other parties owning the same farm irrigated 125 acres.

The rice farm belonging to Cameron & McClure is located on both sides of Hillebrandt bayou. The soil on it is light, but has a fine clay subsoil, which retains the water well. The rice is sown during the season from

March 25th to May 1st, and the reaping is done with the ordinary harvester and binder. They have experimented and found that the straw makes very good hay. The yield has been from 7 to 10 sacks per acre, and the price received for the same ranges all the way from \$1.25 to \$3.40. The lower prices were received for rice of poor quality, much of it being damaged by what is termed "red rice." Owing to the farms being on both sides of the bayou, there are two complete pumping plants. At one of the plants there is in use a 6-foot Menge pump, with a capacity of 12,000 gallons per minute (27 second-feet) against a head of 10½ feet. The engine is of the Skinner type and has a capacity of 75-horse power, and receives steam from a 100-horse power boiler. The other plant has a 12-inch Van Wie pump with a capacity of 7500 gallons per minute (17 second-feet), with a lift here, also, of 10½ feet. This pump is run by a 40-horse power Skinner engine which, in turn, is supplied with steam by a 50-horse power boiler. The flumes are 40 and 60 feet, respectively, in length, and 12 and 8 feet wide by 12 inches deep. They are constructed of 4 by 4 inch timber in the bents, while the sides and bottoms are made of 12-inch planking. This farm irrigated 680 acres during the year of 1902.

The farm of the Viterbo Brothers is situated on Hillebrandt bayou, about 12 or 14 miles southwest from Beaumont. One Menge pump, with a capacity of 25,000 minute-gallons against a lift of 7 feet is used. Two boilers each of 50-horse power furnish the steam to a 75-horse power engine. The canal is 40 feet wide and 2½ miles in length. A reservoir, covering an area of 225 acres, with a depth of 6 feet, holds the storage water. There are 1000 acres leveed in; but not all of this is planted in rice. The yield on this land has been from 7 to 18 sacks per acre. The amount sowed this year is 750 acres.

The Beaumont Irrigation Company operates one of the largest plantations in Texas. Its location is in the northern part of Jefferson county, lying along the south side of Pine Island bayou. There are two lifts to this plant. The first one raises the water from Pine Island bayou and is located at the crossing of the Southern Pacific Railroad. At the first lift there are five steam engines, three of 350-horse power each and two of 250-horse power each, making a total of 1550-horse power. These operate rotary pumps against a lift of 31 feet and they have always given satisfaction. They are located 15 feet above the water in the bayou and force the water 16 feet into the flume. The flume is 4 feet deep, 21 feet wide, 1500 feet long, and has a total fall of only 4 inches. The box is constructed of 1-inch by 12-inch plank, floor and sides being double planked, with all joints broken and tarred. The floor rests on 6-inch by 6-inch sills, and these are supported by four 6-inch by 6-inch uprights; the distance between these bents is 4 feet. The whole farm is on the prairie, the land gradually rising from the first lift. It is about 5 miles from the first lift to the second, the water being raised here 11 feet. At the second lift two 250-horse power and two 200-horse power engines operate the pumps. The flume is constructed similar to that at the first plant, but is only 200 feet in length. It is estimated that about \$135,000 has been expended on the plant. This company irrigated about 5000 acres in 1899, but about 15,000 acres were irrigated during the season of 1902. The custom of renting is to charge 2 sacks per acre for water alone, and 2 additional sacks where the company rents the land, making a total of 4 sacks per acre where both land and water are rented.

PLATE I.

FIG. A.—Canal Building by “Humper.”

FIG. B.—Canal Building by Grader.

PLATE II.

FIG. A.—Threshing Scene. □

FIG. B.—Lake Side Rice Mill.

The plant of the Port Arthur Irrigation Company's plant is located on the Neches river, about 12 miles southeast of Beaumont and about the same distance northwest of Port Arthur. The pumping plant is situated on the bank of the Neches, from which stream the water is pumped, the lift being 21 feet. This plant has been in operation for three years. However, until the season of 1900 there was in use only one 18-inch Ivens pump, with a capacity of 18,000 minute-gallons. But in 1900 there were installed two 24-inch Ivens pumps, with a capacity of 24,000 minute-gallons each. The other operating machinery, including that installed with new pumps, consists of two 125-horse power boilers, four 100-horse power boilers, one Chandler & Taylor engine, and one new Corliss engine of 350-horse power. The former flume was about 100 feet long, 20 feet wide, and 4 feet deep, but this was increased in width to about 60 feet in 1900. The main canal is 100 feet wide, and has very high levees, but it is doubtful whether this is the most economical. The rice straw is baled here as on many rice farms in Texas. The method of baling is illustrated in Fig. B, Plate IV. After baling it is utilized exactly as hay is used, as it makes a good "roughness" feed for stock. All the land on which this rice is grown is black and sticky, and 8500 acres were in rice this season.

The plant of McFadden-Wiess is located on the western bank of the Neches river (or rather on the edge of the marsh that lies between the river and the rice lands), about 7 miles southeast of Beaumont. The water is conveyed from the river to the plant by a feed canal which is dredged out of the marsh. Its length is 2000 feet, width 40 feet, and depth 6 feet. The plant is located on the edge of the marsh and a substantial foundation was made by driving piles 3 feet apart until the whole space under the power and pump house was thus piled. On top of the piles several courses of grillage work were laid and this was capped by a cement foundation for the machinery. There are two Connersville rotary cycloidal pumps, with suction pipes $2\frac{1}{2}$ feet by 6 feet and discharge pipes 4 feet in diameter. The pumps are run by two compound condensing Hamilton-Corliss engines of 250-horse power each. The capacity of the plant, with the lift of 22 feet, is estimated at 70,000 minute-gallons (156 second-feet), which would require an efficiency of 78 per cent. in machinery. The main canal is 6 miles long, 100 feet wide and 2.5 feet deep. The plant cost \$65,000, the machinery costing \$40,000. Nine thousand acres of rice were irrigated in 1902.

In addition to the canal plants in Jefferson county there are quite a number of plants that derive their water from wells. These are located near Hamshire and China. The plant of Geo. J. McManus, near Hamshire, will serve as a type of those in this section. There are two wells 40 feet apart, connected in a pit 22 feet deep. One well is 81 feet deep, while the other is 180. The water bearing sand was found to be 72 feet thick and the screen was put in, in three lengths of 20 feet each. It consisted of an 8-inch pipe with $\frac{3}{4}$ -inch holes bored in it $1\frac{1}{4}$ inches apart. The pipe was then wrapped with No. 16 wire $\frac{1}{8}$ of an inch apart, and on this was wrapped the copper gauze of mesh 60, 30 and 40 to an inch. The 6-inch Van Wie pump is operated by a 22-horse power Gaar-Scott steam engine, using Beaumont oil for fuel. One hundred and twenty acres of rice were irrigated from this plant in 1902. In the same neighborhood H. C. Wheeler has a well plant that derives its water from flowing wells. At one of these wells it was 207 feet to the water bearing sand that furnishes the supply. This sand is 43 feet in thickness, mak-

ing the total depth of this well 250 feet. Near Hampshire the acreage from wells was as follows: McManus, 120; Wheeler, 300; Heisig, 185; total, 605 acres.

The acreage around China from well plants was: Hal Aldridge, 125; J. W. Kerby, 200; Burrows, 200; Southwestern Co., 200; Spiwy, 150; total, 875.

Summary for Jefferson County.

Taylor & Hillebrandt's Bayou's:

George Gill	1,500 acres.
J. G. Garland.....	750 acres.
Jefferson County Rice Co.....	2,300 acres.
J. H. Hoopes.....	600 acres.
Bigham Brothers	1,100 acres.
Lovell Brothers	760 acres.
W. E. Moore.....	60 acres.
C. A. Place.....	500 acres.
Cameron-McClure	680 acres.
Southern Rice and Trust Co.....	900 acres.
Gulf Rice Co.....	300 acres.
Viterbo Brothers	950 acres.

Total10,400 acres.

Totals.

Taylor & Hillebrandt's Bayou's.....	10,400 acres.
From wells	1,480 acres.
Port Arthur Canal—Neches river.....	8,500 acres.
McFadden-Weiss—Neches river	9,000 acres.
Beaumont Irrigation Co.—Pine Island.....	15,000 acres.

Total44,380 acres.

ORANGE COUNTY.

Rice irrigation has been conducted in Orange county for about ten years. F. H. Catron installed a 50-horse power engine in 1891 to operate a Menge pump, with a lift of 8 feet, the whole plant being situated on Cow bayou, about 6 miles southwest of the town of Orange. His ditch was one mile long and 20 feet wide. This plant cost \$6,500, the canals and laterals costing \$5,000, and the engine and pumps \$1,500. The capacity under this lift was 5000 gallons per minute, or 11.11 second-feet. With an efficiency of 75 per cent. for the engine, the pumping of this water called for an exercise of only 14-horse power. In 1896, 600 acres of rice were irrigated. This plant has passed into the control of the Cow Bayou Canal and Irrigation Co., which company has reorganized the whole plant, removed the pump to a more advantageous position, and installed a 250-horse power Viker-Corliss engine with 18x36 inch cylinder, operating two Ivens 18-inch double suction latest improved pumps with a capacity of 30,000 gallons per minute (66.67 second-feet) against a lift of 14 feet. There are 5½ miles of main canal. For the

first 1.5 miles, the width is 80 feet, the next 1.5 miles, the width is 50 feet, and the remainder 60 feet. The water is first pumped into a flume 20 feet wide, 4 feet deep and 300 feet long. The cost of the plant, including engines, pumps, canals, laterals, flumes, etc., was \$25,000. Three thousand acres was planted in rice in 1901, and 4500 in 1902.

Des Moines System.—About 7 miles west of Orange and 4 miles from Terry is located the plant of the Des Moines Rice Company. The plants consist of an Ivens pump of 21-inch discharge pipe, operated by a 125-horse power Atlas engine with a capacity of 20,000 (44 second-feet) gallons per minute against the lift of 17 feet. This duty will require an efficiency of 68 per cent. in the engine. Pine wood was used as fuel, and it took about 5 cords for 12 hours. The flume is 200 feet long and 10 feet wide. The main canal is 3.5 miles long and 100 feet wide, while there are four miles varying in width from 20 to 50 feet. The plant was installed in 1899, and 960 acres of rice were sown that year, which commanded a price of \$3.25 per barrel of 162 pounds. In 1900, 1400 acres were planted; in 1901, 1600 acres, and 1200 acres in 1902.

Orange County System.—The plant of the Orange County Rice Company is located on Adams' bayou, 4 miles from Orange. There are two lifts at this plant. At the first lift one 175-horse power steam engine operates a 24-inch Ivens centrifugal pump against a lift of 16½ feet. The two boilers consume 2 barrels of Beaumont oil per 24 hours. The plant at the second lift consists of a direct connected 24-inch Morris pump and a 100-horse power engine with a lift of 8 feet. The second lift plant (Fig. B, Plate III) has a capacity of 20,000 minute-gallons. Twenty-one hundred acres were irrigated in 1901, and 3500 in 1902.

Clark System.—The Clark Canal Company (A. T. Chenault, manager) of Orange County, takes its water from the east side of Adams' bayou, under a lift of 16 feet. The machinery consists of a 50-horse power Morris steam pump, and 500 acres were planted in 1902.

Giles System.—The plant of Giles Brothers takes its water from Adams' bayou, on the west side, under a lift of 18½ feet. One 50-horse power Ames engine operates the Menge pump, with a 4x4 penstock. In 1902, 550 acres were planted.

Acreage in Orange County.

Acreage in Orange county is as follows: Cow Bayou Company, 4500; Orange County Company, 3500; Des Moines Company, 1200; Samuel Wilson Company, 600; Clark Canal Company, 500; Giles Brothers, 550; total, 10,850 acres.

CHAMBERS COUNTY.

The Trinity Rice and Irrigation Company takes its water from Turtle bayou and Trinity river. The plant is 22 miles south of Liberty, and consists of four large pumps with 24-inch suction and discharge pipes, and with a capacity of 20,000 gallons per minute each, or a total of 80,000 minute-gallons (173 second-feet) against a lift of 32 feet. There are four 250-horse power engines, estimated to exert a total of 1000-horse power. However, with the efficiency of 70 per cent., it only requires 781-horse power to pump the estimated discharge. Three of the pumps should be able to do all of the work demanded. There are three flumes

with a total length of 2400 feet, width of 15 feet, depth of 40 inches; 16 miles of main canals 100 feet wide, and 10 miles of laterals 40 feet wide. The plant cost \$130,000, and in a dry season can irrigate 9,600 acres of rice with the usual evaporation. In 1900, 6000 acres of Providence rice were cultivated, producing 29,000 sacks of rice, which commanded \$3.00 per barrel. The company sowed 9000 acres in 1902. Generally they sow during May and June, using about 60 pounds per acre.

LIBERTY COUNTY.

The Raywood Canal and Milling Company has one of the largest plants in Texas on the east side of the Trinity river, in Liberty county, the cost of which was \$200,000. The plant was installed in the latter part of 1900. The company, owing to the excessive rains, raised a good average crop of Providence rice in 1900. There are 10 miles of main canal, averaging in width from 100 to 150 feet, and 25 miles of main laterals of width from 60 to 80 feet. There are three lifts aggregating 70 feet in all with a pumping station at each lift. The pumps are of the Roots rotary pattern, and those of the river station have, with the 16-foot lift, an estimated capacity of 45,000 gallons per minute (100 second-feet). The suction pipes are 3x8 feet, and four of these pumps have circular discharge pipes 5 feet in diameter, and two others rectangular discharges 3x8 feet. The plant at the river consists of two 475-horse power Lane & Bodley engines, operating two Roots rotary pumps (3x8 discharge). The second station is equipped with two 375-horse power engines, operating two Roots rotary pumps, with a lift of 24 feet. The third station consists of two 250-horse power engines, operating two pumps, with 5 feet circular discharge and suction pipes, against a lift of 30 feet. The soil is a black loam, 6000 acres of which were cultivated in 1900, producing 50,000 sacks, which sold for \$3.25 per sack. The company had in 15,000 acres in 1901 and 15,000 in 1902. The rice is sowed by a drill or broadcast in April, May and June, and $1\frac{1}{2}$ bushels are sowed per acre. The land is let out to renters on the one-half plan, i. e., one-fifth for land, one-fifth for water and one-tenth for seed. This plant uses oil for fuel, which costs about one-third as much as coal.

Near Stilson, 32 miles east of Houston, on the Southern Pacific Railroad, Brown & Son have a rice plant, the water for which is obtained from an artesian well 405 feet deep. The pit is 17 feet deep. The first 280 feet are of 8 $\frac{1}{4}$ -inch casing, the remainder of 5 $\frac{5}{8}$ -inch casing. A 22-horse power Port Huron traction engine supplies the power required to operate the 6-inch Morris pump, which raises the water 12 feet into a flume. The land is composed of a black prairie soil. One hundred and sixteen acres were irrigated in 1901, producing 870 sacks of rice. In 1902, 200 acres were planted.

N. B. Sapp has an 8-inch artesian well 380 feet deep. In boring this well a cypress log was struck at a depth of 360 feet. The operating machinery consists of one 18-horse power Foos gasoline engine and two 16-inch Morris submerged pumps, working under a lift of 8 feet. Water was not procured in time for the 1901 crop.

The well at the plant of the Hill-Brown Rice Land and Irrigation Company (C. A. Brown, manager) is 8 inches in diameter, 485 feet deep, the water rising to within 10 feet of the surface. The machinery consists of a Morris direct connected engine 8x8 inches and two 8-inch Mor-

ris pumps, the steam being supplied by two 30-horse power Erie City boilers. The season of 1901 was so dry that no rice was planted. Additions have been made to the plant of this company, and in 1902 the crop was expanded to 1000 acres.

H. Gigstad watered 105 acres of rice from one well, 85 in Honduras and 20 in late Japan. The former averaged 15.14 barrels per acre, and was sold for \$3.35 to \$3.85 per barrel. The expenses of his crop amounted to \$773, and he cleared \$3,694.

HARRIS COUNTY.

Harris County Systems.

Nearly 90 wells in Harris county are furnishing water for rice irrigation, over half of these being located in the vicinity of Clodine. The following is a list of the plants in this county: Sheldon Canal, 2000 acres; Harris Rice Company, 600 acres; F. B. West, 150 acres; J. E. Ross, 80 acres; A. W. Wilkerson, 250 acres; W. H. Myers, 75 acres; Conrad Bering, 125 acres; C. L. and C. H. Bering, 200 acres; Baldwin H. Rice, 280 acres; Meadow Brook Company, 3600 acres; S. P. Dickey, 640 acres; F. E. Markeley, 60 acres; J. H. O'Donnell, 650 acres; J. E. Cabaniss, 75 acres; A. Stockdick, 40 acres; E. Couthwaite, 65 acres; plants at Stella, 75 acres; T. G. Roberts, 60 acres; Mrs. Ida W. Baker, 75 acres; total, 9100 acres.

Sheldon System.—Two and one-half miles from Sheldon, 16 miles east from Houston, the Sheldon Canal Company takes the water for its 2000 acres of rice from the San Jacinto river against a 40-foot lift. The plant consists of one 300-horse power Corliss engine and one 18-inch Van Wie centrifugal pump. The water is delivered into a flume 226 feet long, which in turn delivers it into the canal, which is 120 feet wide and 4 miles long. The land commanded by the canal lies on both sides of the Southern Pacific railroad.

O'Donnell System.—Thirteen miles south of Houston, near Erin, on the Santa Fe, J. H. O'Donnell has six wells, 50 feet apart. These are all under 98 feet in depth and have 46 feet of water bearing sand and gravel. The whole length of pipe in sand is screened, and the water rises in the well to within 4 feet of the surface. The power is supplied by four 28-horse power Fairbanks gasoline engines, which operates the 5-inch Morris pumps. These are placed in pits 15 to 17 feet deep, and are operated in batteries of three each. The soil is black hog wallow, and 650 acres were irrigated during the season of 1902.

Meadow Brook System.—On the Meadow Brook farm, northeast of Clodine, Fort B. Smith has drilled forty-seven wells and has twelve complete plants, ten operated by steam and two by Fairbanks gasoline engines. A complete plant consists of a central steam boiler, using oil for fuel, and two or three engines with the necessary pumps in either opposite directions from the boiler, or in such position as to form a right angle with the central plant. Thus one of these plants consists of a 125-horse power Erie City boiler operating two 35-horse power engines, which run the centrifugal pumps. Two wells are connected by piping in each pit, and one pump is then connected to the common junction. These companion wells are about 20 feet apart and are usually 150 feet deep and of 10-inch bore.

Katy Systems.—In the vicinity of Katy, in the western part of Harris county, Messrs. J. E. Cabaniss, A. Stockdick and T. G. Roberts operate well plants. The wells of Cabaniss are 93 and 94 feet deep, respectively, with 12-foot screens at the bottom, while the Roberts well is 130 feet deep with a 20-foot screen. The Cabaniss plant consists of a 22-horse power Foos gasoline engine and a 6-inch Morris centrifugal pump. The Stockdick plant consists of a 22-horse power Fairbanks-Moore gasoline engine and 4-inch Gould pump, while the Roberts consists of a 20-horse power steam engine and a 6-inch Morris centrifugal pump. At the Cabaniss plant 75 acres were irrigated; at the Stockdick, 40 acres; and at the Roberts, 60 acres.

GALVESTON COUNTY.

Camp System.—Six miles east of Alvin, in Galveston county, near the junction of the Chigre bayou with Clear creek, Berry W. Camp, of Houston, has in operation a rice farm of 1000 acres, producing, in 1901, 86 bushels per acre. A 150-horse power Corliss engine runs a 15-inch Van Wie centrifugal pump, against a lift of 40 feet, delivering 8000 gallons per minute (18 second-feet). The water is pumped out of an elliptical basin 40 feet across and 17 feet deep that was excavated in the banks of the bayou, and which was walled in with sheet piling and floored with heavy timber. The water is pumped into a flume 2x6 feet and 2000 feet long and delivered to the main canal, 25 feet wide and 2 miles long. Both the Japan and Honduras rice were sowed, 500 acres of each, the seed being imported for the purpose. One and three-fourths bushels were sowed per acre. The soil is black, 3 to 4 feet deep, with clay subsoil. The best machinery for handling the rice has been introduced. The thresher is the latest improved. It threshes, feeds itself, stacks the straw, sacks the grain (two sacks at a time), and has a capacity of 2000 bushels per 8 hours. During 1902, 800 acres were irrigated at this plant.

BRAZOS VALLEY SECTION.

The minimum flow of the Brazos river at Waco was found to be, in April of this year, 19 cubic feet per second. The section where the measurement was taken above the new bridge was 24 feet wide, at an average depth of 7 inches, and had a mean velocity of 1.36 feet per second. While this low flow was not during the rice season, it is a fact that the period of low water is no respecter of seasons, as was shown fully by the experience of the power plant at the Austin dam. Below Waco the Brazos receives the Little river, with a minimum flow greater than that of the Brazos at Waco: the Little Brazos, the Navasota and other smaller streams. But their joint flow below old San Felipe will have to be husbanded and stored if the canals now in existence and those now being constructed receive sufficient water for their rice. The Fort Bend Company has in 750 acres this year, the Brazos, 2000, and the Brazoria, 4800, making a total watered from the Brazos and its tributary bayous and creeks of 7550 acres. In addition to this, the Illinois Irrigating Company has projected a canal to be on the west side of the Brazos, near old San Felipe; and the Texas Land and Irrigation Company has been at work on their canals near Wallis for months. When these two are completed the necessity of each company's constructing its own system

of reservoirs will be emphasized. The Brazos Company has had the foresight to take advantage of Jones creek north of Richmond, and they have a storage reservoir practically 17 miles long that is now a very valuable franchise, and affords an excellent and sure protection against the low water and against the upper canal systems. Its reservoir could, with comparatively small outlay, be enlarged if it is found necessary. This plant and the San Bernard have at present the only reservoir systems as such west of Houston. Two systems at least have reservoirs in Jefferson county, that of the Lovell Brothers and that of the Jefferson county Rice Company. Irrigation by storage is a coming factor in Texas irrigation, not only for rice, but for ordinary crops, and partial storage and partial river supply will force itself as a factor before two more rice crops are harvested, if the same rate of expansion continues.

Under the caption of "Brazos Valley Section" are included all plants that are in the counties that border on or through which the Brazos river flows.

WASHINGTON COUNTY.

The plants that are highest up on the Brazos river are located in Washington and Waller counties, near the crossing of the Houston & Texas Central railroad in the neighborhood of Chappell Hill and Hempstead.

The plant of W. E. Buchanan is located 6 miles from Chappell Hill, in Washington county, and consists of one Atlas 35-horse power engine and an eight (8)-inch Morris pump, which lifts the water forty (40) feet out of the Brazos river into the flume. The soil is the rich Brazos bottoms, and 150 acres were irrigated in 1902. J. P. Buchanan's rice farm is six (6) miles northeast of Chappell Hill, and his plant consists of two engines, one Beaumier Bros. 125-horse power, and the other of 40-horse power, operating 15-inch and 10-inch Morris pumps, respectively. Water at this plant is supplied to land owners and to renters. The total acreage in 1902 was 630.

The floods about the first of August of this year practically ruined all of the rice in Washington county. The high water changed the course of the river and left the J. P. Buchanan pumping plant on the deserted channel nearly a half mile from the new channel, and changed it from Waller to Washington county. The season was so far advanced that no attempt was made to transfer the plant to the water or make any other provisions for the crop of 1902.

WALLER COUNTY.

The plant of Heber Stone, in Waller county, is on the east side of the Brazos river, and consists of one Beaumier Bros. 125-horse power engine, which operates the pump that lifts the water 40 feet out of the river into the flume. During the current season, 200 acres were irrigated.

In addition to the river plant mentioned above, there are a few well plants in Waller county near the Katy station on the M., K. & T. railroad. These, respectively, belong to C. J. Nelson, 90 acres, and W. Eule, 50 acres. The Nelson plant consists of a 14-horse power traction engine, operating a 6-inch Van Wie pump. His well is 100 feet deep, it being 70 feet to the water bearing sand, with a 16-foot screen. The plant of Wm. Eule consists of a 22-horse power Foos gasoline engine

and a 4-inch Morris centrifugal pump. His well is of a total depth of 102 feet, 72 feet to water bearing sand. A 16-foot screen is used.

AUSTIN COUNTY.

Kackborth & Koy System.—The plant of Kackborth & Koy is located on Mill creek, from which it takes its water six miles northeast of Sealy, and consists of an 8-inch Morris pump and an Erie City 40-horse power engine, working against a lift of 21 feet. The soil is described as a "red buckshot," with an admixture of black, 150 acres of which were irrigated during the current season of 1902.

Stone System.—On east San Bernard creek James and Stephen Stone have installed an irrigation system $1\frac{1}{2}$ miles from Beard, with which 390 acres were irrigated in 1900, producing after the Galveston storm six sacks to the acre, commanding \$3.00 per sack; and 300 acres in 1901, yielding 3000 sacks, which also sold for \$3.00 per sack. The plant consists of one 150-horse power Westinghouse automatic compound engine, operating a No. 13 Ivens pump, having a 15-inch suction and a 13-inch discharge pipe. The estimated capacity is 7000 gallons a minute (16 second-feet), under a lift of 27 feet. The flume is 5 feet by 2 feet by 520 feet long, and delivers the water into a canal 2 miles long and 100 feet wide. The laterals are $\frac{3}{4}$ of a mile long and 15 feet wide. The soil is light and sandy, from 1 to $1\frac{1}{2}$ feet deep. Wood is used for fuel, requiring 3 cords per day for the 390 acres irrigated in 1900. The experience here in 1900 but confirms the estimate of irrigators in the Beaumont section, and in Western Louisiana, that it requires fully 9 gallons a minute for each acre irrigated, or 8 second-feet for each 50 acres. In 1902, 300 acres were irrigated.

Jahn System.—Just north of Beard, G. A. Jahn and associates (the San Bernard Company) have a rice farm, and obtain the necessary water from San Bernard creek by impounding it in a reservoir of 100,000,000 gallons capacity. A crib work dam, 350 feet long, backs the water up 1 mile and deflects it into a canal and pit. The water is then pumped, under a lift of 25 feet, into a reservoir covering 180 acres. The water is pumped out of the reservoir into the supply canals by two 18-inch Van Wie pumps. The power is supplied by a 300-horse power Corliss engine. This company irrigated 700 acres in 1902.

Magruder System.—Ten miles southeast of Sealy and 4 miles north of Chesterville, Dr. Magruder has constructed a dam across the Little Bernard, forming an impounding reservoir from which, with a 28-horse power engine, he pumped water upon 70 acres of rice during the season of 1902.

FORT BEND COUNTY.

The Fort Bend Irrigation Canal Company has two pumping plants. The second plant pumps from Smithers Lake, which, during an average season, has an abundance of water for ordinary purposes. The lake has a drainage area of 14 square miles, and to make doubly sure the outlets are dammed to prevent waste. But notwithstanding this, it was made evident early in the season of 1901 that the long continued drouth in the coast country, which extended practically from September 8, 1900, to September, 1901, had completely exhausted the resources of the lake.

PLATE III.

FIG. A.—Steam Plowing.

FIG. B.—Pumping Plant second lift Orange County Company.

At the second lift the plant is composed of one 50-horse power Chandler & Taylor engine, and one 13-inch Ivens pump, the capacity of which is estimated to be 10,000 minute-gallons, with the lift 18 feet. The soil is black prairie land with a good subsoil, 400 acres of which were irrigated during the current season. The plant at the river consists of an engine of 300-horse power, operating the pump against a lift of 45 feet. This plant pumps the water into Dry bayou, and this in turn flows into Lake bayou. A dam has been constructed across Rabb's bayou to hold the water from passing out. The acreage in 1902 was 750.

The pumping plant of the Brazos Canal Company is located on Jones creek, 5 miles north of Richmond, Texas, and 30 miles west of Houston. The water is taken from the creek, which possesses the characteristics of a bayou, and acts as a storage reservoir 17 miles long. The lands to be irrigated lie west of Houston, and fall generally to the eastward from the pumping plant. An extra pumping plant is located on the Brazos river just below the upper junction of Jones creek with the Brazos, and at low stages of the river will have to lift the water 32 feet into the reservoir. A tunnel is excavated from the bayou reservoir to the river, and when the level of the river water rises 32 feet it flows into the reservoir without pumping or can be shut off if desired. At the second pumping plant the water will be lifted 32 feet into a canal, giving 4 feet of water in the canal, which, with the configuration of the country, can cover the lands to the east by gravity. During 1902 only 2000 acres were irrigated.

The Brazoria Rice and Irrigation Company takes its water from the Brazos river above the crossing of the Santa Fe railroad. The plant consists of a 900-horse power Greenwald engine, operating a Worthington high lift 36-inch pump against a head of 47 feet, and has an estimated capacity of 35,000 minute-gallons. The 100-foot canal from the river conveys the water into a lake 27 acres in extent, about $1\frac{1}{2}$ miles from the river. The water is pumped out of the lake into the second canal by a 450-horse power Greenwald engine and a 36-inch Worthington pump against a lift of 17 feet. The canals extend at present to the eastward, crossing the tracks of the Columbia Tap railroad near Riceton. It is contemplated to construct another canal crossing the Santa Fe railroad, to irrigate land south of Arcola Junction. Only 4800 acres were irrigated by this company in 1902.

BRAZORIA COUNTY.

In Brazoria county the following named parties have plants: J. A. Bent, William Masterson, Howard F. Smith, H. and G. Munson, Judge Walker, John Chase, Travers Smith and A. H. Bartel.

Two miles south of Arcola Junction, J. A. Bent has a small plant of about 40 acres, where a small dinky engine, with a 4-inch Morris pump, raises the required water from a well.

The rice farm of William T. Masterson is 4 miles southwest of Sandy Point, and derives its water from Oyster creek. A 25-horse power Erie City engine operates an 8-inch Morris pump against a lift of 17 feet, and in 1901, irrigated 30 acres in rice, yielding 250 sacks. Forty acres were sown in 1902.

The plant of Rod Oliver is 10 miles southwest of Angleton. A 25-horse power engine, against a lift of 10 feet, operates a special pump

designed by a Mr. Baker, of Angleton. It discharges through a vertical penstock 3x3 feet. Seventy-five acres were to be irrigated in 1901, but none is planted this year.

The plant of H. and G. Munson is 3 miles west of Angleton, on Oyster creek, and consists of an 80-horse power Erie City engine, operating a 15-inch Morris pump, against a lift of 10 feet. The plant was late in getting to work in 1901, but notwithstanding this, 250 acres were irrigated, but only 100 were harvested, yielding 900 sacks that sold for \$2.50 per sack. Seven hundred acres are being irrigated this season.

The rice farm of Walker & Cain, near Angleton, Brazoria county, has three pumping plants. The first is located on Bastrop bayou, and consists of one 150-horse power engine operating two 15-inch centrifugal pumps against a lift of 10 feet, and having an estimated capacity of 25,000 minute-gallons. The second plant is located on Oyster creek, and constitutes an emergency plant in times of low water in Bastrop bayou. One 125-horse power engine pumps the water from Oyster creek into the canal that leads to Bastrop bayou. A dam has been constructed across Bastrop bayou to keep back the salt water, but it also acts as a storage reservoir for the fresh water. Plant No. 3 constitutes the second lift for the main supply canal. It is 2 miles from plant No. 1, and a 75-horse power engine operates the pumps against a lift of 6 feet, and has an estimated capacity of 15,000 minute-gallons. During the current season, 1400 acres were planted.

John Chase also gets the water for his rice farm from Bastrop bayou, 6 miles southwest of Angleton. The pump used is a special propeller, made by Mr. Baker of Angleton. It is run by a 25-horse power Erie City engine under a lift of 8 feet. The crop was badly injured by salt water in 1901, the yield being two sacks per acre. Sixty acres were planted this season.

J. G. and Travers L. Smith own and operate two rice farms 6 miles north and 9 miles west of Columbia, respectively. The first derives its water from a lake covering 2000 acres, but the lake failed in 1901, and the result was no crop. The plant is composed of two Atlas engines of 40 and 25-horse power, and two Morris pumps, 15 and 12-inch, respectively. The lift is 12 feet and the estimated capacity is 6200 minute-gallons. The plant was first operated in 1900, when 85 acres of rice were raised. The second plant, 9 miles west of Columbia, is to derive its water from an 8-inch well 270 feet deep. One Nagle 40-horse power engine runs an 8-inch Morris pump, against a lift of 10 feet. Five hundred and fifty acres were irrigated in 1902.

The plant of A. H. Bartel is 6 miles from Angleton on the Bastrop bayou, and consists of a 25-horse power engine and a 12-inch Lawrence pump operating against a lift of 8½ feet. He irrigated 100 acres in 1902.

Halley System.—One and one-half miles south of Algoa, R. B. Halley sunk seven wells 42 to 45 feet deep early in 1901, and arranged them in battery formation, four on one side and three on the other. The operating machinery consists of a 22-horse power portable Foos gasoline engine and an 8-inch vertical Morris suction pump. The pumps are placed 8 feet below the surface, but the water will rise in the pit to within 4 feet of the ground surface. After the pumps are started the water levels are lowered 10 feet, giving a lift of 18 to 22 feet. The soil is black

prairie. The water supply for 1901 failed, and 250 sacks of Providence rice were raised, but 200 acres were again sowed in 1902.

Wilkerson System.—Three miles from Genoa, on the Galveston, Houston & Henderson railroad, A. W. Wilkerson has an irrigation plant, consisting of two stations about a half mile apart. At one there is a portable 22-horse power engine and an 8-inch Morris pump, and at the other a 7-horse power Foos gasoline engine, running a 6-inch Morris pump. The water is obtained from 560 feet deep, 8½ inches in diameter. The soil is a rich black prairie, and 250 acres were irrigated in 1902.

ACREAGE IN BRAZOS VALLEY.

Washington County.—J. P. Buchanan, 630 acres; W. E. Buchanan, 150 acres; total, 780 acres. (The former crop was destroyed by the flood.)

Waller County.—Heber Stone, 200 acres; C. J. Nelson, 90 acres; W. Eule, 50 acres; T. G. Roberts, 60 acres; total, 400 acres.

Austin County.—Hackborth & Kay, 150 acres; Jahn, 700 acres; Steve Stone, 300 acres; Dr. Magruder, 70 acres; total, 1220 acres.

Fort Bend County.—Fort Bend Company, 750 acres; Brazos Company, 2000 acres; Brazoria Company, 4800 acres; Willis & Young, 350 acres; Jones & Gordon, 500 acres; H. F. Ring, 165 acres; B. A. Evarts, 125 acres; H. Kempner, 80 acres; Trav. Smith, 60 acres; total, 8830 acres.

Brazoria County.—J. A. Bent, 40 acres; W. T. Masterson, 40 acres; Munson Bros., 700 acres; Judge Walker, 1400 acres; John Chase, 60 acres; A. H. Bartel, 100 acres; R. B. Halley, 200 acres; Travers Smith, 610 acres; total, 3150 acres.

COLORADO VALLEY SECTION.

Much speculation has been indulged in as to the amount of flow of the Colorado river at various points and its capacity in rice acreage. The configuration of the country, the character of the soil, and the height to which the water would be lifted render the economical production of rice above Columbus on a large scale highly improbable. It is admitted by all that rice culture in the Colorado valley is in its infancy, and yet the river watered 52,000 acres of rice below Wharton during the season of 1902. That this is beyond the capacity of the low flow of the Colorado is well known to competent observers. But fortunately for the rice growers, the raft that extends from the Nile Valley pumping plant, just west of Bay City, for several miles down the river, forms a loose dam that impounds the waters of the Colorado and forms a storage reservoir. Thus at the ferry, the Nile Valley plant is 260 feet wide and 25 feet deep, and is practically 25 miles long. To this storage capacity may be added the contents of the various lakes that lie along the course of the river. In addition to these sources of minimum supply (the low flow of the river, the stored water and supply) may also be added the increase at low stages of the inflow from the water bearing sand. The depth from the ground surface to this sand near El Campo and Pierce is about 15 feet. At this depth a water bearing sand is encountered, which, for the shallow wells, can be averaged at 30 to 40 feet for wells sunk between El Campo and the river. The water supply, then, for the

rice farms below Wharton is derived from the river flow, the impounded waters, the lakes and the underground source.

But neither the flow of the river nor the storage capacity above the raft can avail should some canal company install an extensive pumping plant or plants on the river near Eagle Lake, and extend canals to the eastward north of Eagle Lake and deflect to the southward to bring the lands to the north of south of Lissie under cultivation. The same conditions could be brought about by a canal system on the east side of the river above or below Eagle Lake, or by a similar system on the west side.

The flow of the river at Austin in the early part of July, 1902, was 210 cubic feet per second, and if a new canal system near Eagle Lake watering 15,000 acres, making a total watered from the river by canals in that vicinity of 25,000 acres, practically no water would be left in the river below Garwood at low stages of the river. Its reinforcement by the feeble supplies between Eagle Lake and Wharton would leave a scanty supply of the direct flow for the systems below Wharton. All this is at present possible, for under the latest decision of the Supreme Court (Appendix B), the upper proprietor can take the water out of the river for the purposes of irrigation even though he does not leave sufficient water for the lower proprietor for the same purpose, provided that he (the upper proprietor) can establish the fact that irrigation is necessary for agricultural purposes.

The whole situation emphasizes (as suggested by the late Capt. Dunovant) the necessity of storing the waters during the time of floods or freshets, and of husbanding them for dry times. An allowance of 7.5 gallons per minute per acre, or one cubic foot per acre per minute, or a flow of 1 second-foot for 60 acres, would require 36 inches of water on the land during a season of 90 days. An allowance of 5 gallons per minute for 90 days for each acre would mean a supply of 2 feet on the surface.

That each canal system should be compelled to obtain part of its water from its own storage system is equitable and just, and that some plan of this kind will have to be adopted is clear. If we allow 7.5 gallons per minute, or 3 feet for the whole season, and let half of this be supplied by a storage reservoir, with an effective depth of 9 feet, then one-seventh of the land would have to be devoted to reservoir purposes, or if an effective depth of 12 feet could be obtained, only one-ninth of the land would have to be devoted to reservoir purposes. If only five gallons were to be allowed per minute on each acre, a reservoir 9 feet deep, furnishing half of the water necessary to cover the land; that is, to supply 1 foot of water per second, only one-tenth of the land would have to be devoted to storage purposes.

That the storage system is feasible has been demonstrated by the San Bernard Irrigation Company (F. A. Rossier, manager), near Sealy, Texas, where a reservoir of 180 acres has been constructed, to carry 700 acres of rice. In other words, one-fifth of the land has been devoted to reservoir purposes.

COLORADO COUNTY.

In 1899, Capt. Wm. Dunovant irrigated 250 acres of rice near the town of Eagle Lake, Colorado county. This was the first rice irrigated along the Colorado river, and proved so successful that in 1900 30,000

acres were irrigated in the Colorado valley, and in 1902, 56,000 acres. Near the town of Eagle Lake there lies a beautiful, clear, fresh water lake of the same name, covering an area of about 2500 acres, having an average depth of 6 feet, and having a drainage area of fifty square miles. It was not until 1899 that the idea was put into practice of utilizing this body of fresh water for irrigation purposes. In that year Capt. Dunovant installed a plant consisting of a 12-inch Van Wie double suction pump, throwing 4000 gallons per minute. The lift was then 27 feet. The three boilers were old style tubular, and were moved from a burned up sugar mill. The engine was of 200-horse power. The flume had a length of about 350 feet and was made of piping. With this equipment, 250 acres were irrigated in 1899. The plant has been increased from time to time, until it now consists of three pumping stations, two on the lake and one on the river. That on the river consists of a 300-horse power engine, operating three centrifugal pumps, one 18-inch Morris, one 15-inch Morris and one 18-inch Ivens, all working under an ordinary lift of 14 feet. The lift would have been much more than this, but the canal to convey the water from the river to the lake was so deepened that the low lift of 14 feet was secured. The old plant on the

FIG. 3.—Cross-Section of Vineyard and Walker Flume.

lake consists of three engines, two of 150-horse power each, and one of 60-horse power. These operate against a lift of 22 feet. Three centrifugal pumps, one 12-inch Van Wie, one 20-inch Morris, and one 12-inch Ivens. This plant delivers the water into a flume that connects with the main canal system, crossing the tracks of the Cane Belt railroad by means of an inverted siphon. The third plant is situated on the lake between the towns of Lakeside and Eagle Lake, and is operated by an electric motor that derives its power from the engines of the gin in Lakeside. The pump is a 12-inch Morris, and works under a lift of 27 feet. The water is delivered into a flume which connects with a main canal that also crosses the Cane Belt tracks, and there parallels the tracks, crossing the canal of the Eagle Lake Rice Company, and connects with the canal from the original pumping station. Eighty barrels of Beaumont oil are used for fuel per each 24 hours at these stations. Thirty-six hundred acres were irrigated in 1902.

The Eagle Lake Rice Company (A. M. Waugh, secretary) has erected a pumping plant about $\frac{1}{4}$ mile north of Capt. Dunovant's plant No. 1. Their farm lies near the town of Eagle Lake, immediately north of that of Capt. Dunovant. There are two complete pumping plants belonging to this firm, one situated on the lake, the other on the Colorado river, which pump the water from the river to the lake. The pump at the lake

is a 24-inch centrifugal Ivens, and has a capacity of 20,000 minute-gallons, lifting the water 27 feet. The 250-horse power Skinner engine receives steam from a battery of three boilers of 125-horse power each. The flume (Fig. 3) is 1000 feet long, 6 feet wide, and 3 feet deep, with a fall of 1 inch in 1000, and is one of the most substantial flumes in Texas. It is made completely of oak. The box is tongued and grooved and leaded. The foundation is set on heavy oak blocks, 6x6 pieces stand on these and support the flume.

The canal is 60 feet wide at its head, or where the flume enters it,

FIG. 4.—Map of Eagle Lake Canals.

but after the rice farm is reached, the width is increased to 100 feet. The total length of this canal is $3\frac{1}{2}$ miles. There are two large laterals leading off from the canal, 4000 and 300 feet long, respectively.

A few hundred feet from its head the canal crosses the Cane Belt railroad by means of an inverted siphon. The ends of this siphon are made of brick formed into a horseshoe cross-section. Owing to the jar caused by passing trains, it was considered wise not to extend this brick conduit under the track. Consequently, the brick work stopped on both sides just before the track is reached, and the water is carried on through by means of pipes. The falling and rising curves in the siphon are easy, so as to eliminate as much friction as possible.

The pump at the plant on the river is a 30-inch centrifugal Ivens, and is run by an Erie City 325-horse power engine. The capacity of this pump is 30,000 gallons per minute, and it lifts the water 22 feet. The river plant is supplied with fuel oil from the tanks on the S. A. & A. P. railroad through a pipe line. The company irrigated 3500 acres in 1902. The soil on the farm is black sandy. And the contour of the land proves to be of great advantage, for after a certain distance the ground falls, thereby making a second lift unnecessary. A map of the canal systems near Eagle Lake is shown in Fig. 4, where those marked D belong to the Dunovant system, those marked E to the Eagle Lake Company; S, the Sigler plant; H, the Harbart-Stafford, and R B, the Red Bluff Company.

West of the Colorado River.

West of the Colorado river and near the stations of Altair and Rock Island on the San Antonio & Aransas Pass railroad, several small rice plants have been introduced. On the west bank of the Colorado river a few feet below the railroad bridge stand in plain view of the passing trains the pumping plants of Dr. H. C. Sigler and that of the Harbart-Stafford Rice Company. The rice farm of the former (see Fig. 4) lies along both sides of the railroad track, and the plant consists of a Wells 8-inch pump operated by a 35-horse power Atlas engine. With a lift of 34 feet, the capacity of the plant is estimated at 2500 minute-gallons. The plant cost \$4,500, and from it 150 acres of rice were irrigated in 1902. The plant of the Harbart-Stafford Rice Company (H, Fig. 4) is just below that of Dr. Sigler, and west from the Colorado river. The plant consists of 150-horse power Atlas engine, operating an 18-inch Van Wie pump, with an estimated capacity of 16,000 gallons per minute (35 second-feet), with a lift of 33 feet from the river level to the flume. The flume is 200 feet long, 5 feet wide and 2 feet deep, discharging into the main canal, which is $1\frac{1}{2}$ miles long and 40 feet wide, with 2 miles of laterals 20 feet wide. The plant cost \$8,000, and the company planted 350 acres of rice in 1902.

Four miles from the Aransas Pass railroad bridge, J. W. Westmoreland has a rice farm of 225 acres. The water is taken from the Colorado river by an 8-inch vertical suction Morris pump. The engine is a 50-horse power Erie City, and the water is raised to a height of 42 feet.

Four miles east of Rock Island and one mile below the crossing of the S. A. & A. P. railroad with Skull creek, the Brandon Brothers have a rice farm that derives the necessary water from Skull creek. The plant consists of a 40-horse power Erie City engine and an 8-inch Van Wie pump that operates against a lift of 32 feet, and during the season of 1902 irrigated 85 acres of rice.

In the country lying between Rock Island and Garwood there is quite a number of small rice farms that derive their water from wells. The wells are somewhat similar in construction, and always consist of a pit, either circular or rectangular in cross-section, excavated to a depth of from 18 to 22 feet deep, with a bored well in the bottom of the pit. This well must always extend through sufficient water bearing sand and gravel to give sufficient flow for the farm. A screen must be let into the sand strata, which will keep the sand as far as possible out of the pipes, and which will admit sufficient water. These screens are of various

forms and lengths, and upon the screens often hang the success of the whole enterprise.

The first step in a scheme of this kind is to get the well and do nothing further till it is an assured fact. The screen can be of side or end suction. In the former case the pipe is perforated with holes $\frac{1}{2}$ to $\frac{3}{4}$ inches in diameter, 2 to 3 inches apart. Around the pipe is then wrapped fine wire, almost touching, and over this a copper gauze is stretched—the mesh varying with the kind of sand, and often experience is the only test. The end suction screen will be described later. The wells of Baker Brothers and W. C. Jones will serve to illustrate those west of the river in Colorado county. The Baker well has a screen 27 feet long at the bottom of a 67-foot well, while the Jones well encountered water at a depth of 34 feet, and from this depth he placed a 30-inch screen 29 feet long, through coarse gravel. The suction pipe is attached to the screen pipe and generally a centrifugal pump is placed in the bottom of the pit and the vertical shaft extends several feet above the surface of the ground. A pulley is mounted on this shaft and the pump is operated from the engines by belts. The engines for a single well are generally small steam engines of 15 to 40-horse power, or gasoline engines of 12 to 28-horse power. A good well outfit ought to be put in for about \$1,600.

The following will show the well plants west of the river in Colorado county: Frank Marshall, 50 acres; A. W. Small, 100 acres; Berry Bros., 90 acres; E. D. Rone, 135 acres; W. C. Jones, 200 acres; John Duncan, 100 acres; Baker Bros., 100 acres; Berry, Cox & Johnson, 85 acres; Will Car, 80 acres; total, 940 acres.

Red Bluff System.—Just north of Garwood the plant of the Red Bluff Rice Company (R. B., Fig. 4) takes its water from the Colorado river. The plant consists of two 150-horse power Erie City boilers, and one 300-horse power Corliss engine. The pump is a 20-inch Morris centrifugal, with a lift of 42 feet, and has a capacity of 15,000 minute-gallons. The water is delivered into a flume 2x8 feet, and then into a 100-foot canal $1\frac{3}{4}$ of a mile long. Twelve hundred acres were watered this season.

The total rice acreage in Colorado county west of the river is as follows: From well plants, 940 acres; Brandos Brothers, 85 acres; J. W. Westmoreland, 225 acres; H. C. Sigler, 150 acres; Harbart-Stafford, 350 acres; Red Bluff Company, 1200 acres; total, 2950 acres.

East of River.

In that section lying east of the Cane Belt railroad and lying between Sealy, Hungerford and East Bernard, there are twenty well plants, averaging two wells to the plant, the acreage varying from 75 to 550. These plants, lying mostly in that section bounded by Eagle Lake, East Bernard and Chesterville, have a common bond, in that they obtain their water from the water bearing (W. B.) sand lying under the upper blacker soil. The complete list of plants is shown in tabular form below. A few typical plants will be described.

Hudson & Ayers System.—Two miles east of Eagle Lake is a plant that irrigates from wells. On this farm in 1900, Geo. Vick sank a well 12 feet in diameter and 34 feet deep, and with a submerged Ivens pump discharging through a 5-inch force main he irrigated 125 acres of rice. The pump was operated by an Avery traction engine, which was also used

PLATE IV.

FIG. A.—Canal partially filled with water.

FIG. B. —Baling Rice Straw.

PLATE V.

Bay Prairie Company's Pumping Plant.

for threshing purposes. The pipe discharged into a small flume 12x12 inches, which in turn discharged into a ditch 25 feet wide and 1 mile long. In addition to the 125 acres irrigated from the pumps, 25 acres were irrigated by damming a small stream, forming a storage reservoir. Mr. Vick sowed in 1900 $1\frac{1}{2}$ bushels to the acre, but increased this to $1\frac{3}{4}$ to 2 bushels per acre in 1901. The crop of 1900 was damaged by the Galveston storm, but notwithstanding this he realized 19 bushels per acre, which he sold for \$1.50 to \$4.50 per sack. The cost of the total plant used in 1900 was \$2,250. This plant is now owned and run by Hudson & Ayers. A new 45-horse power Erie City engine has replaced the traction engine. Beaumont oil is used as fuel, and it requires about 3 barrels per 24 hours' run. One hundred and sixty-five acres were irrigated in 1902.

Adams System.—The feasibility of using windmills for rice irrigation was thoroughly tested at the plant of Adam Adams, 4.5 miles east of Eagle Lake, and was found insufficient. He installed nine Gamble long stroke windmills, with a 3x14-inch cylinder and a 10-foot wheel, operating the pumps with a 2-inch suction and discharge pipe against a lift of 25 feet from the seven wells that furnish the water. The windmills failed to give sufficient power and a surface well was sunk 47 feet deep, 27 inches to water bearing sand, the screen being only 7 feet long. A Fairbanks-Morse 22-horse power gasoline engine operating a 6-inch Morris centrifugal pump raises the water to the flume. Eighty acres were irrigated in 1902.

Gray System.—Near Lissie George Gray has installed a 28-horse power Fairbanks & Morse gasoline engine, which operates a Van Wie pump having a 6-inch discharge pipe and an estimated capacity of 2,200 gallons a minute (5 second-feet). The plant cost \$4,500. The water is supplied by two wells, one an 8-inch well 103 feet deep, with 91 feet of water, the other a 10-inch well 140 feet deep, with 115 feet of water. The main canal is $\frac{3}{4}$ of a mile long and 8 feet wide. The soil is black and sandy, with a clay subsoil. One and one-fourth bushels of rice are sowed to the acre. For the land rented one-fifth of the crop is charged for land rent, one-fifth for water, and one-tenth for seed—*i. e.*, for land, water and seed, one-half of the crop is charged. In all, 120 acres were irrigated in 1901, but the cold weather ruined 50 acres. The 70 acres saved yielded 740 sacks. During the current season Mr. Gray operated two distinct pumping plants, and has made arrangements for a third. He sowed 400 acres this season.

Malmquist System.—C. T. Malmquist irrigated 38 acres from one well by an 8-horse power Fairbanks & Morse gasoline engine, operating one No. 4 Ivens pump having 5-inch suction and 4-inch discharge pipes, and an estimated capacity of 600 gallons a minute (1.33 second-feet) under a lift of 16 feet. The plant is 1 mile from Chesterville. The yield was 300 sacks, which sold for \$3.15 a sack. During the current season he irrigated 60 acres.

McLain System.—Four and one-half miles from Chesterville George McLain irrigates 160 acres from two wells. One Charter 18-horse power gasoline engine runs a No. 4 Van Wie pump having a 5-inch suction and a $4\frac{1}{4}$ -inch discharge. The plant has an estimated capacity of 1200 gallons a minute (2.67 second-feet) under a head of 15 feet. Only 5 acres were planted in 1900, and the crop was considerably damaged by the Galveston storm. The soil is black waxy, and produced 7 sacks to

the acre in 1900. The water supply failed in 1901, and Mr. McLain raised no rice, but in 1902 he sowed 150 acres.

Townley System.—The plant of J. C. Townley, $\frac{3}{4}$ mile from Chesterville, consists of one No. 8 Morris pump having 9-inch suction and 8-inch discharge, operated by a 35-horse power Erie City engine. The lift is 20 feet and the estimated capacity 1700 gallons a minute (3.8 second-feet). The soil is black and sandy. Two hundred acres were irrigated in 1902. The plant, exclusive of land, cost \$3,000.

Linderholm System.—One-fourth mile from Chesterville John Linderholm has three of the most effective well plants in Texas. Three No. 6 Van Wie pumps, having 8-inch suction and 6-inch discharges, and one No. 3 Van Wie pump, having 5-inch suction and 3-inch discharge, are operated by four Fairbanks & Morse engines of 34, 28, 34 and 12-horse power, respectively, against a lift of 20 feet, each estimated to have a capacity of 8000 gallons a minute (18 second-feet). The wells are on the highest points of the land, and no flumes are necessary. Two reservoirs have been constructed, but so far they have not been utilized. The soil is a sandy loam, and the 125 acres irrigated in 1900, notwithstanding the Galveston storm, produced 8 sacks to the acre, commanding \$3.50 per barrel of 162 pounds. Four hundred acres were irrigated in 1901, the yield being $9\frac{1}{2}$ sacks to the acre, commanding from \$3.00 to \$3.10 a sack. Land is rented on the usual one-half plan, *i. e.*, one-fifth of the crop for land, one-fifth for water, and one-tenth for seed. Watts oil is used for fuel. During the season of 1902, 550 acres were irrigated by these plants, and when visited by the writer in July the rice was of good growth, well advanced and excellent color.

At plant No. 2 of John Linderholm at Chesterville 135 acres of rice were irrigated in 1901, although a late start was made. The machinery consists of a 28-horse power gasoline engine, operating a 6-inch Van Wie pump. The plant cost \$2,150, expenses, \$500, and the crop paid for the plant, expenses and the land estimated at \$12.50 per acre. This season Watt's refined Beaumont oil is used as a fuel in the gasoline engines.

Electric System.—Instead of having several distinct power plants, each to carry its own pump and acreage, the San Bernard Rice and Irrigation Company (C. B. Sloat, manager), has on its plant 2 miles east of Lissie erected a central power plant, consisting of a steam engine and boiler, capacity sufficient to carry three whole pumping plants. The power is conveyed to a 75 K. W. electric motor and by this power is transmitted electrically by wire to smaller motors of 20-horse power capacity at the three pumping plants on the farm. The experiment will demonstrate clearly the most economical method of operating plants where pumps are located in different parts of the farm.

A typical surface well for the Chesterfield plants would be 41 to 44 feet deep, 19 feet to water bearing sand and then 20 to 25 feet of sand, followed by clay. A very successful screen with bottom suction 8 feet long is used in this neighborhood. It consists of a wooden pipe about 8 inches in diameter, from which longitudinal ribs project. Fig. 5 is an illustration of this screen. A heavy wire is wrapped spirally around the vanes, making another cylinder varying in diameter from 24 to 36 inches. Around the wrapped cylinder on top of the wire is attached a wire gauze of 24 wires to the inch, which holds back the sand while permitting the water to enter. The vanes extend below the bottom of the pipe and are attached to a bottom cap, thus leaving an open space for the water to

FIG. 5.—Shallow Well Screen at Chesterville.

enter the bottom of the central wooden cylinder. The suction pipe of the pump is attached to the wooden cylinder near top of the screen. A good well and a good screen are the *sine qua non* for a successful well plant. All failures can be traced to their absence. This is the reason that active plants of 1901 are idle in 1902. They constitute the foundation stone of success in a prairie rice farm. Without them the biggest pumps in the State could not raise water. Many plants in Texas in the last two years have been started at the wrong end. Elaborate canals, excellent machinery, fine black hog-wallow land are futile without sufficient water of the right kind.

The acreage from well systems in the section between Chesterville and Hungerford is shown in the following: Hudson & Ayres, 165 acres; W. W. Miller, 200 acres; R. B. Dobbins, 100 acres; J. E. Ervin, 40 acres; Adam Adams, 80 acres; John Linderholm, 550 acres; J. C. Townley, 200 acres; C. T. Malmquist, 60 acres; W. S. Strickland, 100 acres; Geo. McLain, 150 acres; Geo. Gray, 400 acres; Bernard Rice Co., 210 acres; H. Cordz, 300 acres; Paul Jockets, 80 acres; McBride & Lester, 100 acres; W. S. Moore, 100 acres; L. Pietsch, 170 acres; Longworth & Caylor, 300 acres; J. M. Everitt, 140 acres; Hudgins & Taylor, 450 acres; total, 3890 acres.

El Campo Plants.

In that section of Wharton county west of the Colorado river along the line of the New York, Texas & Mexican railroad, near the stations of Pierce, El Campo and Louise, more well plants are in operation than in any other section of Texas. Two systems of wells are used, the shallow and the deep. The shallow wells are all of one general type. A pit rectangular or circular in cross section is excavated to the depth to or above which the water will rise, and in the bottom of the pit one or more wells are bored through or into the water bearing sand or gravel. Into this is placed the screen. The pits vary in depth from 10 to 19 feet, and the wells from 40 to 70 feet. The soil is generally black sandy, underlaid by clay, which lies over the water bearing sand. The Milner well, 1 mile west of Pierce, will serve as a type for the deep wells. This well is 180 feet deep, 10-inch bore, and has 60 feet of screen. The log of the well shows 14 feet of black soil, thin stratum of red clay, 6 feet of quick sand, 4 feet of clay, 16 feet of coarse sand and gravel and three thin layers of clay alternating with thicker strata of sand and gravel. This well, with its companion shallow well (both in the same pit), constitute in their combined capacity by far the best well found in the Texas rice belt.

A few typical plants are here described:

Blumquist System.—One of the best shallow well plants found in this section is that of Fred Blumquist, $1\frac{1}{2}$ miles east of El Campo. His well is located in an 8x10 pit, 10 feet deep, and was bored to a depth of 40 feet from the surface. One 14-horse power gasoline engine operates a centrifugal 5-inch Morris pump. The plant exclusive of land cost \$970. Thirty-five acres were irrigated in 1901, producing 741 sacks, 4 bushels each. He sold this rice for \$3.25 to \$3.50 per sack. His plant thus paid double for his first outlay.

Higbee System.—R. E. Higbee during 1900 irrigated 98 acres of Honduras rice, yielding 1500 sacks. His soil is black hog-wallow. His well

is 48 feet deep, the water rising to within 13 feet of the surface. The plant is 1 mile east of El Campo, and consisted in 1901 of a 6-inch Van Wie pump and 25-horse power Case engine.

Brunes System.—The plant of Chris. Brunes is just east of the Beard plant. It consists of a 5-inch Morris pump operated by a 20-horse power Advance traction engine. The well is 48 feet deep, the water rising to within 19 feet of the surface. The lift is 24 feet and the capacity estimated at 800 gallons a minute. The engines, pumps, belts, etc., cost \$1,500. Fifty acres were irrigated in 1901, yielding 785 sacks, commanding \$3.10 a sack. During the season of 1902, 105 acres were irrigated.

Nordin's System.—P. H. Nordin's plant is 2 miles north of El Campo. The well is 48 feet deep, the water being 20 feet below the surface. He uses a 20-horse power J. I. Case traction engine and a 6-inch horizontal centrifugal pump. The capacity is estimated to be 700 gallons a minute under a head of 21 feet. The engine and pumps cost \$1,350. Fifty acres were irrigated in 1901, yielding 413 sacks. The plant irrigated 100 acres this season.

J. B. Carlson's System.—The pit of the well is 8 feet in diameter and 25 feet deep; the bored part of the well is 27 feet, making a total depth of 52 feet. The pump, a 6-inch Van Wie, is in the bottom of the pit, and has a lift of 26 feet. It is operated by a 16-horse power Fairbanks-Morse gasoline engine. A test made at this plant shows that it requires 46 gallons of gasoline each twenty-four hours, or nearly 3 gallons to the horse power. In earload lots the gasoline costs 12 cents a gallon, delivered at El Campo. A second pumping plant run by a traction engine is conducted by Mr. Carlson. One hundred and seventy-five acres were irrigated in 1902.

Leech System.—One of the most up-to-date well plants in this section is that of J. W. Leech, $2\frac{1}{2}$ miles northeast of El Campo. He operates two plants 300 feet apart. His wells are of a total depth of 60 feet, and have a 16-inch screen 20 feet long at the bottom of the well. At each plant the 6-inch Van Wie centrifugal pump is located in a pit 20 feet deep and is operated by a 22-horse power Fairbanks-Morse gasoline engine. The actual capacity of these plants was found to be 1000 minute-gallons each, and they watered 160 acres of rice this season. The yield was 2268 sacks, which was sold for \$3.30 per sack, or the total crop for \$7,284.40. The crop paid all expenses and left a profit of \$6,500. This was a clear profit of \$40.67 per acre for the first year's crop.

Embry System.—The farm of J. R. Embry is $4\frac{1}{2}$ miles east of El Campo, and the soil is a black hog-wallow, 90 acres of which were irrigated in 1901, yielding 625 sacks. The pit is 4x16 feet by 6 feet deep. Two 8-inch wells were bored in the pit to a depth of 40 feet below the ground surface, and the water rose to the bottom of the pit. One 18-horse power gasoline engine operates a 6-inch Morris centrifugal pump.

Shult System.—Six miles east of El Campo Oscar Shult irrigated 100 acres in 1901, which produced 858 sacks. The water was furnished by a 14-inch well 39 feet deep. The pit at this well is 8x9 feet and 9.5 feet deep, leaving the bored part of the well 30 feet deep. An 18-horse power gasoline engine furnished the power to operate a 6-inch horizontal centrifugal pump. The soil is a black hog-wallow, and $1\frac{1}{4}$ bushels of Japan and $1\frac{1}{2}$ of Honduras were sowed per acre.

Wharton County Acreage.

Well plants east of Colorado: W. S. Strickland, 100 acres; Geo. McLain, 150 acres; Geo. Gray, 400 acres; C. B. Sloat, 210 acres; H. Cordz, 300 acres; Paul Jockets, 80 acres; McBride & Lester, 100 acres; W. H. Moore, 70 acres; L. Pietsch, 170 acres; Longworth & Caylor, 300 acres; Hudgins & Taylor, 450 acres; J. M. Everitt, 140 acres; total, 2470 acres.

Well plants west of river: O. R. Johnson, 150 acres; Oscar Nelson, 60 acres; A. Denielsen, 80 acres; Fred Blumquist, 120 acres; A. P. Olsen, 60 acres; R. E. Higbee, 70 acres; N. Thompson, 200 acres; A. Berglund, 50 acres; T. J. Rolf, 40 acres; Axel Bard, 60 acres; J. W. Leech, 160 acres; W. H. Vaughn, 100 acres; J. R. Embry, 75 acres; Johnson & Jensen, 70 acres; Oscar Schult, 250 acres; James Milner, 750 acres; P. A. Nelson, 50 acres; A. P. Borden (two plants), 90 acres; N. J. Sunwall, 50 acres; Mr. Barnhart, 250 acres; W. S. Wood et al., 300 acres; Chris Brunes, 105 acres; P. H. Nordin, 105 acres; Boehm Bros., 60 acres; J. B. Carlson, 175 acres; Nelson Bros., 200 acres; Fritz Bender, 60 acres; A. E. Carson, 75 acres; Woolsey Estate, 120 acres; A. S. Thompson, 75 acres; O. B. Scroggins, 50 acres; W. S. Lewis, 75 acres; E. G. Sterner, 150 acres; L. Cahn, 60 acres; John Bacek, 30 acres; William Neizer, 50 acres; Frank Garetzky, 50 acres; John Wetzel, 40 acres; T. A. Hill, 120 acres; total, 4635 acres.

Plants near Louise: W. G. Davis, 60 acres; G. W. Barnett, 50 acres; Otto Peterson, 40 acres; E. M. Clark, 400 acres; Sadler & Rome, 250 acres; Sadler & Thomason, 200 acres; Sadler & Thomas, 240 acres; total, 1280 acres. When visited in July, the Davis and Peterson plants were the only ones that were watering all the rice they had in.

A successful typical well here has hardly been found. The well of W. G. Davis presented some peculiarities. At 96 feet deep a granite-like rock was encountered, and the drill cut through a 4-foot layer of this, making the well 100 feet deep in all. The suction pipe was set directly on top of this rock, and no screen was used. The well furnished more than ample supply of clear, fresh water. The machinery consists of a 22-horse power Foos gasoline engine and a 6-inch Morris pump. Sixty acres of Japan rice were irrigated during the season of 1902, but the well had water for double this acreage.

JACKSON COUNTY.

Ganado Plants.—I am indebted to N. P. Mauritz, of Ganado, for the data in regard to the plants in Jackson county. The acreage around Ganado was as follows: N. P. Mauritz, 200 acres; D. B. Mayfield, 50 acres; Mr. Boquette, 60 acres; A. W. Everitt, 50 acres; L. Ward, 70 acres; total, 430 acres.

The Mauritz plant has three wells of depths of 51, 88 and 117 feet, respectively. The water is raised by Fairbanks gasoline engines and 6-inch centrifugal pumps. The Mayfield plant consists of a 25-horse power portable steam engine and a 6-inch centrifugal pump, and a 70-foot well. At the Boquette plant a 22-horse power traction engine operates a vertical centrifugal 6-inch pump, raising the water out of the 80-foot well and irrigating the 60 acres of rice. At the Everitt plant a 20-horse power engine, a 40-horse power boiler, an 8-inch centrifugal

pump raises the water out of the 117-foot well to the 100 acres of rice. It is reported that Mr. L. Ward, of Jackson county, has 60 acres of rice.

Lane City Plant.—Eight miles below Wharton, and surrounding Lane City, is the rice farm of the Bay Prairie Irrigation Company (often called the Lane Company). The pumping plant is located on the banks of the Colorado river, from which it takes its water. There are in all three pumping plants. The river plant, shown in Plate V, has a lift of 33 feet, and consists of two 54-inch Van Wie pumps operated by a Bates-Corliss 250-horse power engine. The capacity is estimated at 120,000 minute-gallons, and the engineer, L. E. Beadle, estimates that it will require 8 gallons per minute for each acre, but he has provided for an emergency of 10. There are two flumes, one at the river and the other across Jarvis creek. The former is 5x12 feet, 182 feet long, while the latter is 4x20 feet and 350 feet long. There are 3½ miles of main canals and laterals varying in width from 80 to 120 feet. At the second lift of 7 feet a 250-horse power compound engine operates a 45-inch centrifugal pump which has a capacity of 50,000 minute-gallons. At the third lift an Atlas-Corliss of 200-horse power operates a 24-inch Van Wie pump, which, with a lift of 3½ feet, is estimated to have a capacity of 20,000 minute gallons. The water is carried under the tracks of the Cane Belt railroad by terra cotta and timber invert. Under the first lift 9500 acres are under cultivation, under the second 5000, and under the third 1500, making a total of 16,000, and 15,000 acres of this were irrigated in 1902.

Bay City Plants.—Near Bay City, in Matagorda county, eight large companies have opened up extensive rice farms, as shown in Fig. 6. The Moore-Cortes Canal Company has installed its plant 6 miles from Bay City on the west side of the river. Their pumping plant, shown in Plate VI, consists of one 300-horse power Vilter-Corliss engine operating a 30-inch Ivens pump, which, under the lift of 12 feet, has an estimated capacity of 56,000 gallons per minute. The main canal is 7 miles long and 100 feet wide. The laterals 10 miles long with a width of 40 feet. There were 5500 acres irrigated in 1901, yielding 10 sacks per acre. In 1902 the company irrigated 10,000 acres.

Bay City Company's System.—The pumping station (Fig. B, Plate VII) of the Bay City Irrigation Company (Victor LaTulle, manager) is 3 miles north of Bay City, and takes its water from a lake that is connected with the Colorado river. The pumping plant consists of two 140-horse power Erie City engines operating two 24-inch Morris pumps, which, under the lift of 12 feet, has an estimated capacity of 50,000 minute-gallons. There are 7 miles of canals, 150 feet center to center of embankment. The cost of the plant exclusive of land was about \$30,000. In 1902, 5000 acres of rice were irrigated.

Adjoining the lands of the Bay City Company are those of the Matagorda Company. The pumping plant of the latter is 2 miles northwest of Bay City and consists of one Greenwald 650-horse power engine and one 100-horse power Nagle engine. There are two Worthington 36-inch conoidal pumps, which, under the lift of 10 feet, have an estimated capacity of 102,000 minute gallons. These pumps are driven by Manila rope transmission. Beaumont oil is used for fuel, and is received through a pipe line 2 miles long, which has its intake on the Cane Belt railroad. The water is pumped from a lake which is connected with the Colorado river. During the season of 1902 the company irrigated 9000 acres. A

view of the pump plant of the Matagorda Company is shown in the frontispiece. This was taken before the building was completed.

Colorado Canal Company.—Near the Matagorda plant is that of the Colorado Canal Company. This plant is located on an intake connecting with a lake, which in turn at certain stages of the river connects with it. The machinery consists of a Murray Bros. 200-horse power compound condensing engine and a Connersville blower pump with discharge pipe 32x96 inches. The lift varies from 8 to 12 feet, depending upon the stages of the river and lake. It requires 20 barrels of Beaumont oil per day, which costs at Bay City 43 cents per barrel, making a total cost of \$8.60 per day for fuel. The capacity of the plant is 50,000 minute-gallons. During the present season 5300 acres were under contract.

The Nile Valley System.—The Nile Valley plant is on the banks of the Colorado river less than $\frac{1}{2}$ mile from the Colorado Company. This plant (Plate VIII, Fig. A) takes its water directly from the Colorado river $\frac{1}{2}$ mile above the head of the famous raft. Two 80-horse power Duplex engines operate the two 30-inch Morris pumps against the maximum lift of 8 feet. The canal of this company forms a levee and serves to protect Bay City and the lands below. Twenty-two barrels of Beaumont oil are used per day. Twenty-five hundred acres were irrigated in 1902 from this canal.

Stewart Canal.—At the Stewart plant 12 miles below Bay City an 80-horse power engine operates a 24-inch Morris pump against a maximum lift of 21 feet. Seventeen hundred acres were irrigated by this canal in 1902.

Sexton Plant.—The Sexton plant uses a simple 80-horse power Greenwald engine and a Menge pump under a lift varying from 18 to 20 feet. This plant irrigated only 500 acres this season. It is located several miles below Bay City on the east side of the Colorado river.

Cleveland Plant.—Sixteen miles south of Bay City, S. J. Cleveland irrigated 160 acres of rice from the Colorado. His plant consists of a 22-horse power traction engine, which operates a 6-inch Morris centrifugal pump against a lift of 17 feet.

Planters' Canal.—The pumping plant of the Planters' System is located on the west side of the river below the Moore-Cortes, and its main canal crosses that of the Moore-Cortes by an inverted flume or siphon, and irrigates land to the west and north of the latter system. During the season of 1902 this company irrigated 950 acres of rice.

Summary of Matagorda Plants.—Bay City Irrigation Company, 5000 acres; Matagorda County Rice Co., 9000 acres; Colorado Company, 5300 acres; Nile Valley Company, 2500 acres; Stewart Canal Company, 1700 acres; Sexton Canal Company, 500 acres; Moore-Cortes, 10,000 acres; Planters' Canal Company, 950 acres; Prairie Bluff Company, 350 acres; S. J. Cleveland, 160 acres; total, 35,460 acres.

DE WITT COUNTY.

Buchel System.—The only water power plant in Texas that irrigates rice is that of Otto Buchel, 3 miles north of Cuero. A masonry dam across the Guadalupe river produces an effective head of 10 feet. This is one of the most substantial dams in Texas, and it cost with its equipment \$100,000. The power is generated by 50-inch turbines, which operated the pumps to raise the water into an adjacent reservoir. An auxil-

iary steam plant of 400-horse power is used for supplementing the energy generated by the water plant. This plant furnishes power for three rice farms—that of Mr. Buchel, Schleicher & Crouch, and Rathbone & Wofford. The farm of Schleicher & Crouch is above that of Buchel, and on the east side of the river. The power for operating the pump is transmitted electrically from the Buchel power plant. The farm of Rathbone & Wofford is on the west side of the river, and also receives its power by electric transmissions from the Buchel power plant. In all, 750 acres of rice were irrigated at these farms in 1902.

VICTORIA COUNTY.

The plant of the Victoria Rice and Irrigation Company is located 10 miles south of Victoria, and takes its water from the Guadalupe on the east side. At the first lift on the river there are two 225-horse power Brownell engines operating the pumps against a lift of 22 feet. The river plant delivers the water into a flume 1400 feet long and this empties into a reservoir 24x125 by 9 feet deep. The second lift is 41½ feet, and two 525-horse power Corliss engines operate the pumps. The second flume is 400 feet long and delivers the water into the main canal. There are 5 miles of 100-foot canals, 2 miles of 75-foot laterals and 2 miles of 60-foot laterals. The highest point of land to be irrigated is 62 feet above the ordinary water level of the river, and there is a fall of 18 inches from the second lift to this highest land. Twenty-seven hundred acres were irrigated in 1902. Wood is used as a fuel at present, but it is the intention to substitute Beaumont oil soon, transmitting it down the canal by boat to the plant.

Four miles west of Victoria, Harry Rathbone has 60 acres in Japan rice this season. He obtains the water from Pridham's lake. A 60-horse power engine operates the 5-inch centrifugal pump under a lift of 8 feet. The soil is sandy river bottom.

Twelve miles above Victoria, Jno. T. Rusk has a well plant rice farm, but the lateness in obtaining water renders its acreage doubtful, for the well could not supply sufficient water for the rice.

BROWNSVILLE IRRIGATION SYSTEM.

The center of rice culture in Texas takes its way considerably westward for 1902, on account of the big irrigation system near Brownsville on the Lower Rio Grande. During 1901 this system was experimental, consisting of the machinery of an unused irrigation plant. The experiment was so successful, however, that the company, the Brownsville Land and Irrigation Company (W. M. Ratcliff, manager), has made plans to extend the system on a large scale, at a cost \$250,000. The plant is 5½ miles below Brownsville. Rice, sugar and cotton will be raised by irrigation. The plant now consists of one pump, having 28-inch suction and 24-inch discharge pipes, and an estimated capacity of 80 second-feet under the lift of 11½ feet. The horse power of the engine, if actual, ought to treble this discharge. The water is first pumped into a flume 3 feet by 18 feet by 40 feet long, and then is delivered into the canals. The main canal is 12 miles long and 120 feet wide, and there are 16

PLATE VI.

Moore-Cortes Pumping Plant.

PLATE VII.

FIG. A.—Market Scene.

FIG. B. —Bay City Company's Plant and Canal.

Corrections.

The paragraph with reference to the Treadway Canal Company should read: "The Treadway Canal Company will take its water from the Pine Island Bayou" etc, etc. In stating the acreage of this company a typographical error occurred. It should have been 55000 acres instead of 25000.

297
900

12 810
 701 810
 89 70
 2 201 70
 701 810

miles of laterals 100 feet wide. The fuel used is mesquite wood. During the season of 1902, 3000 acres were irrigated by this company.

SUMMARY BY COUNTIES.

Jefferson county	44,380 acres.
Matagorda county	35,460 acres.
Wharton county	23,600 acres.
Liberty county	16,200 acres.
Colorado county	11,450 acres.
Orange county	10,850 acres.
Harris county	9,100 acres.
Chambers county	9,000 acres.
Fort Bend county	8,830 acres.
Brazoria county	3,150 acres.
Cameron county	3,000 acres.
Victoria county	2,770 acres.
Austin county	1,220 acres.
Galveston county	800 acres.
Washington county	780 acres.
DeWitt county	750 acres.
Jackson county	430 acres.
Waller county	400 acres.

Total 182,170 acres.

In regard to this summary, it should be stated that this is the acreage reported as sowed. It does not represent the amount watered or harvested. It is very probable that the effective acreage was not over 150,000.

In addition to the systems described above, there will be several big plants operating in 1903. The Treadway Canal Company will take its water from the Neches river northwest of Beaumont and irrigate land on each side of the Southern Pacific railroad. It is contemplated to bring 25,000 acres in cultivation by this canal. The canals are already under construction.

The Texas Land and Irrigation Company are installing a plant to take its water from the Brazos river northeast of Wallace. Its canal, already under construction, will extend in a southerly direction, and it is intended to bring the land between Wallace, Rosenberg and East Bernard under canal.

The Illinois Irrigation Company proposes to take out a canal from the Brazos river north of Sealy near San Felipe and irrigate lands north and south of Sealy.

The San Jacinto Rice and Irrigation Company expects to put in a plant on the San Jacinto river east of Houston in 1903.

The Wallace-Radford Company intends to irrigate lands to the east of Eagle Lake by putting in a canal system, taking its water from the Colorado river.

APPENDIX A.

RICE IRRIGATION IN JAPAN.

Rice is grown throughout Japan with success as far north as Tsugarn Strait, latitude 41-30 degrees, it being a summer crop, and in its term of development—usually six months from (May to October)—it requires an average temperature of at least 68 degrees F., and a soil saturated with water, at least in the early half of its growth, except for one variety, known as upland rice. The upland rice (*oryza montana*), called “okabo” by the Japanese, which grows on elevated or sloping ground, flourishes upon the moisture supplied by rain, and matures in about four months. This variety is of minor importance compared with the common rice (*uruchi*) and glutinous rice (“*mochigome*”) grown in wet fields.

Throughout Japan the rice farmers’ work generally begins in April with the laying out of one corner of the field as a seed bed. To this end the ground is first dug over with a long bladed hoe, then leveled and surrounded with a little smoothed and hardened wall of earth, about one foot in height and width. A small gutter or irrigation channel is brought into connection to flood the bed, as may be required. A favorite manure is the slime dug from a neighboring canal, if one is near. The seed bed is covered with this to a depth of several inches. In default of such slime, ashes from wood or straw and other quick working fertilizers, such as bean cake, compost and faecal matter, are used. Next the dam is broken at some point and water admitted, until the bed is covered to a depth of from two to three inches, when the seed is scattered by hand over its surface. In many cases it is soaked in water during several days before sowing. The grains of rice sink quickly to and into the muddy bottom. The water soon evaporates or sinks into the ground, and in the absence of rain is promptly renewed from the irrigation ditch. Frequently, however, the seed bed is flooded only at night and left dry by day. Thus it is protected against cold, while enjoying the warming influence of the sun. Within about four weeks, if the weather be favorable, the sprouts reach a height of six or seven inches and are ready for transplanting.

Nearly every one of the thousands of streams fed by melting snows of the mountains is tapped and diverted in its course to the sea to irrigate the rice fields, which upon terrace after terrace fill the valleys and spread over the plains. These fields are subdivided into plots, seldom exceeding a quarter of an acre in area, separated from each other by raised banks of earth from one to two feet in width. The smallness of these plots the abundance and cheapness of labor have thus far effectively prevented the introduction of labor-saving machinery, and rice in Japan is now sown, raised and harvested in precisely the same manner as that which prevailed two thousand years ago.

Near Osaka and in a few other localities the ground is broken by a clumsy, antique plow, drawn by an ox, but the usual tools for this purpose are spades, long bladed hoes and mattocks. Green manure, consisting of grass and weeds, together with straw and lime, is now worked into

the soil, water is let in and the field thoroughly hoed until the mud becomes homogenous and free from lumps. In a few weeks the manure decomposes and all traces of it disappear.

From the seed beds the sprouts are carried to the fields, where the farmer, his wife, children and all available relatives and dependants, wading knee deep in mud and water, take each four or five sprouts at a time and plant them together in a bunch. The bunches are located about eight inches apart, and this patient, back-breaking process is followed exclusively over the 6,958,885 acres of Japanese rice fields. There are, on an average, about 2000 bunches to an acre. [99,000?]

Close attention and much hard work must be given to the fields, the supply of water must be kept uniform, plants that show weakness or failure to take root must be replaced by fresh ones, by hand all sprouting weeds are removed, and by hand the mud about the roots of each bunch is frequently stirred.

Harvest follows usually in October. The stalks are cut close to the ground, the farmer grasping the bunch in his left hand and cutting with a small sickle. Bundles are tied up and hung over poles or upon the trunks of adjacent trees, or conveyed immediately to the farm yard.

Threshing is accomplished by drawing the stalks through a row of upright iron teeth, like a hatchet used for cleaning hemp. Another method is simply to strike the panicles against the edge of a tub or barrel. The flail is sometimes used also.

Winnowing is generally done by one person pouring the mingled grain and chaff from a flat basket, held aloft in front of two large winged fans, which are worked rapidly by an assistant. A boxed wheel fan is frequently employed.

The husk is almost invariably separated from the grain by pounding in a wooden mortar with a heavy wooden pestle. This pestle is usually swung in hand. Frequently it is attached to a long heavy beam, the end of which is raised and let fall like a seesaw by leg power. Water power is often utilized, and within recent years a number of steam power rice cleaning mills have been erected. Rice is transported and stored throughout the country in straw bags, holding a little less than two bushels each.

The average product of rice per acre in Japan is $28\frac{1}{2}$ bushels. The average annual yield of the entire empire during the past decade is estimated at 228,819,820 bushels. Average annual yield during the past decade 196,588,111 bushels. Average product per acre $28\frac{1}{2}$. Area of rice fields in 1899, 6,958,855 acres. Area of empire, not including Formosa, 94,498,066 acres. Population of empire, not including Formosa, on December 31, 1898, latest census, 43,760,815.—*Compiled by Col. S. F. B. Morse.*

APPENDIX B.

TEXAS IRRIGATION LAW.

A water course, as the words are used in this connection, has been defined as "a stream usually flowing in a particular direction, though it need not flow continually. It may sometimes be dry. It must flow in a definite channel having a bed, sides, or banks, and usually discharges itself into some other stream or body of water." 27 Wis., 661; Cooley Torts, 238.

It will be observed that the water supply need not be sufficient to cause the stream to flow all the time. It must flow habitually, though not necessarily uninterruptedly. There must be a definite channel; that is, a bed or palce where the water passes along over the same depression or lower surface, which is bounded or limited by ascertained and definite sides or banks. When these things concur, the water thus confined and seeking a regular outlet is a water course or stream. Water standing in a depression and not flowing is not a stream. Water flowing not in a defined channel, as surface water after a rain, is not a stream. In our changeable climate it is sometimes difficult to determine the question as a fact regarding any particular body of water. Sometimes there is a well-defined channel, but no water except immediately after rains; again there are channels down which water flows frequently, but not continuously. How often it is to run and how long during the year must be answered from the facts in each case. If there is a well-defined channel down which water passes usually—habitually—it is enough, though it may sometimes be dry. If, however, it is usually dry, with water flowing in it only occasionally, it is not a stream.

The water passing in these streams is not owned by any one. The proprietors of the land crossed by or bordering on the stream have legal rights in its use, but have no property in the water itself. These rights, like all others, have their correlative duties, and the proprietors of the several estates must have regard at all times to the obligations under which each rests toward the other. All persons who own land along a stream are coproprietors in its use. These uses are of two kinds—domestic or natural on the one hand, and artificial or commercial on the other hand. As to the first, the right of use is very extensive, and the proprietor who first gets access to the water lawfully may completely exhaust it in these natural or domestic uses without incurring liability in so doing. It is not so with the second—the artificial or commercial. Here no one has an exclusive privilege. The upper proprietor can use it for these purposes, provided that after this use he permits it to leave his land at the same place, in the same quantity, and of the same quality that it would have but for such use.

It is apparent that the rights and liabilities of the parties vary greatly as the use made of the water is of the one or the other classes. It therefore becomes imporant to understand what uses fall in each class. Domestic or natural purposes embrace drinking purposes for one's family and his own domestic animals, culinary purposes, and washing, and all

the uses about one's premises necessary to sustain life. Artificial or commercial uses are all those in which water is not used directly to sustain life or to give comfort, but is a means of pecuniary profit or indirect means of comfort. This seems to be the line of separation. It works out different results in different localities. It seems to be considered everywhere that the uses mentioned under the head of domestic purposes are such, and that for any of these purposes the upper proprietor or the one first getting lawful access to the water may use it to the entire exhaustion of the supply.—*Judge John C. Townes.*

RHODES VS. WHITEHEAD, 27 TEXAS; APPEAL FROM BEXAR COUNTY, 1863.

Among other points decided were the following: (1) The appropriation of water for natural uses, such as for the use of people and cattle, and for household purposes, which must be absolutely supplied, can afford no ground for complaint by the lower proprietors, even if it were entirely consumed. (2) It may be admitted that the purpose of irrigation is one of the natural uses, such as thirst of people and cattle, and household purposes, which must be absolutely supplied: the appropriation of the water for this purpose would, therefore, afford no ground of complaint by the lower proprietors if it were entirely consumed.

TOLLE VS. CORRETH, 31 TEXAS, 365; APPEAL FROM COMAL COUNTY, 1868.

It was decided: (1) That the colonization laws of Texas and the statutes of the State recognize the right to use water for irrigation purposes. (2) Where the defendant owned the land upon which there was a spring he had a right to use the water for the purposes of irrigation; provided, he restored it back to its natural channel before it reached the lands of the adjoining proprietor, and if the flow was thus weakened so as to damage the adjoining proprietor, the defendant was not liable for such damage.

FLEMING VS. DAVIS, 37 TEXAS, 173; APPEAL FROM SAN SABA COUNTY, 1872.

Syllabus 2.—Irrigation of land, however beneficial in some portions of this State, is not one of the natural wants which will justify the owner of a head spring in exhausting the water which flows from it, to the injury of proprietors lower down on the natural channel of the stream. The maxim *sic utere tuo ut alienum non loedas* applies. The case of Tolle vs. Correth, 31 Texas, 362, is not understood to have decided a contrary doctrine.

Syllabus 3.—In the distribution of the water of a natural stream among the riparian proprietors the principles of the common law furnish the only rules judicially known in this State: and a suit, it seems, can not be sustained to partition a natural stream among riparian proprietors by allotting to each a specified time to appropriate its waters.

BAKER VS. BROWN, 55 TEXAS, 377; APPEAL FROM SAN SABA COUNTY, 1881.

Syllabus 1.—The right to use water for purposes of irrigation, when its use is not indispensable, but is resorted to for the purpose of increas-

ing the products of the soil, must be subordinate to the right of a coproprietor to supply his natural wants and those of his family, tenants and stock by using the water for necessary and domestic purposes.

Syllabus 2: Limitations; riparian rights.—The rights of a riparian proprietor to the use of the water may be restricted or lost by grant or by prescription, under such adverse, continuous, uninterrupted user and occupation by another as would, by analogy to the statute of limitations, bar the right of entry upon lands. Ten years' use and occupation would in Texas be the period of prescription.

MUD CREEK IRRIGATION CO. VS. VIVIAN, 74 TEXAS, 171; APPEAL FROM KINNEY COUNTY, 1889.

Syllabus 1: Irrigation corporations.—An irrigation company chartered under general law and whose charter designates the locality of its canals acquires thereby no exclusive right to the use of the waters of a flowing stream on which it depends for its supply. By virtue of the charter of its incorporation, which authorized the acquisition by gift, purchase or condemnation of all property necessary to the irrigation enterprise, it secured the right to obtain in the manner designated the privilege of using the water of a stream, but the charter did not *proprio rigore* confer that right in the absence of a purpose, gift or condemnation.

Syllabus 2: Constitutional law.—The Legislature can not destroy or impair the vested rights of a riparian proprietor by conferring a special privilege on an irrigation company without providing for the payment of a just compensation.

Syllabus 3: Riparian proprietors; irrigation cases reviewed.—Tolle vs. Correth, 31 Texas, 365, and Fleming vs. Davis, 37 Texas, 173, reviewed, and the doctrine announced that a riparian proprietor has the right to divert water flowing along or through his land to purposes of irrigation, although the effect of such use is to leave to a riparian proprietor on the stream below him a supply of water insufficient for irrigation. No opinion is expressed as to whether water can be used by a riparian proprietor for irrigation so as to render insufficient the supply for ordinary use to those owning land lower down the stream.

Syllabus 4: Prescription.—A prescriptive right to use water for irrigation will be acquired by the uninterrupted use of the water for such purpose under a claim of right. But this right can only be enforced against riparian proprietors on the stream below when the water has been continuously used for ten years under a claim of right. It can not be asserted against a riparian proprietor by or through whose land the water flowed before it reached the point where it is appropriated by the one claiming the prescriptive right.

Syllabus 5: Presumption of grant.—The presumption of a grant from long continued enjoyment can exist only as against those who might have prevented or interrupted the use of the subject of the supposed grant.

In rendering the opinion in this case Judge Gaines said: "It is true that the Act of March 10, 1875, provides that 'any * * * canal company' shall have the free use of the waters and streams of the State," but the provisions of that act applied as well to ordinary companies as to corporations. Laws Second Called Session Fourteenth Legislature.

17. Besides, we are of the opinion that the provisions could be held only to apply to streams upon the public lands of the State, since the Legislature had no power to take away or impair the vested rights of riparian owners without providing for the payment of a just compensation. If the defendants or the owners of the land along the stream in controversy had the right to use the water for the purpose of irrigating their lands, that right remained unaffected by the plaintiff's incorporation or by the legislation of the State passed for the encouragement of irrigation. It seems to be the rule of the common law that a riparian owner has no right to use the water of the stream for irrigating his lands, provided it interferes with the uses of the water by those who own the lands upon the stream below. That this is a proper rule in England and in those States where the rainfall is sufficient for the purpose of agriculture we freely concede, but we are of opinion that in those sections where irrigation is necessary for the successful pursuit of farming it should not apply. What is not a necessary use in the one case becomes necessary in the other. *Evan vs. Merriweather*, 3 Scam. (Ill), 496. It was so held in *Tolle vs. Correth*, 31 Texas, 365, and though this decision was criticised in the subsequent case, *Fleming vs. Davis*, 37 Texas, 173, we are of the opinion that it recognizes a correct rule of law as applied to the present case.

"We think it a matter of common knowledge that there are portions of our State where the business of agriculture cannot be successfully prosecuted through successive years except by irrigation, and it is to be inferred from the allegations of the petition that the section where the stream in controversy is situated is of that character. We think, therefore, that the defendants had the right to divert the water which flowed in the stream along or through their lands for the purpose of irrigating them, although the effect of such use was to leave the plaintiff corporation an insufficient supply for the same purpose. Whether they had a right to divert the whole of it and leave an insufficient supply for the ordinary use of the lower riparian owners we need not in this case determine."

From these cases it is clear that the purposes named above as domestic are regarded as such in this State, and that irrigation ordinarily is not such a use, but that if in any particular locality the business of agriculture can not be successfully prosecuted through successive years except by irrigation, such use in such locality may be regarded as domestic, in a qualified sense; that is, so far as to give the right to so use the water, even though it may deprive lower proprietors of the opportunity of similar use, though this can not be done to the extent of cutting off the supply for drinking water, household purposes, or for stock.

PLATE VIII.

FIG. A.—Nile Valley Pumping Plant.

FIG. B.—Cottonwood Creek Flume near Bay City.

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