ENGINEERING AND SCIENCE
Monthly
Vol. IX, No. 11 November, 1946

Imperial Valley Looks to the Future

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TODAY the world is food-conscious. As the population increases, the farming areas, their fertility, and their crops become more important. For the next few years, or perhaps longer, the United States is destined to play a large part in the feeding of the world. Its ability to do this will depend upon the development of many rich farming areas throughout the country. It is no exaggeration to say that the Imperial Valley of California is one of the most important of these, and since it is being further developed, the present article will show it will continue to play a larger part in the farming industry. This part will include not only the actual growing of crops, but the setting of an example for others in the solution of its complex problems and in its ultimate success.

CROPS

The Imperial Irrigation District which delivers water to more than 400,000 acres of normally farmed land in Imperial County, California, is the largest in the United States. The actual gross acreage under canals is 612,000 acres, with an additional 250,000 acres of land assigned for future development on the East and West Mesas. Irrigation of this quarter of a million acres will be possible because of the All-American Canal, which will be discussed later. Agriculture is the dominant industry in the Imperial Valley, with manufactures chiefly related to the processing and packaging of farm products. The chief advantage of the area, in addition to its abundant water supply from the Colorado River and its rich soil, is the warm climate which causes crops to develop early, permitting entry of the markets before competition. To take full advantage of this opportunity, the Valley has specialized in the raising of winter vegetables, early cantaloupes, tomatoes, and many other truck and field crops. Since only a minor portion of the land is in permanent crops, the agriculture is very flexible and able to follow any favorable marketing trends. In general, also, agriculture is highly commercialized and conducted on a large scale. The 1940 census showed that 30 per cent of the acreage was in farms of 1,000 acres or more, while only 16 per cent included farms of less than 100 acres. A regular pattern of crop rotation is followed, with alfalfa almost universally used to restore the productivity of the soil after the growing of truck, flax, and grains. The most successful general practice is to use the best land for truck crops about three years out of six or seven.

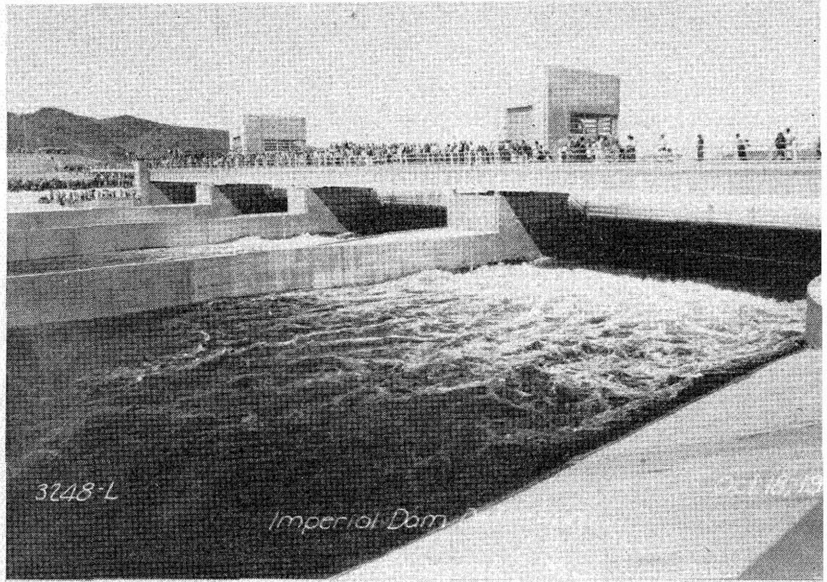
The crop values, including livestock, shipped out of the Valley varied from 41 million dollars in 1938 to a low of 19 million dollars in 1932 to a high of 64 million dollars in 1945, with the following general breakdown in 1945:

Crop	Value dollars (millions)	Crop	Value dollars (millions)
Cantaloupes and Honey Dews	7.5	Flax	4.5
Lettuce	9.2	Alfalfa	11.8
Peas	0.7	Sugar Beets	2.1
Carrots & Cabbage	6.0	Cattle, Sheep & Hogs	9.4
Tomatoes	1.4	Dairy Products	1.0

Plate 1. Rice field west of Imperial.

Plate 2. Imperial Dam dedication October 18, 1938. There is usually water flowing in all channels as it is here. The people on the dam are reflected on the roller gates.

Plate 3. Completed section of New Briar Canal from drop 5. This is a typical canal section.



Thus there is reason for the contention that the Imperial Valley can be reckoned a major factor in our food production. It grows roughly 25 cents of every hundred dollar's worth of crops raised in the United States.

Although a large portion of the products of the Imperial Valley is shipped to all parts of the United States by rail, a considerable amount is sold to the constantly growing markets of San Diego and Los Angeles. This proximity to major markets is also a very important factor in the success of the Valley.

LOCATION AND PHYSICAL CHARACTERISTICS

A prerequisite to the understanding of the Imperial Valley, its problems and their solution, is the realization of its location, physical characteristics, and attributes. The area that is now known as the Imperial Valley lies in the Southeastern corner of California, on the floor of what was once in the geologic past an arm of the Gulf of Lower California. About half of the Imperial Valley area, known as Mexicali Valley, is situated in Mexico. In past ages the Colorado river, in the process of building its delta as it flowed into the gulf, dammed off the upper end, which, when the water evaporated, became a deep inland valley, for the most part below sea level. From time to time the Colorado would overflow its banks and fill up this dry lake, forming a large inland body of water. Eventually, however, the water would disappear and leave the bed an open desert. It is estimated that the last of these lakes disappeared about 700 years ago. During these inundations, the Valley was packed to a great depth with fine silt laid down almost level but with a gentle slope to the north. These rich alluvial deposits, representing the top soil from about one-thirteenth of the United States, plus some coarser textured wind-transported material, constitute the present soils of the Imperial Valley.

Thus Nature set the stage in the Imperial Valley for great things; climate, fertile level land, and a convenient source of water was provided. Man had only to see the possibilities and develop them. Nature had, however, disguised her gifts. Before irrigation the Imperial Valley was an extremely dry, hot desert, very difficult to cross, with water holes few and far between.

HISTORY

When the Spanish explorers in the middle of the sixteenth century became the first white men to gaze upon the Imperial Valley and Colorado River, they dreamed not of the possibility of agricultural development but only of the fabled gold which lay to the north across its hot sands and along the banks of the Colorado in the legendary "Seven Cities of Cibola." A century and a half later when De Anza and Father Junipero Serra trudged wearily across the wasteland upon which grew only cactus and lizards, it was not their promised land but a necessary evil in the journey between Mexico and the Missions of California. In the days of the 49'ers, the Imperial Valley, then known as the Colorado Desert, lay on the trail from Fort Yuma to San Diego. The wagon trains did not tarry on that hot trail unless absolutely necessary. Many broken wagons and charred bones bear mute testimony that not all who started from Yuma reached their destination. These men filled with the gold fever, as were the early Spaniards, failed to note the richness of the soil, the flat and for the most part, cleared land, and the gradual slope from the Colorado River which made the desert ideal for something more substantial than the smoke dreams of gold. All men apparently were asleep to the facts which lay before their eyes; that is, all except one, Dr. O. M. Wozencraft, who is considered to be the real "father" of Imperial Valley. He alone did not curse the sand and the heat and the lack of water, as in him was born the idea of converting the desert by irrigation. Although Dr. Wozencraft dreamed of great things and saw the tremendous possibilities, his endeavors were drowned by the Civil War.

After Wozencraft's death in 1887, it was only a

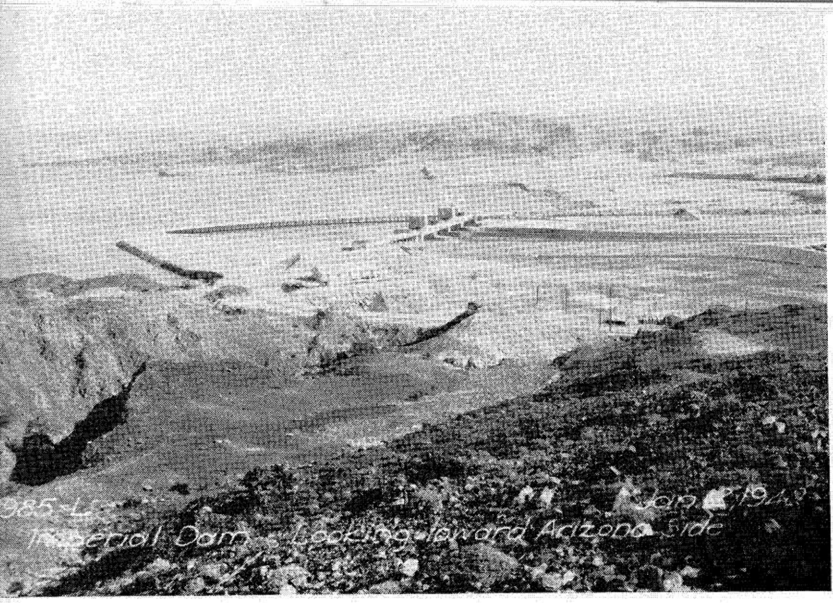


Plate 4. Imperial Dam, looking toward the Arizona side. Rockwood Heading is to the far right.

matter of a few years before a civil engineer, C. R. Rockwood, stumbled upon the fact that the large area could be irrigated from the Colorado River and with a visionary's enthusiasm began the battle to get water into the Colorado Desert. He conducted careful surveys in 1892-1893, in which he ran lines from a proposed headgate near Yuma, Arizona, down some old Colorado River overflow channels and into the Salton Sink in the vicinity of the station of Flowing Well on the Southern Pacific Railroad. He discovered that the canal would have to go through Mexico, since in the United States there was a natural barrier of high lands and sand hills between the river and the basin. Furthermore, the series of passages around the high lands which had been formed by the Colorado River through the centuries on its way to the Salton Sink provided a natural and economical diversion canal. When he attempted to obtain a right-of-way across the lands of Mexico for the canal, however, the trouble was started with that country which was to last for 30 years. To make possible the irrigation of the desert, the "California Development Company" was formed in 1896, with little capital but a wealth of hope. Rights were finally obtained from Mexico for the canal through its territory, and after a bitter financial struggle, water from the Colorado River was first delivered into the Imperial Valley in 1901.

This was not the end of the story, however; it was just the beginning. Many hardships and trials were to be endured before the Colorado River would be conquered and a measure of security attained for the people of the Imperial Valley. For the first few years after 1901, there were problems for the farmers in getting their land under cultivation and learning what crops would grow the best. They found that almost anything they tried was a success, since the soil was fertile and warm winters made for a long growing season. Through their efforts the cultivated area continued to increase until in the winter of 1903-1904 it had reached considerable proportions. So much so, that in this winter there was a serious water shortage when the riven went down and the headgate would not divert a requisite quantity of water. The cause of the lack of diversion capacity was the deposition of silt in the headgate and upper mile of the main canal. This was the Valley's first experience with the silt which in the following years would become a constantly increasing menace. Since the California Development Company had not necessary equipment to remove the silt, a plan was decided upon whereby the Colorado itself was to carry the silt from the main canal. About 15 miles down the canal, in Mexico, was a shallow lake into which the Colorado periodically overflowed. A waste gate was installed in the canal at an advantageous point on the shore of this lake. During the flood season, an extra-large quantity of water was to be diverted from the river and the excess subsequently wasted at this point. According to the theory, this large volume of water would sluice the silt deposit out of the upper channel, lowering it in preparation for the next drought season. The plan was carried out and the flood diverted through the headgate.

Although the large flow seemed at first to be behaving as planned, the benefits were only temporary, for, as the flow decreased, it became evident (in the summer of 1904) that the canal grade for the upper four miles had been raised to such an extent that no diversion could be made at even moderately low water. Although dredging equipment available was not sufficient to remove the deposit from the upper canal channel, it was capable of doing a smaller job. With the need for water becoming more urgent day by day as the river fell, the decision was reached, after much discussion, to make a new cut from the Colorado into the main canal at a point below the silt deposit at which only 3300 feet of easily removable river deposits separated the two channels. This new cut had to be made in Mexico, and thus the consent of the Mexican Government was necessary. However, since there was little time for waiting, the California Development Company, believing that an understanding had been reached, proceeded to make the cut and to send elaborate plans for a controlling gate to Mexico City. Since permission of the Mexican government was also necessary prior to the construction of any controlling structure, every effort was made to obtain early approval. Meanwhile, the Colorado took advantage of the unprotected channel.

With the new diversion in operation during the summer and winter of 1904-1905, there was ample water for irrigation of corps. However, as the winter waned, the wiser heads began to wonder what would happen when a flood came through the open cut. About that time, February, 1905, a series of unusually early floods arising in Gila River, a tributary, marked the Colorado's first efforts in a two-year battle which almost wrote a finis to the Imperial Valley and the high hopes of the inhabitants. Contrary to all precedent, three floods came down the river during the months of February and early March, 1905. The cut widened until a veritable torrent was being diverted from the river into the main canal. Since this tremendous inflow of water was far more than was required for irrigation purposes, the excess ran into the Salton Sink, which was originally dry, and began to fill it, forming what is now known as the Salton Sea. With haste born of necessity, a series of fruitless afforts was made to close the cut, which, in spite of all endeavors, grew larger. Through the summer of 1905 and the following winter and the summer of 1906 the gap widened until the entire flow of the Colorado was all but submerging the Imperial Valley. It was not until the following February, 1907, that the break was finally closed, after six expensive failures. The successful closure was made largely through the efforts and at the expense of the Southern Pacific Railroad. This company was vitally interested in the fate of the Imperial Valley because of the revenues it derived therefrom, and also because its tracks paralleling the Salton Sea were continually being flooded and had to be moved farther back as the water level rose.

IRRIGATION PROBLEMS

From the beginning, the Imperial Valley has had a multitude of irrigation problems to face, some of which have threatened the very life of the Valley itself, as did the flood which has already been discussed. Since the Imperial Irrigation District came into existence in 1911, it has attacked and solved most of the problems completely. Although it has achieved only a partial solution for the remainder, the future promises complete success. The following is a summary of the principal engineering problems which confronted the Imperial Irrigation District when it was formed:

1. Danger of flood from the Colorado.
2. Inadequate water supply in drought years.
3. High silt content in the water, which made necsary continual dredging of canals and raising of the levee from the intake to the Gulf of California.
4. Dependence on water supply which flowed through Mexico.
5. Alkali accumulation in the soil and high ground water table caused by lack of drainage.

Since the first four problems have been very nearly solved, they will be discussed first, along with their methods of solution.

As was mentioned in the brief history of the Valley, a drought followed by a flood was the cause of the first serious trouble other than that of a financial nature which the residents of the area encountered. Although the Colorado is one of the major rivers of the United States, draining about one-thirteenth of the land area, its flow is very unpredictable. The discharge at Yuma, Arizona, has varied from 200,000 cubic feet per second to a low of about 1,000 cubic feet per second. During the maximum flow the levees were hard put to keep the flood out of the Valley, and in drought times there was not enough water in the river to maintain livestock. Thus it was necessary in the past to keep constant watch along the river levees from the intake to the Gulf, maintaining a rock train and crew in preparation for a flash flood which could break through. The problem was further complicated by the fact that silt in the river continuously built up the channel grade at the lower end near the delta. To offset this action, levees had to be raised from time to time, at great expense. Equally as troublesome as the flood danger was periodic lack of water, which was made more critical by the agreement existing with Mexico in exchange for the right to deliver water to the Imperial Valley through that country. The Mexican lands were entitled to half of the available water, although the irrigated acreage was much smaller than that on the United States' side. In addition, the Imperial Irrigation District had to provide levee protection and irrigation facilities for the Mexican lands without cost. Thus, Mexico received half of the available water and paid only the cost of distributing it to the lands. In view of these international complications, the need for a main canal entirely in the United States was very apparent.

The Colorado River, in addition to being one of the chief rivers of the United States, is also one of the largest in volume of silt carried. It has been estimated that prior to the completion of Boulder Dam the Colorado deposited 137,000 acre feet of silt per year onto its delta at the head of the Gulf of Lower California. This silt continued to build up the delta and raise it higher and higher above the floor of the Imperial Valley. In addition, it deposited in the canals, so that the Irrigation District had to employ dredgers constantly for cleaning operations. The canal banks continued to grow in height, and as they did, the maintenance cost increased steadily. The burden of silt carried by the river was not only expensive in forcing the erection of the elaborate levee system in Mexico and in canal maintence, but also tended to seal the land, preventing proper penetration of water. Actual measurements of the amount

Plate 5. Rockwood Heading, showing the Colorado River to the left and the Alamo Canal to the right. Water is diverted to irrigated lands in Mexico. Formerly all Imperial Valley irrigation water passed through here.

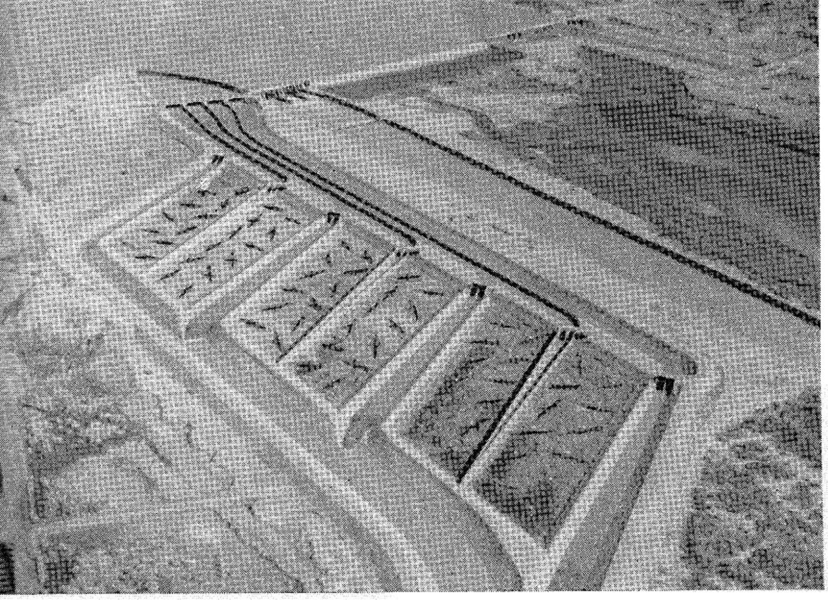


Plate 6. Imperial Dam and desilting works. The scrapers rotate constantly at a very low speed. The basins, usually full, are empty in this picture.

of silt carried in the canals indicated that the maximum reached as much as 30 per cent by volume, with an average of 15 per cent for an entire month. The annual cost of dredging the canals alone was $750,000.

The answer to the first two problems of flood and drought was obvious, namely, upstream storage. This came in 1935 with the completion of Boulder Dam. Boulder Dam is also proving a partial solution to the silt problem, since the dam is in a position to catch a large quantity (about 95 per cent of the Colorado's silt burden, and Lake Mead has a large enough capacity to retain the accumulation for an indefinite period of years. Also, conceivably, Boulder Dam aids in controlling the alkali menace, not by decreasing the total amount of salts in the water, but by portioning the percentage of dissolved chemicals throughout the year. This is important, since in the pre-storage days the salt content ran well below 600 p.p.m. during flood season, but in the period of low flow, the salts increased to as much as 2500 p.p.m., an amount which made the water undesirable for humans, animals, or irrigation purposes. Thus Boulder Dam serves the Imperial Valley in four important irrigation functions: water storage, flood control, silt storage, and equalization of dissolved salts. As an example of the degree to which the drought problem has been solved, it may be stated that Lake Mead stores enough water to supply downstream users for a period of four years without inflow.

Although Boulder Dam was the answer to several of the problems of the Imperial Valley, a major difficulty still remained, namely, the dependence on Mexico for water supply. This was taken care of by the All-American Canal, which was authorized as a part of the Boulder Dam Act in 1928. As discussed previously, the main canal from the river was originally routed through Mexico, (1) because the natural overflow channels of the Colorado were followed, and (2) because the digging of an All-American Canal at that time was entirely out of the question from a monetary standpoint. In addition insufficiency of engineering excavation equipment available at that time made the operation economically unfeasible if the money had been available, and there were many who felt that a cut through the sand hill barrier would not remain open but would be filled with the drifting sand. This latter point has proved to be entirely false since the completion of the All-American Canal, because no difficulty has been experienced with major movements of the sand hills, although the cut through this treacherous area in places is over 300 feet.

The All-American Canal has its diversion point at the Imperial Dam between California and Arizona, about 15 miles upstream from the town of Yuma, Arizona. It roughly parallels the Colorado to a point a mile north of the Mexican border. From here it turns to the west, remaining just inside of the international boundary until it reaches the Imperial Valley. Figure 6 is a photograph of the Imperial Dam, with the desilting works in the foreground. In the background are the Gila diversion works in Arizona. In the center of the Imperial Dam is the overflow section, adjacent to it is the wasteway, and at the near end, on the California side, is the gate structure, housing four diversion gates 75 feet long, for the channels pictured. Three of the four diversion channels lead to the desilting basins, which can be used or not, as desired. A fourth desilting basin may be installed in the remaining channel at a future date. The desilting basins were not used for the first few years of All-American Canal operation, since silt was deposited behind Imperial Dam. Since this structure is intended for diversion only, its silt storage capacity was soon exceeded with the result that it has been necessary to employ the desilting basins for over a year. Figure 2 is a photograph taken on October 18, 1938, when water was first diverted through the gates into the canal. Figure 7 shows the siphon structure which was necessary across New River Channel in the Valley itself. New River is a wasteway which drains into the Salton Sea. It was eroded during the 1906 flood, previously mentioned. The capacity of the canal is 15,000 cubic feet per second at its head, but through diversions and a waste-way-drop back into the Colorado its flow is decreased to 10,000 cubic feet per second when it enters Imperial Valley. The Irrigation District can now deliver water to Mexico at the border and does not encounter the international difficulties inherent in the former arrangement. The use of drops in the All-American Canal for power development will be discussed later under "Power Development."

In connection with the All-American Canal it is interesting to note in passing that some problems have now arisen because of lack of silt in canals. First, in some cases, canals have been widened in order to reduce the erosive effect of the clear water; and second, a rather serious moss condition has developed in canals and drains because of the relatively clear water. Moss could not grow in the formerly "silty" water.

Although Boulder Dam and the All-American Canal have eliminated most problems, one very pressing danger remains to be met. There is need for drainage both in order to lower the water table in numerous places and to remove the alkali accumulation which in the past has ruined many fertile acres.

The principal agricultural soils in the Valley are made up of alluvial deposits of fine-textured clays, silts, and sands which were laid down in the geologic past by the waters of the Colorado. There is also some land made up of coarser-textured wind transported material. Natural drainage of soils has been retarded by their relative imperviousness, insufficient surface slope, and lack of underground gravel beds. In many of the areas having inadequate drainage, the water table has come up to within six feet of the surface and alkali has accumulated in sufficient proportions to eliminate a part of the land as an efficient crop-producer. Thus large areas of the Imperial Valley in the past lay idle because of the alkali menace. Since it has been found that the high salt content of the Colorado (some 600 p.p.m.) does not increase the alkali content of the properly drained land, the Irrigation District has been carrying out an extensive drainage program. This program has been conducted actively for over 20 years. but the amount of work done per year has varied. For a few years during the depression, practically all efforts of this kind ceased, but with operations now in full swing, the District is nearing completion of ts program to provide a main outlet drain for every 160 acres of irrigated land. About 1200 miles of the projected drains are now completed, with about 100 remaining. Actual drainage of the farm lands is left to the individual owners who use either open cuts or tile drains. The variation in the types of soil has made any universal solution of the individual problem impossible. On the lighter soils, tile drains have proved very effective, with 500 miles in operation at the end of 1942 serving an area of 12,000 acres. Recent experiments indicate that tile works satisfactorily on some of the heavier soils, and pumping, which had not been thought feasible, has in a few special cases economically and practically justified itself.

Although the drainage problem is far from being solved, the adverse trend of conditions has been checked in that decline in some lands has been more than offset by improvements in others. This produces a hopeful picture, as compared with the situation in 1922, before the drainage program had been instituted and when a large acreage of formerly good land had gone out of production altogether.

A rather novel means has been found to reclaim some of the most alkalied and "tight" land in the Imperial Valley. That is by growing rice on it. The water standing on the land slowly goes into the ground, taking the soluble salts. A large quantity of water is required to dilute the salt so that the rice will live, but rice needs the water and the reclamation pays for itself, since the crop produced has a ready market. After the rice has been grown for two or three years, depending on how serious the original condition, another higher-return crop, such as flax, is put in for a year or two before rice production is again necessary. In this manner, much of the land previously considered hopelessly alkaline is being brought into fruitful production. Figure 1 is typical of a rice crop grown on this formerly "useless" soil.

POWER DEVELOPMENT

In addition to its original purpose of keeping the water for the Imperial Valley in the United States, the All-American Canal performs other services. First, it will make irrigable about 250,000 more acres on the East and West Mesas which were formerly above existing canals, and second, it provides a convenient source of electric power. The development of more land in the future is a straightforward proposition and therefore requires no additional explanation. Power development however is so interesting as to call for further discussion.

Since much of the territory traversed by the All-American Canal is covered with very light soil, and since the flow at times carries silt from the Colorado River, the canal grade was carefully designed to maintain the proper velocity of flow and prevent either scouring or deposition. It was thus necessary to construct a number of drops at points where changes in grade were essential. At four of these drops with an aggregate head of 126 feet the development of power is feasible. In anticipation of this development, the Imperial Irrigation District in 1936 installed a diesel plant at Brawley, California, one of the principal cities, and entered the power business. Since mutually satisfactory terms could not be reached with the California Electric Power Company, which was then operating in the area, the District commenced business in direct competition with the privately owned company in May, 1936. As the operation became more successful, the diesel plant was enlarged to take care of the constantly increasing

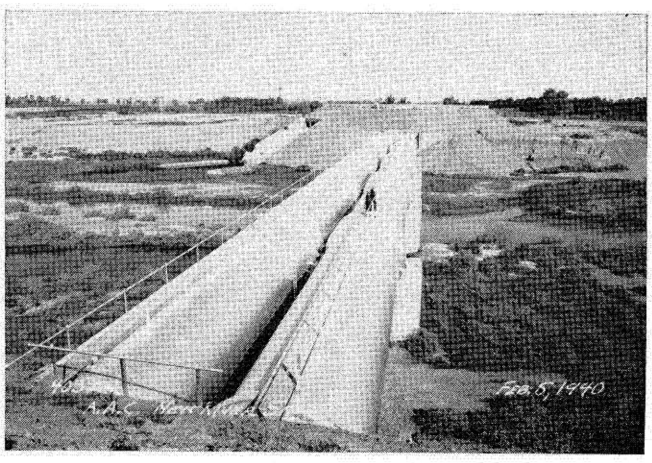


Plate 7. A.A.C. New River Siphon. The pipes are 15′ 6″ in diameter, and canal capacity at this point is 2600 second feet.

needs. The ultimate purpose of this plant, which now has an installed capacity of 12,000 kw, was to act as a source of standby and peak power loads after the units were installed at the All-American Canal sites. The first installations on the canal consisted of one unit in each of two drops. These would have an aggregate capacity of 14,400 kw, and they were ready for operation in 1940. This development represents a small portion of the total installed capacity of 91,500 kw which will be available and developed in the future. The number of customers on the District's lines increased steadily until in 1942 it obtained 62.4 per cent of the electric revenue of the Valley. In April, 1943, the District reached an agreement with the California Electric Company, covering purchase of the latter's properties in the Imperial and Coachella Valleys.

Since the firm capacity of the diesel standby plant in Brawley is only 9,000 kw, while none of the hydro power can be classified in this manner, the District needed an additional source of firm power to serve its territory with a 25,000 kw load. This was taken care of by a contract with the United State Bureau of Reclamation whereby the District secures 15,000 kw of firm capacity from Parker Dam. The District in return sells surplus power back into the Parker system. At the present time, plans are being completed for the installation of more hydro units at the existing power houses on the canal and for construction of a 20,000 kw steam plant at El Centro.

In addition to its primary purpose of providing electricity for the farms and homes of Imperial Valley, the power development on the All-American Canal serves another equally or perhaps more valuable service. It is the sale of power from these four drops which makes the All-American Canal financially feasible. In spite of the Imperial Valley's dire need for the canal, as has been pointed out, it is doubtful that the cost of the canal could have been carried by assessment on the lands. However, by development and utilization of these power possibilities, revenues are being provided which will, to a large extent, repay the cost of the canal.

PROSPECTS

With most of its irrigation problems either solved or definitely approaching solution the Imperial Valley *faces a period of almost assured prosperity.* To the advantages which Nature bestowed have been added the works of the farmers and engineers. The flood, drought, and silt problems are things of the past, and there will be fewer complicated international problems now that delivery of water is entirely within the United States. Large amounts of money will be saved the Irrigation District in maintenance of levees and canals in Mexico. This saving of money will extend to the United States side of the border because the absence of silt has made unnecessary the constant dredging of canals. Last, the All-American Canal, which is operating very successfully, will furnish electricity to the farms and cities of the Imperial and Coachella Valleys. Revenues from the sale of this electricity will be the principal source of funds with which the cost of all of the All-American Canal will be repaid.

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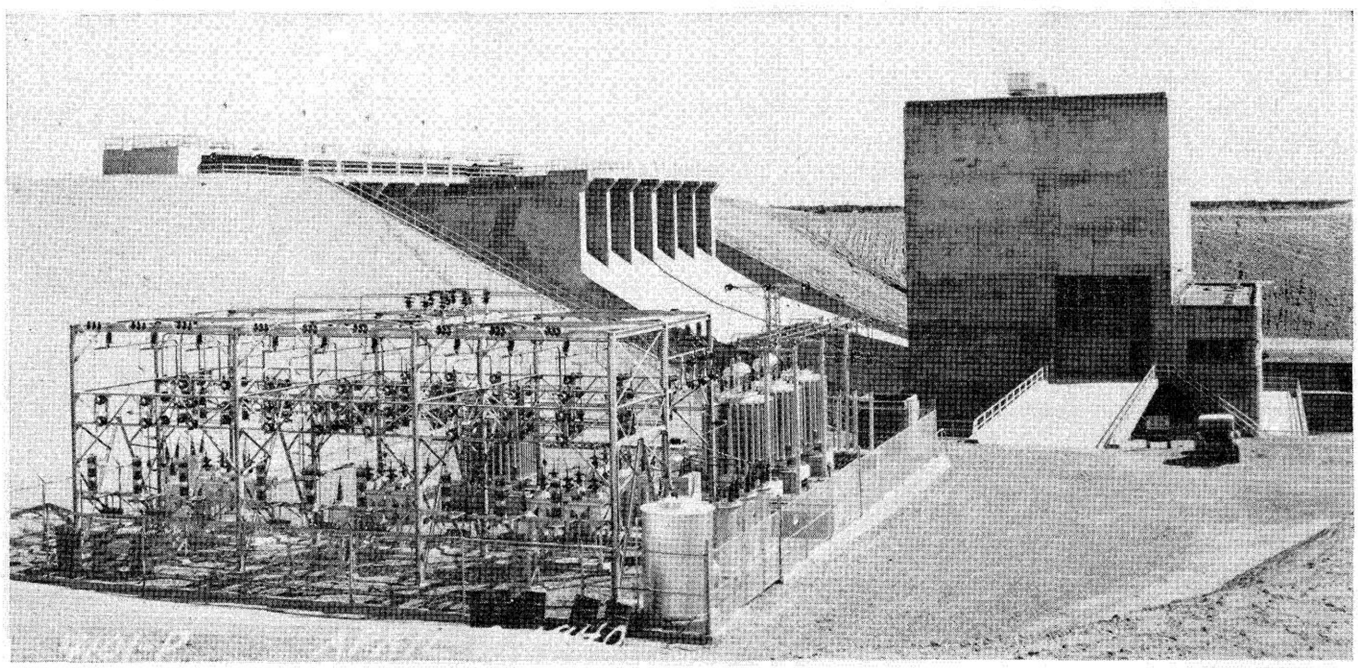

Plate 8. A.A.C. power drop 4. The turbine house is in the center of the gate structure. Spillways are on either side. Drop is 52 feet, giving 9600 kilowatts now, with a 19,200 kilowatt capacity planned eventually.