IRRIGATION OF THE YUMA VALLEY.

BY DAY ALLEN WILLEY.

One of the most important and interesting projects connected with the reclamation of arid territory in the Southwest is technically known as the Yuma project, as it is intended to irrigate an extensive territory located in the Yuma Valley and bottom lands adjacent

Reversed Abatis. Note Accumulation of Driftwood.

to the Colorado and Gila rivers in the States of California and Arizona. As is well known, the Colorado forms the western boundary of Arizona and a portion of the southern boundary of California. The Gila River enters it from the east a short distance from the town of Yuma in the extreme southwestern corner of Arizona. These two watercourses provide an abundant supply for the area to be irrigated, which for the present will comprise about 100,000 acres. The topography of the country and its formation make the work of constructing dams, canals, and suitable storage reservoirs unusually difficult. There is no natural formation of which engineers can take advantage, as in many other portions of the West, where nature has thrown up rock walls which can be utilized in storing the water supply. As readers of the SCIENTIFIC AMERICAN are well aware, the Colorado has for years been forming a bed for itself, annually carrying down an immense amount of silt in solution, which is deposited along its course. The channel of the Gila is somewhat similar to the Colorado, and this stream also is subject to very sudden and extreme changes in the volume of water, so that especial care must be taken to protect irrigation works against floods.

When the question of irrigating these bottom lands of California and Arizona was considered in 1904, the engineers of the Bureau of Reclamation decided that the best way to construct permanent works would be to erect a diversion dam across the Colorado River at a point below where the Gila flows into it. It would be necessary, however, in the opinion of the engineers, to have elaborate protection for the dam, and embankments large enough and of sufficient

strength to confine the waters of the rivers when in flood. The problem to be solved was how to secure a foundation for the levees and other works, and a form of protection against the flood waters which would prevent the barriers from being badly damaged if not entirely washed away by the flood currents. The plan adopted was decidedly unique from an engineering standpoint, as it was decided to depend upon earthworks guarded by wooden dams or abatises to check the flow of water against them. When it is stated that the levees considered necessary will when completed extend a distance of nearly 75 miles on the Colorado

it has been thoroughly tested by exposure to flood currents, with the result that no damage of importance has been done to either the concrete structure or the protecting banks.

The extensive mileage of levees is partly necessary to protect the main irrigating canals, of which there will be one on each side of the Colorado. The canal on the Arizona side will be 16 miles in length, the one on the Colorado side 10 miles in length, making a total of 26 miles and serving 138 miles of laterals, by which the water will be distributed over the bottoms. The water will enter the canals through gates, while pumping machinery will be installed at several points, where it will be necessary to raise the water supply to a higher level to serve the laterals. It is calculated that the dam, which is the only one of its kind in this country, will be of sufficient capacity to fill the main storage reservoir, which will have an area of 10 square miles. The dam is known as an India weir dam, being of a design which has been very successfully employed in East Indian irrigation, where it is usually constructed of wood.

In building the dikes or levees, much of the labor is done by scrapers and plows drawn by horses, as the soil being stoneless and soft can easily be heaped up and graded to the proper level. The work of building these levees is quite similar to the artificial embankments formed to restrain rivers in the South, the width at the bottom usually being several times the width at the top, although the crest of the embankments is ample to permit the building of railway tracks here and there, thus using it as a roadway. As the quantity of concrete required would be so great that it would be far too expensive to use in protecting the levees, and deposits of natural stone

Construction of Brush Fencing and Matting.

and Gila rivers, an idea of the magnitude of this work alone can be gained.

The diversion dam or Laguna dam, as it is called, will extend for a distance of 4,780 feet across the Colorado at a point 12 miles from the town of Yuma. Owing to the friable foundation of the river channel, the dam is of enormous width in proportion to its other dimensions, being 267 feet wide on the bottom, although but 19 feet in height. It will require 356,000 cubic yards of concrete to complete, and have a displacement in the water equal to the weight of 600,000 tons. This may be called the main work, and it is about two-thirds completed at the time of writing. Before work was begun, however, it was necessary to build a very extensive coffer dam as well as other temporary barriers to drain the river bed, so that a foundation could be laid. Work was also begun upon the levee protections referred to, until the construction has reached such a point that

Teams at Work on the Yuma Levee.

are too far distant to be employed, the main defense of the levees against the flood currents, as already stated, is woodwork in some form. This is obtained from timber tracts in the vicinity. Young trees are used extensively, the trunks being cut into suitable lengths, and used for the foundation of the matting or abatis. This foundation is fastened securely together, and upon it laid smaller limbs, their ends pointing up and down stream like the fascines of ancient fortifications. Bunches of brushwood and

Partly Completed Portion of Yuma Levee, Showing Brush Work Constructed Along the Levee.

Detail of Abatis. Note the Mats on Which It is Constructed and How Framework is Fastened Together.

shrubbery form the next layer, being worked in among the boughs beneath. In another form of wooden framework, posts are driven into the earth deep enough to secure a firm foundation, in which they hold rigidly. Then a sort of fence is made by nailing limbs of trees from post to post. The face of this fence is further protected by driving piles into the earth in front of its upstream face. Both in the front and rear of the fence are arranged layers of boughs and brushwood, sometimes covered over with earth and sometimes left bare.

These dikes are intended not only to protect the embankments, but to be land makers. Each extends outward from the levee a certain distance into the river channel, but at such an angle that it will catch driftwood and other flotsam which may come down the stream. This material will be piled against it, and as the mass enlarges, it will constitute a stronger barrier against the flood. The idea is similar in some respects to the jetties which have been constructed at various points on the Mississippi, not only to lessen the course of the currents and eddies against the embankments, but to restrain the debris on the surface, thus using it as a reinforcement to the bank, preventing it from becoming a dangerous menace when the river is in flood.

One of these levees has been completed from the town of Yuma to the site of the dam, and its brushwork defenses have been finished for a distance of about seven miles. Another levee has been completed from Yuma to the Mexican boundary, a distance of 20 miles. This section has already been called upon to resist several floods in the Gila, and has withstood the impact of the waters without a break, although it contains no stonework whatever, and its composition including its dikes is merely earth and wood. In completing plans for the Yuma system, the engineers in charge had to consider another difficult proposition—how to free the water in the rivers from the detritus which is held in solution at all seasons of the year, especially during high water. If the canals were to be filled directly from the rivers by the usual headgates, such a deposit would be carried into them and their branches that frequent excavation would be necessary to keep the ditches from being filled. As the water distribution in this way would be impracticable, the plans decided upon included arrangements for intercepting the deposits carried in solution to such an extent that the water entering the canals will contain but a small percentage, even during the flood season. While the Laguna dam will divert the water of the Colorado into the main canals described, it will be really of more importance in forming what might be called a settling basin. Here the velocity of the current will be restrained, and a pool formed, permitting such precipitation. But the brushwood dikes described will also be an important adjunct in this respect, especially during high water. They are not intended to prevent the water from flowing through them to a certain extent, but to check the current. During this operation much of the detritus, it is expected, will be caught against the dikes, and thus they will serve to filter the streams.

The Yuma project is expected to be entirely finished next year when water will be available for the hundred thousand acres mentioned. The soil to be treated has been analyzed, and found to be of an extremely fertile character when sufficiently moistened, while the climate is favorable for the raising of crops native not only to the temperate zone but the tropics. Yet this is a country of which the scientists have said, "It has no bottom," owing to the great depth of alluvial soil which covers the natural surface, carried down by the Colorado and its tributaries. Consequently, the work of the Reclamation Service in constructing irrigation works of such magnitude in this region is an engineering feat of no little importance.

Prof. Forbes's Theory of Jupiter's Eighth Satellite.

The great distance of Jupiter's eighth satellite from the planet, and its retrograde motion, which are matters of profound interest in the astronomical world, have led Prof. George Forbes, F.R.S., to advance an interesting and reasonable suggestion in regard to this celestial object.

"While speculation is premature," says Prof. Forbes, "it is impossible to resist the conjecture that there is a bare possibility that this new satellite is really the long-lost Lexell's comet which was discovered in 1770, with a periodic time of five and one-half years. In August, 1779, this comet approached Jupiter within 0.01 of the earth's mean distance from the sun and has not been again observed."

At that distance Jupiter's attraction exceeds that of the sun in proportion of at least 200 to 1, and the

distance from one of the satellites may have been very small and in this way, Prof. Forbes thinks, it is not impossible that the comet may have been diverted into an elliptic orbit round Jupiter, and a retrograde motion round the planet would be as likely to ensue as a direct motion.

The learned English professor concludes his observations by saying: "Should further observations reveal a moderate eccentricity the impossibility between this satellite and Lexell's comet will be proved."

Disturbing attraction of the outer planets has ever been a hard question for the astronomer—involving the question of orbits in limitless space either parabolic or elliptical, on which so much depends in astronomical calculations. Laplace, the eminent French astronomer, worked for years on the problem, which has arisen in this recent discovery, in the orbit of the giant member of our solar system. Laplace found that when an irregular comet passed closely in front of a larger planet its velocity would be retarded to such an extent that it would fall into an elliptical orbit and become periodic. If the planet were Jupiter it would be said that the comet had been "captured" by Jupiter and belonged to Jupiter's family. Its aphelion point would then remain near Jupiter's orbit, as Jupiter's mass is greater than all the other planets combined and its influence over comets is proportional to its mass.

Bacteria and "Molecular Motion" Seen with the Naked Eye.

Very fine particles suspended in a liquid perform oscillatory movements which were first observed by the English botanist Brown and are known as Brown's molecular motion. The phenomenon, which, until recently, has been observed only with microscopes of high power, is very conspicuous in the milky sap of

Section of Completed Portion of Yuma Levee.
IRRIGATION OF THE YUMA VALLEY.

the *Euphorbia*, which holds in suspension very fine globules of resin and caoutchouc. As the diameter of the largest of these globules does not exceed 1/50,000 inch, while the diameter of the smallest object that can be perceived, in the ordinary manner, with the eye is about 1/2,000 inch, no hope of observing the phenomenon with the naked eye was entertained; but Prof. Molisch of Prague has discovered that the motion may be made visible by a method of illumination similar to that which is employed with the microscope. A drop of the sap is placed on a glass slide which is held in a vertical or slightly inclined position before the eye and observed by the transmitted light of a sunbeam which strikes the glass obliquely. When the proper position has been found by trial the molecular motion suddenly becomes visible as a rapid flickering and dancing of the globules, which are tinged with beautiful colors due to diffraction. The brilliancy and distinctness of the picture are increased by placing a black background a couple of inches behind the glass. The visibility of the phenomena under these conditions is probably due to the enlargement, by diffraction, of the retinal images of the globules.

Bacteria, which are in general much larger than the *Euphorbia* globules, have been seen with the naked eye by Prof. Molisch in the same manner.

The American Society for the Prevention of Cruelty to Animals will shortly begin experiments with a new method for killing animals. Henry Bergh, the treasurer and former president of the society, has invented an air gun of large size, working like a pneumatic hammer. The society some time ago offered a reward of \$500 for an improved and humane method for slaughtering purposes. Mr. Bergh thinks his invention fulfills the requirements of the society for an improved device for slaughtering animals.

The \$25,000 Transvaal Stope Drill

Competition.

We have already briefly referred to the Transvaal stope drill competition, which has been organized by the Transvaal government and the Transvaal Chamber of Mines. The London Engineer publishes the following additional information:

The object of the competition is to obtain a small drill capable of economic use in narrow stopes on the Witwatersrand, which are at present worked for the most part by hand labor. It is stated in the rules that no entry will be accepted in respect of a machine which weighs more than 100 pounds. It is desirable that the machines should be as light as possible. The main part of the trials or competition will, it is thought, extend over a period of six months. In order to reduce the entries for the prolonged underground test to a number that can be conveniently handled, elimination trials will be held successively on the surface and underground. Only those machines which have passed the surface elimination trial will be allowed to enter the underground elimination trial. At the conclusion of the latter trial the committee will arrange the entries taking part in the chief test in the order of merit with regard to footage drilled and air consumed, and will then decide which may enter the competition. Two machines of each entrant will be run for 300 shifts each by day and night continuously, with the exception of Sundays and legal holidays. The length of shift will be of equal duration on each mine. The mines and working places in which the competition will be carried out will be selected by the committee, and, so far as practicable, each entry will be run for an equal period in each stope in each mine selected.

During the competition the machines will do ordinary mining work, in accordance with instructions given to the miners. Not more than two holes on any rig-up shall be counted, unless the committee expressly sanction it. The competing machines will not be required to cut pillars, box holes, etc. Numerous other regulations dealing chiefly with spare parts are given which we have not space to reproduce here. The last two rules state that the air pressure must not exceed 75 pounds per square inch, or be less than 60 pounds per square inch. The air consumption of each machine will be tested on the surface at least once a month during the competition.

Handsome rewards are offered to the winning machines. The first prize is \$20,000 and will be awarded to that group of machines for which the total cost, when divided by the total footage drilled by them during the competition, is least. The second prize of \$5,000 will be awarded to that entry which is considered by the committee to be the second best. The right is reserved, however, in case of two or more entries showing approximately equal results, to ignore small differences in points, and award the prize to that entry which is considered most suitable for the conditions prevailing upon the Rand, having regard to weight, general design, ability to drill deep holes, freedom from stoppages and breakdowns, facility of handling, and suitability for narrow stoping. Those who are interested in this competition should apply to the secretary of the Transvaal Chamber of Mines, 202 Salisbury House, Finsbury-circus, London, E. C., England, for a copy of the regulations.

Providing for Future Railroad Ties.

The Santa Fé system is perfecting plans for a forest of eucalyptus trees in San Diego County, California, from which to obtain a steady supply of crossties. A ranch of 8,000 acres has been purchased for this purpose, and as a start 600 acres will be planted. It is estimated that in eighteen years the company will be able to harvest from six to eight ties to a tree, and keep up the harvest thereafter continually. At present the Santa Fé system uses about 3,000,000 ties annually. In eighteen years the company thinks it will be able to obtain from its forest 7,000,000 annually.

The growing scarcity of timber suitable for ties, with a resultant increase in their cost, has led eleven roads, including the Santa Fé, to start forests. Ten roads in the East have already planted in their respective forest sites thousands of catalpa, black locust, red oak, pin oak, and chestnut. The Santa Fé has selected the eucalyptus because of its rapid growth and adaptability to the climate of California, New Mexico, and Texas.

Eucalyptus ties in Hawaii are said to last fifteen years. East of Albuquerque the Santa Fé is using Georgia pine. At present both the Santa Fé and Southern Pacific are using many thousands of redwood ties on the coast. They are also getting oaken ties from Japan.