PAP-40

To H. M. Martin

Charles W. Thomas
April 7, 1953

SOME IMPRESSIONS OF EUROPEAN ENGINEERING PRACTICES

C. W. Thomas
Hydraulic Engineer
Bureau of Reclamation
Denver, Colorado

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Last September I obtained a leave of absence from the Bureau of Reclamation and have spent the past year studying and traveling in Europe and North Africa.

This research was made possible by a Fulbright grant which was awarded to me. Perhaps some of you may be interested in the Fulbright program. The Fulbright Act, Public Law 584, 79th Congress, passed in 1946, authorizes the use for educational purposes of some of the funds acquired abroad by the United States from the sale of war surplus property. These funds remain in the currency of the foreign countries and can be used to finance an American citizen while he is studying, doing research, or teaching in the participating countries. Not being in dollars, these funds cannot be used in the United States, but they may be used to pay the transportation of foreign students to and from the United States. Some other means must be provided to finance the education of the foreign student while he is in this country.

The program is administered by the Conference Board of Associated Research Councils. The mechanics of obtaining a Fulbright grant are, briefly, first, an application is tendered by the applicant. In this application, numerous questions are answered by the applicant concerning his educational qualifications, his experience, and numerous other inquiries regarding his personal affairs. In the application, the applicant must state definitely what he wants to do, where he wants to do it, and by what means he proposes to accomplish the work outlined.

Secondly, the application is passed or rejected by the Board committee. This committee is composed of experts in the field chosen by the applicant. For instance, in the engineering field, engineers constitute the Board.

Third, the applicant is cleared by the State Department and by the Educational Commission of the foreign country where he wishes to study. If everything is in order and the applicant has a worthy proposition, the grant is awarded and the study is begun.

In my request, I stated that the award would be used to conduct research toward the improvement of (1) hydraulic features of irrigation systems; and (2) methods of applying irrigation water to the land, with particular emphasis on control and measurement of water and the design, operation, and maintenance of open and closed irrigation systems.

The greater portion of the time was spent at Grenoble, France, in the Alps near the junction of French-Italian and French-Swiss frontiers. The reason for selecting this particular location was, briefly, that it was possible because of an existing agreement to obtain credit toward a degree, doctor-engineer, from the University of Grenoble while engaged in research work at the NEYRPIC Hydraulic Laboratory.

This laboratory is operated by a stock company engaged in the manufacture of equipment for hydraulic structures, including turbines, gates, valves, and similar items. To give you some idea of the importance of this company; in 1950, NEYRPIC delivered approximately the same tonnage of completed hydraulic equipment as S. Morgan Smith Company in the United States.

In 1932, the government of Algeria assigned to the Hydraulic Laboratory the problem of developing equipment for proposed irrigation systems for that country. Since that time, the engineering staff at the laboratory has been actively engaged in many irrigation developments. Therefore, it may be seen that an opportunity for study of irrigation development was afforded. Also, the company has subsidiaries in Spain, Portugal, Italy, North Africa, and other parts of the world. The subsidiary organizations provided contacts through which arrangements could be made to see the irrigation systems and equipment in operation in the various countries.

I visited the major irrigation developments in France, Portugal, Italy, Algeria, and Morocco and saw some of the engineering work in these and other countries of Europe.

Although I went to Europe to study hydraulics and hydraulic structures, I was able to observe some of the economic and political aspects and their relation to engineering.

To mention a few of the political aspects and the manner of thinking of the people in Europe, I would like to cite a few incidents.

Many people feel that aid from the United States, financial and otherwise, is given too freely to the countries who were enemies of the Allies during the war. A currently circulating story in Europe illustrates my point. It seems that the Cabinet members of the newly formed state of Pakistan were assembled and engaged in serious consideration of the extreme financial difficulties facing their new country. The discussion had been going on for considerable time when one of the Cabinet members proposed a plan. His plan was that Pakistan declare war on the United States. His reason for this was that, of course, Pakistan would lose the war and then they would receive huge grants of dollars as Japan, Germany, and Italy are now receiving. The suggestion was taken seriously, and no one offered any comment for some time. Finally, the chairman of the meeting said, "I do not wish to appear pessimistic, but what if we win this war? We would certainly be in the devil of a fix."

I encountered considerable language difficulties throughout Europe. The countries there are small, and each time a border is crossed a new language must be dealt with. I had a working knowledge of Spanish and French when I entered Europe, so I was able to get along fairly well. However, in some of the countries, such as Portugal and Italy, it was quite difficult. I do not believe we in the United States quite understand the language problem with which the people in Europe are faced. Their very close neighbors sometimes speak an entirely different language. One has to travel only a few miles in some places to pass from one country to another and from one language to another. The language difficulties, of course, did not permit me to learn all that I might have if I had had a better knowledge of all the languages of the countries through which I traveled.

There are a number of amusing incidents connected with the various languages, and one, particularly, that I had told to me a number of times because I was an American. It seems that in many places signs are posted "English is spoken--U. S. understood." I was glad to find out that the U. S. language is understood in a number of places, and I was able to at least get the necessary food to eat. Speaking of food, I found, in general, that it was very good, especially in France.

I also heard of another incident regarding a restaurant which displayed a large sign outside the door, "All languages spoken here." A British subject entered the restaurant and asked, in English, for a meal. The waiter did not seem to understand, so he repeated his request in two or three other languages, and finally called the manager. He said, "I don't understand. You have a sign outside the door, 'All languages spoken here,' and yet I ask the waiter in several different languages for certain items of food and he does not understand me. What about this sign? Who speaks all these languages?" The proprietor quickly replied, "Oh, my customers!"

We will now dismiss these aspects and look into some of the engineering features.

The first thing I want to point out is that in European engineering practices a theoretical approach to the solution is generally employed. In the United States, we usually employ an empirical approach to our design problems. I do not mean to say that there are not a great number of empirical coefficients, etc., left in the European method of design, but, all in all, they do use a more rational approach to the solution of design problems than we use. Possibly this gives them a more rounded knowledge of the fundamentals, but there may be (and this is my personal opinion) also some deficiency in linking purely scientific developments to practical application.

In the solution to engineering problems in general, the European does a great deal more investigation than we do. I might put it this way: We find the Europeans still moving pencils, while we are already moving dirt on the project.

The large amount of investigation is partially brought about because of the difference in cost of manpower and materials between the European countries and the United States. In the United States, we have an abundance of raw materials, but our labor costs are quite high. Generally speaking, the reverse is true in Europe. In many countries materials such as steel cannot be wasted. A great deal of planning and investigation can be done with a relatively minor amount of money, but to use excess material is costly. Also, some developments are considered to be of an economic necessity and are not evaluated on the same basis as ours.

For instance, let us consider the water problem in North Africa. This problem is a life or death matter. The engineers must improve the living conditions of these native people, since they have ceased to improve their own conditions several hundred years ago. You can readily see that there is a social obligation to better the condition of the natives, and the monetary value cannot be considered in the same manner as it is in the case of many of our projects.

The European engineers are working in a ripe economy; we in this country are still working in a relatively new economy. In the future, as our natural resources become depleted or more fully developed, we will be faced with the same problems that these engineers are faced with today, so perhaps we should study their approaches and, in all probability, we could learn a great deal from them that will be quite valuable to us in the future.

As an example of the differences in economies, I would like to use as an example the development of the arid areas in North Africa which are under French control. The development in these areas, of course, represents European practice. We in the United States develop stepwise. Their experience causes them to make bold strides. In other words, they convert a great many of the barren areas almost directly into production. Maybe their pace is not quite as fast as ours. In the United States, we can trace the history of the development of irrigation, but in North Africa historical procedures and the new procedures can be found side by side.

A few color slides will illustrate some of my points and show how fertile the field for engineering advancement is in some parts of these countries.

In my description of the slides that follow I will not take time to give you the details of the structures. In most instances I have rather complete technical data for the engineering works. If any of you are interested in the details, I will attempt to answer your questions with material from my files.

Slide 1: This picture shows a native in the arid regions of Morocco harvesting wheat. The wheat grows only a few inches high and the heads are very short. Only a small amount of grain is produced by each plant. As you can see from the picture, the reaper has almost to gather each head singly. These people manage to live, although it is difficult to see how. They live only one step removed from the animals which are always present with them. This picture was made in an area that is scheduled to be irrigated in the near future.

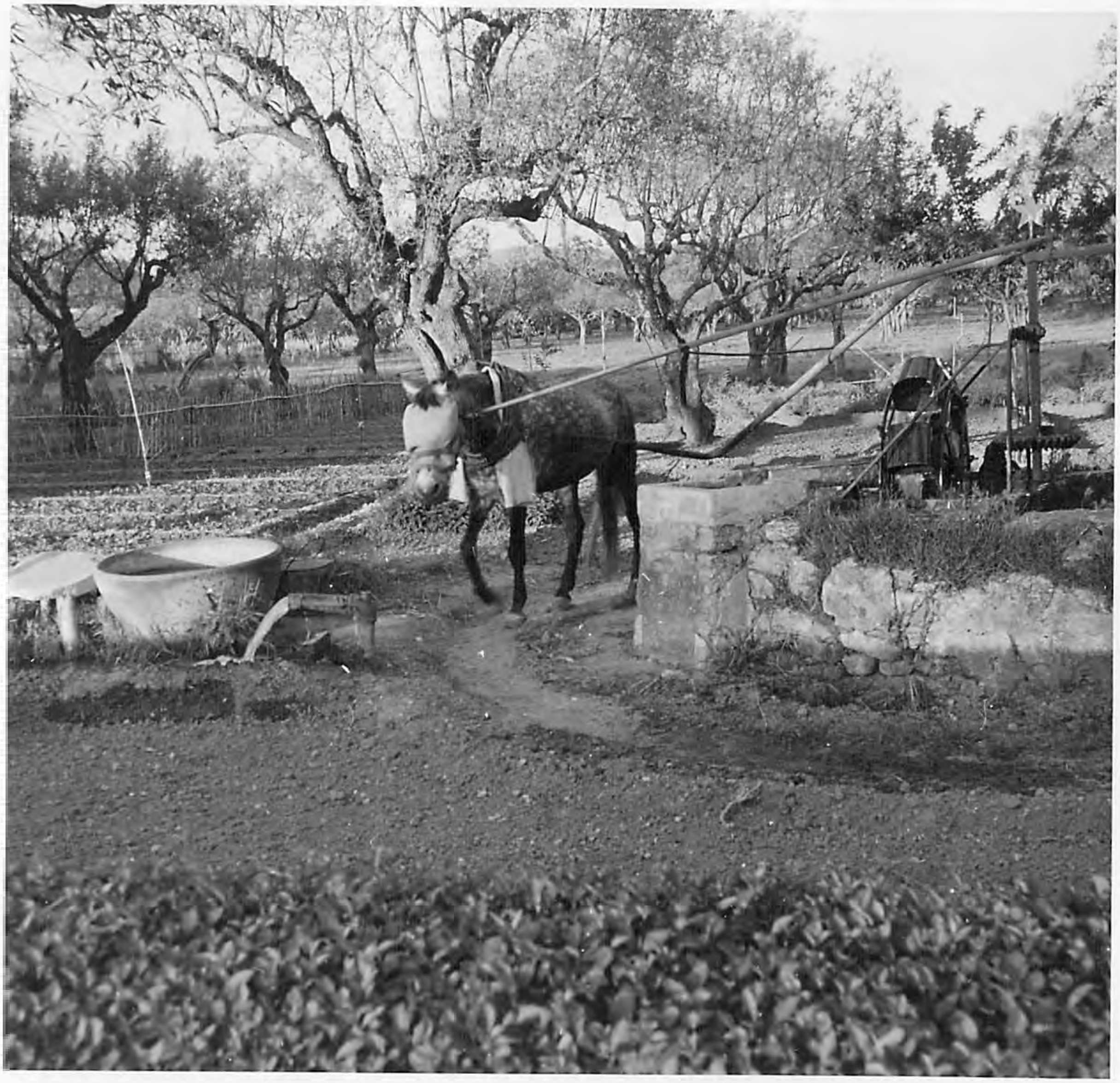
Slide 2: The harvested wheat is being transported to the threshing area on the backs of the camels. This job may also be accomplished by donkeys, and in many instances human beings serve as the carriers. Threshing is normally not done in the fields. The wheat is either transported to an area near the native village or out of the field where a hard surface is found. There are many spots where the desert winds have blown the top soil away and the hard subsoil or rock is exposed. These hard, level areas are utilized as threshing surfaces. Some unthreshed grain and a threshing area with its pile of straw may be seen in the background. The line of trees in the far background is in an irrigated area.

Slide 3: Only very primitive methods are employed throughout the area. Here the threshing is accomplished. The sharp-hoofed animals are driven around and around over a thin layer of the harvested wheat and the grain is literally trampled from the straw. The camel, having a padded foot, is spared this chore, but young cattle and donkeys serve together. Note the bands of sheep in the background.

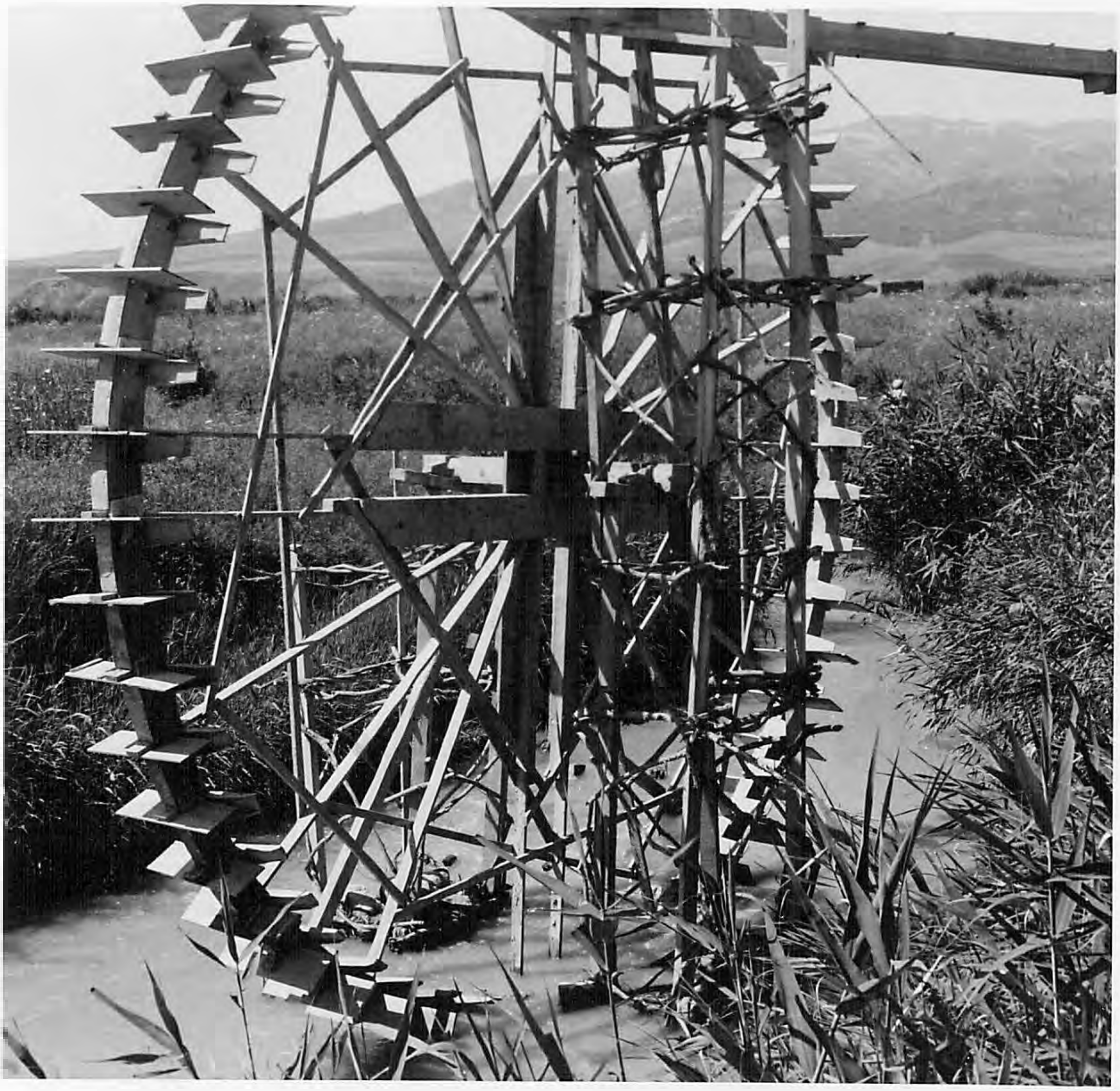
Slides 4 and 5: Here the threshing is being done in the field. The centuries-old custom of using the wind to separate the chaff from the grain is followed. By sign language I asked this native to throw some of the material into the air, and he indicated that since there was no wind it was useless, so he leaned on the wooden fork until a breeze started and I got the second picture. He seemed to enjoy performing for me, and I also took some movies.

Slide 6: In some instances the natives have attempted to better their positions. In the area between Casablanca and the Valley of the OUM-ER-RHBIA the ground water table is about 30 to 40 feet below the surface. Here one may see a number of one-camel power pumps. These are crude affairs fashioned of wood. The motive power of the camel is transmitted through a pair of wooden gear to an endless belt upon which are fastened tin cans, earthen urns, or buckets that dip into the well and carry the water to the surface. Each well can irrigate from 3 to 5 acres, after a fashion, and little oases are formed in the desert.

Slides 7 and 8: In Spain and Portugal there are literally hundreds of these bucket pumps powered by a horse, donkey, or ox which lift water from shallow wells for domestic and irrigation use. These pumps are of better construction and more efficient than the camel-powered pumps in the last picture. Much of the irrigated area, especially in Spain, receives its water from these devices. These pictures were taken in the NABAO RIVER Valley near TOMAR, PORTUGAL. This is a very productive valley.



Slides 9, 10, and 11: In Morocco, the road from PETITJEAN to FES crosses the Valley of the OUED MIKKES. At this point there are many waterwheels of the undershot type that serve to irrigate the land immediately adjacent to the stream. These wheels of local design and manufacture are entirely of wood, even the axles and bearings. They are about 20 to 25 feet in diameter and are fitted with paddles that dip into the stream to insure rotation. The rims are hollow and are formed into cells which fill with water when they are submerged in the stream. On arriving at the top, the water spills into a wooden trough that leads to the fields. The velocity of rotation is about 1 to 2 rpm and each wheel delivers from 2 to 4 liters per second (about 0.075 to 0.15 cfs). This little valley has been completely altered by the use of these wheels and presents a green garden spot in the midst of a very barren expanse. It is a good example of an attempt of the natives to better their living conditions in this area.



Slide 12: The ARAB peoples have no conception of maintenance. Many of them wear several layers of clothing, each succeeding garment covering holes in the other. Here a number of natives are installing a new waterwheel. The old one had been pulled onto the bank and discarded and a new one takes its place. It seems to be easier to replace than to repair. In digging the wells a crude wooden windlass is used to raise the material from the hole. The material is taken by hand from the bottom of the well by a native and placed in a basket suspended on a rope. The basket is pulled to the surface by another native, with the aid of the windlass. The rope eventually wears the wooden windless in two and the basket of stone falls, killing the man in the well. A new windlass and another ARAB are procured, and the well digging goes on.

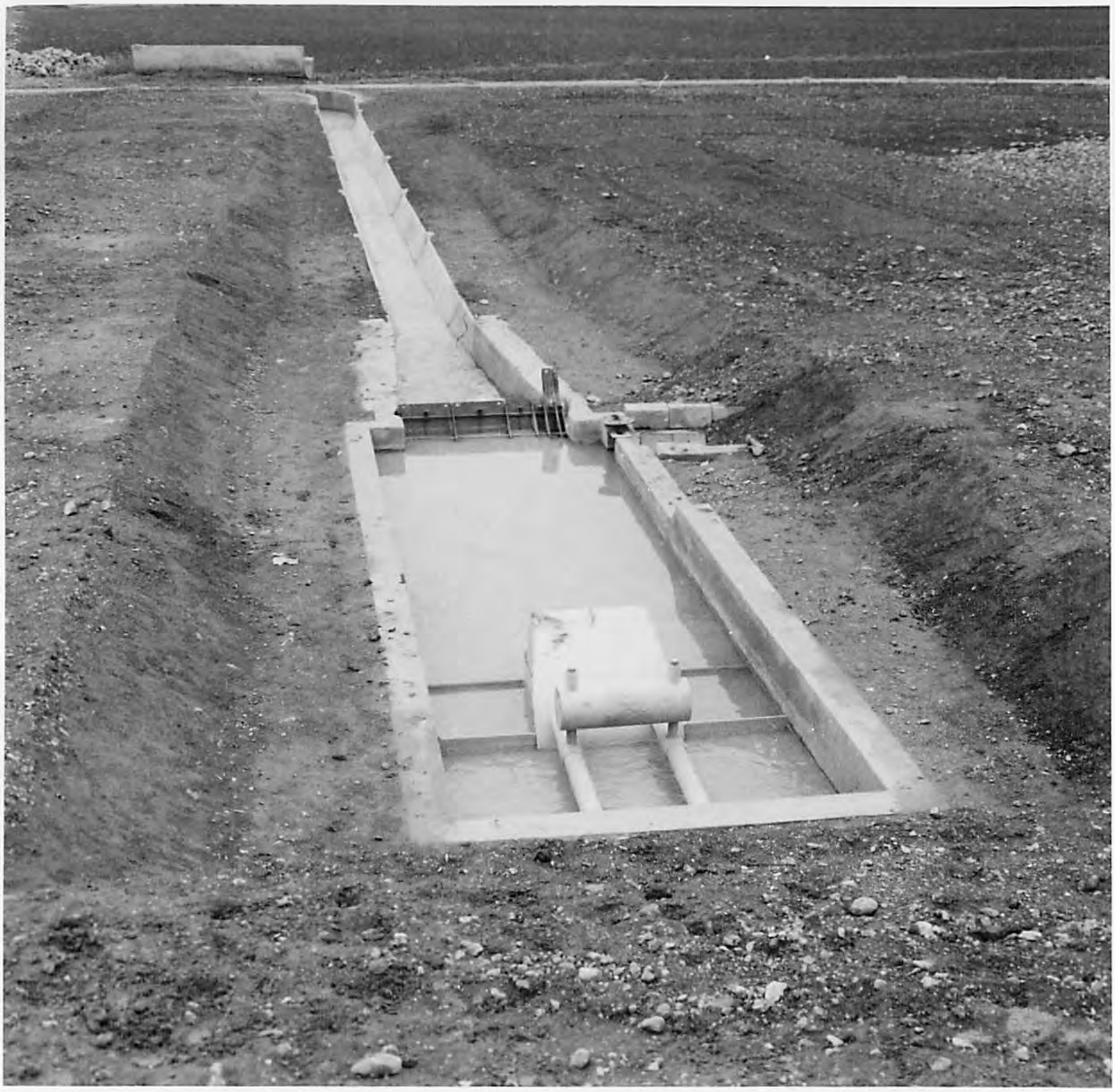
Slide 13: I have shown you a few pictures of what might be termed individual effort to bring water to the land. This picture shows the results of collective effort. Here is a field of artichokes produced as a result of the benefits derived from a large government-developed irrigation project. This land lies in the INKERMAN project in the CHELIFF Valley in ALGERIA. Note the extreme contrast between this and the dry-land wheat scene shown previously.

Slides 14 and 15: I would now like to give you a quick look at some of the details of the irrigation systems being built in North Africa. In some of the older systems are found unlined canals excavated in earth. In all the newer systems the main canals, with the exception of the large ones, the laterals, and the farm ditches, in many instances, are built entirely of pre-cast concrete sections, usually prestressed. This type of section, although expensive, has many advantages, particularly in this region. Without enumerating these advantages, I will say that this type of construction is, in my opinion, an excellent solution. These two photographs show the precast, prestressed section installed below ground level on the new main canal leading from FOUDDA Dam on the CHELIFF RIVER in ALGERIA to the ORLEANSVILLE-OUED FODDA Irrigable Perimeter. This canal has a capacity of 245 second feet. Note the manner in which road crossings are accomplished.

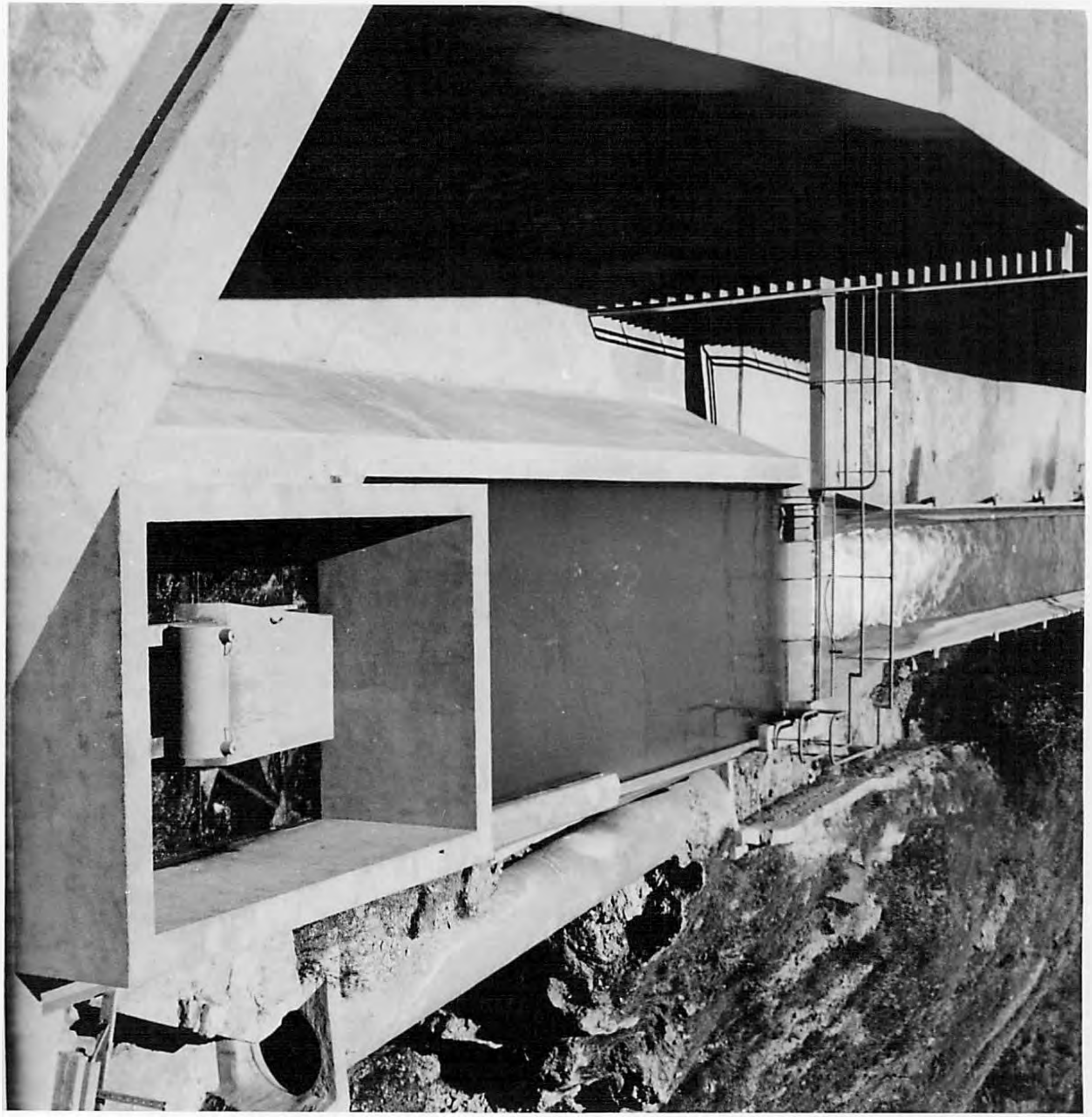
Slide 16: A view of the same canal a short distance downstream. Here the section is placed above ground on prefabricated supports. This type of construction permits a more or less straight line canal instead of the many curves necessary when contour lines are followed. Turnouts may be made on either side. This view shows a turnout equipped with fixed area orifices set at a low level. In this position considerable change in water level in the main canal will not appreciably change the quantity delivered into the turnout.

Slide 17: Another view of the new canal on the ORLEANSVILLE-OUED FODDA PERIMETER. The canal at this point is still under construction. Note the height of the supports. These supports are precast in sections and placed one on the other until the proper grade is attained. Only the footings are fabricated in place in the field. The cradles to support the concrete canal sections are all precast. This canal replaces an old canal partly earth section and partly lined. The straightening of the new canal and the decrease in friction loss in the section accounts for the increased elevation of the canal. Considerable new acreage can now be included in the project because of this higher grade line.

Slide 18: Another item that is in general use in the areas of French influence, both in France itself and in North Africa, is a constant downstream level gate. This gate is float operated and is balanced in such a manner that a constant level is maintained downstream from the gate. The water delivered to the turnout is measured through a "module." This device is either fully opened or fully closed and is sectionalized to deliver a prescribed amount of water. This particular "module" and downstream constant level control gate is on the outlet from a regulating reservoir at the end of a pump discharge line on the INKERMAN project in Algeria.



Slide 19: Another installation of a constant downstream level control gate. This gate and module are at the head of the main canal to the ST DENYS DU SIG AREA. The parapet in the foreground is on the diversion dam. Since the storage for this project is a considerable distance upstream from the diversion, re-regulation of the flow is necessary. This gate maintains a constant flow in the main canal regardless of the water level in the regulating basin upstream from the dam.



Slides 20 and 21: Another type of gate very extensively used throughout the areas that I visited is the constant upstream level control gate. This gate provides a near-constant water surface elevation upstream. It is float operated and is fully automatic. In operation, the water levels are controlled to within 2 or 3 inches of the top of the concrete canal. This gate was developed for this type of canal section and may be installed almost anywhere along the line by simply clamping it to the canal. Note the float on the face of the gate leaf, the counterweight, the dashpots to prevent hunting, and the method of attachment to the concrete section. This gate is installed on one of the laterals of the PERREGAUX project in Algeria.

Slide 22: Another view of fully automatic gate controlling the level upstream. This is a large gate, fabricated of steel tubing. It is placed in a concrete lined trapezoidal canal in a specially constructed setting. The gate is mounted with the support upstream, in a reverse position of that in which these or radial gates are normally mounted. This gate is in the main canal of the BENI AMIR AREA in Morocco.

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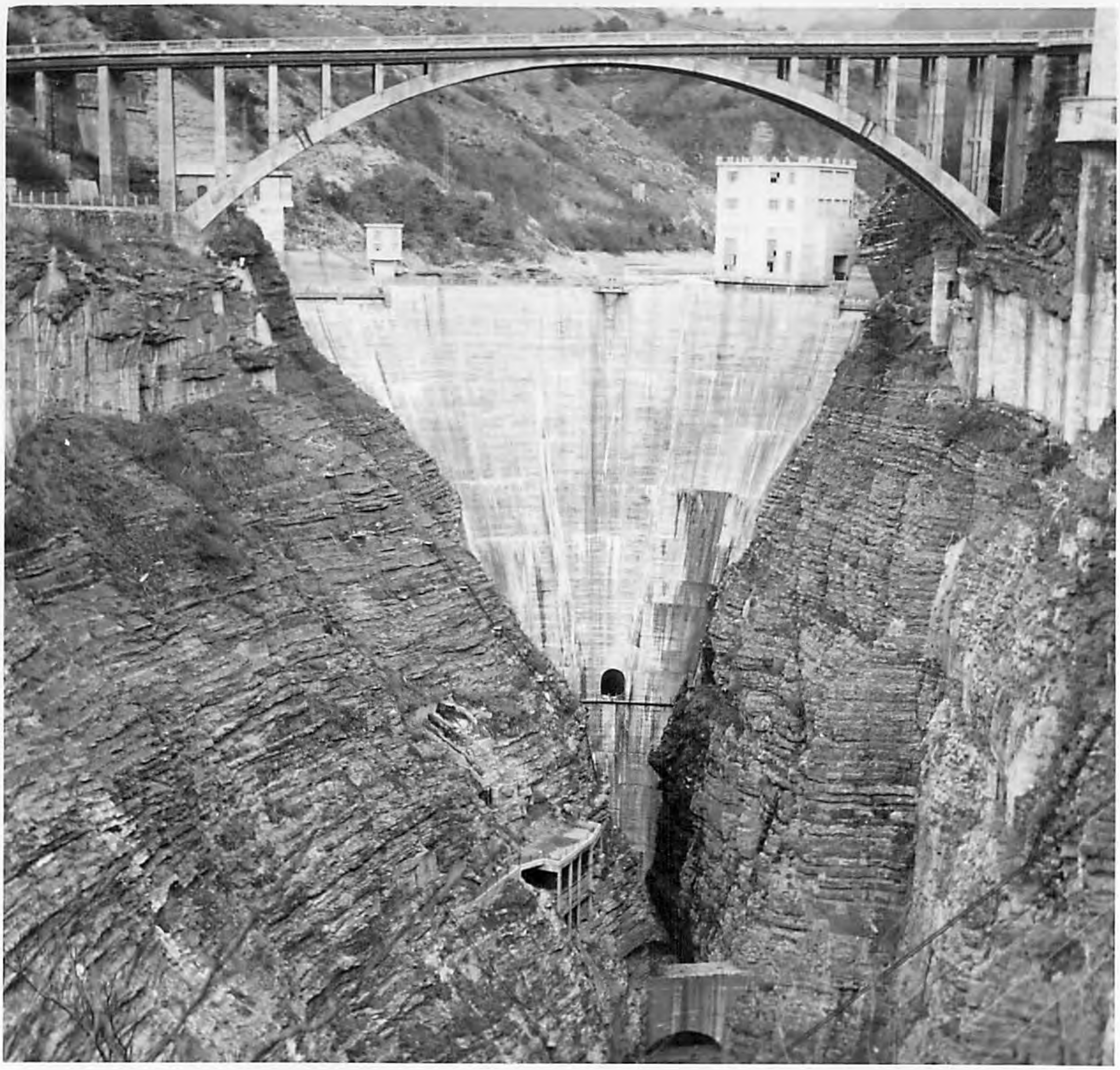
Slide 23: These are two turnouts from the main canal immediately upstream from the automatic gate seen in the last picture. Each turnout is equipped with a module. The small turnout is for a farm ditch to the right of the main module. This turnout will provide water for the area in the picture adjacent to the main canal. Note that the lateral is of precast, prestressed concrete section.

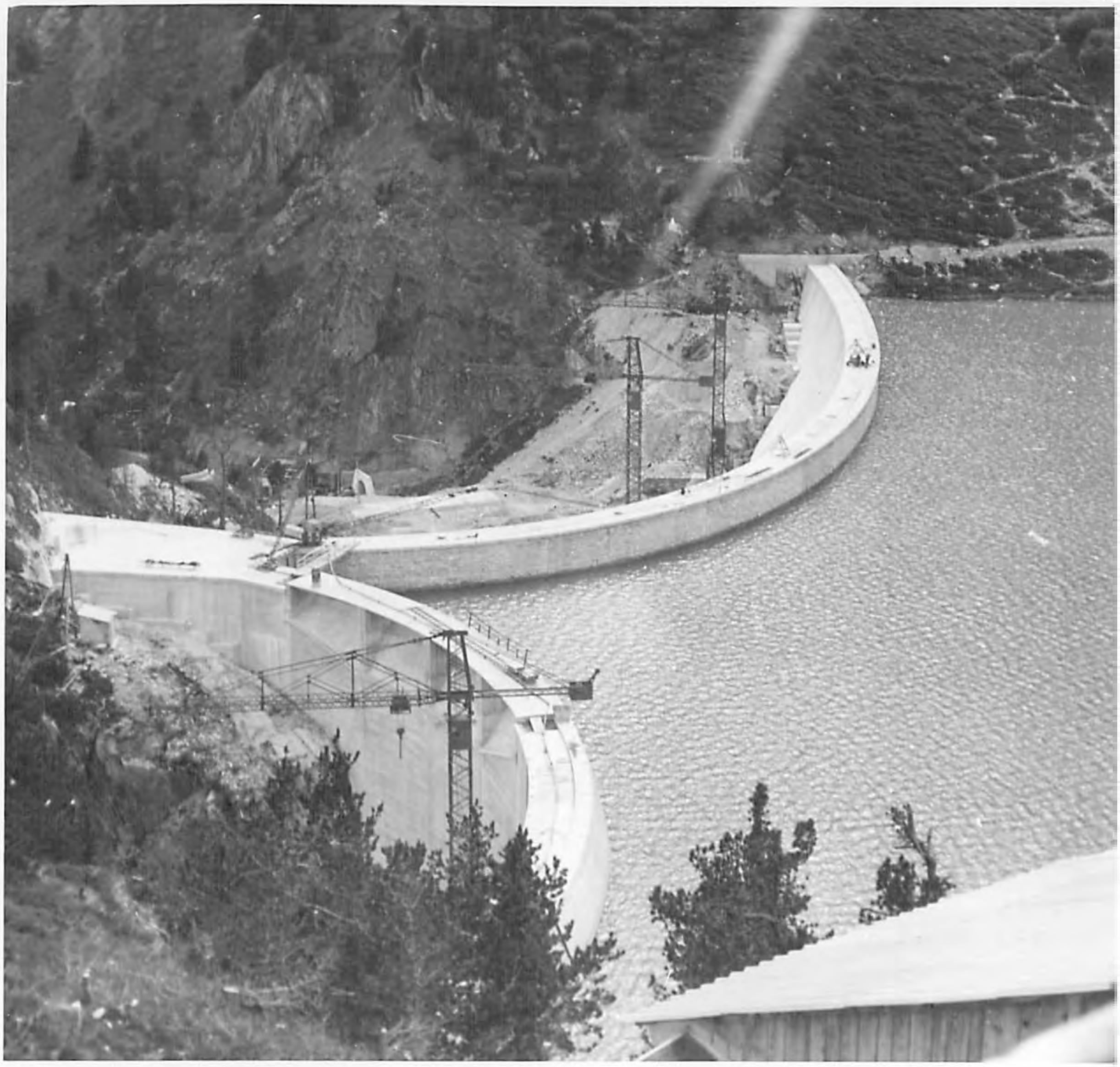
Slide 24: Water is without doubt the most valuable commodity in a large area of Morocco. Here we can see an irrigation canal furnishing hot and cold running water for a native barber shop. This is an indication of the high value placed on the water. These canals are used as a means of conveyance of the water to the farms; to water the stock; they are used for laundries for domestic water supply; and for many other things. At this particular location in the main canal to the BENI AMIR AREA in Morocco a long "vee-shaped" weir has been installed to provide the near-constant head for the turnout to the lateral in the immediate foreground. Because of the weir it was necessary to raise the concrete lining about 2 feet.

Slide 25: Throughout the areas visited, one of the outstanding things, to me, was the attempt to maintain automatically systematic levels in the irrigation networks. As has been pointed out, this has been accomplished by automatic gates and by weirs. This view shows a long weir built in connection with a turnout in an irrigation system in the PO VALLEY in Italy. This is an old system, but this structure is more recent. It is interesting to note that the gates are supported on a stone framework and the gate leaf is a reinforced concrete slab. The lift stem, the lift, and a protecting angle on the edges of the leaf and the reinforcement in the leaf are the only metal parts of the installation. This is common practice in Italy.

Slide 26: In engineering construction, the principle of the arch is used very generally in Europe. This is a view of SAUTET DAM on the DRAC RIVER in the FRENCH ALPS not far from the Italian Border. This is a thin arch concrete dam 416 feet high above the foundations. The length at the crest is only 264 feet. The reservoir storage capacity is 105,000 acre feet. This dam serves two power plants. There is one plant at the foot of the dam. Since there was not room to install the plant in the narrow canyon, it is mainly underground. From the tailrace of this plant the water enters a tunnel through which it flows downstream to CORDEAC PLANT where a head of 300 feet is utilized. Note also the arch bridge across the canyon above the dam.

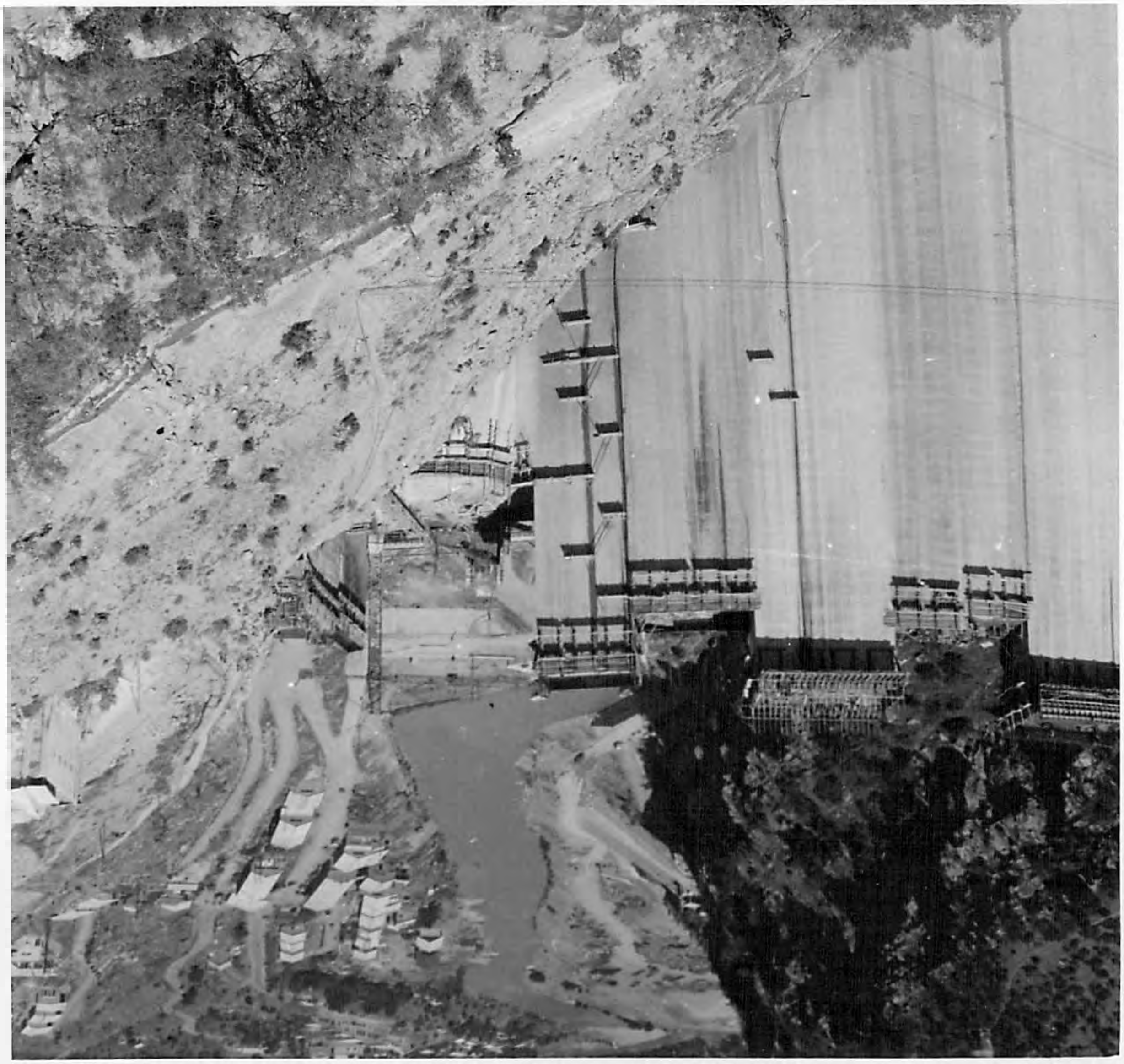


Slide 27: This is the double arch dam that forms the regulating basin and forebay for the AUSSOIS Power Plant in the FRENCH ALPS. Note the type of crane used in construction. The water enters a tunnel from this pool and thence into a steel penstock where it is dropped to the plant under a head of approximately 2,880 feet. This dam is a beautiful example of the utilization of the arch principle.

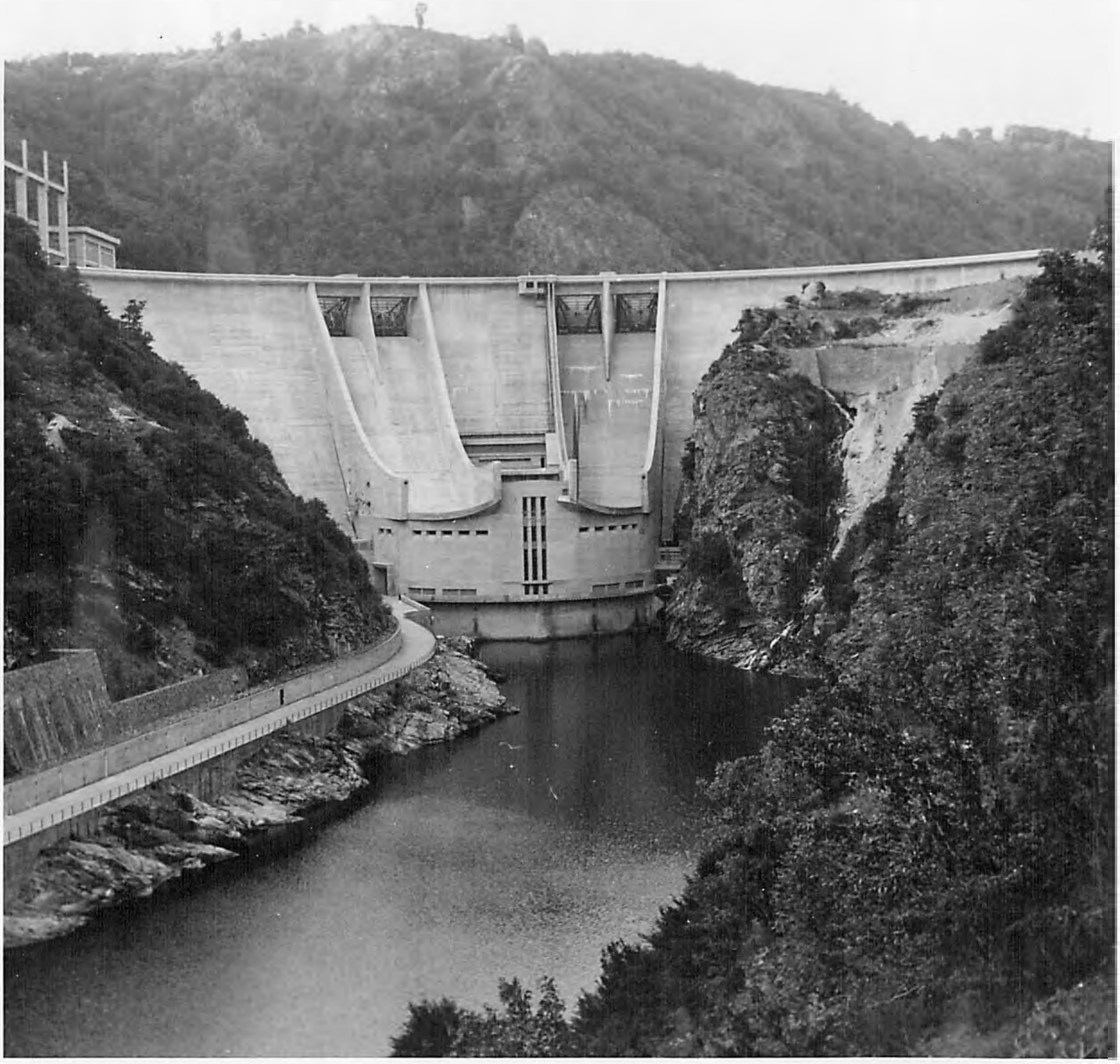


Slide 26: This is another illustration of the extensive use of the arch principle in the construction of dams. This is [illegible] Dam and the secondary diversion dam, also built as an arch, for diversion to the irrigation canal downstream from the main dam. This is on the extension of the Verdon Canal System in southern France. The dam is a thin concrete arch 289 feet high, and the length at the crest is 558 feet. It is 59 feet thick at the base and 13.8 feet thick at the top. The small diversion dam downstream is a uniform thickness arch about 19.5 feet high above foundations.

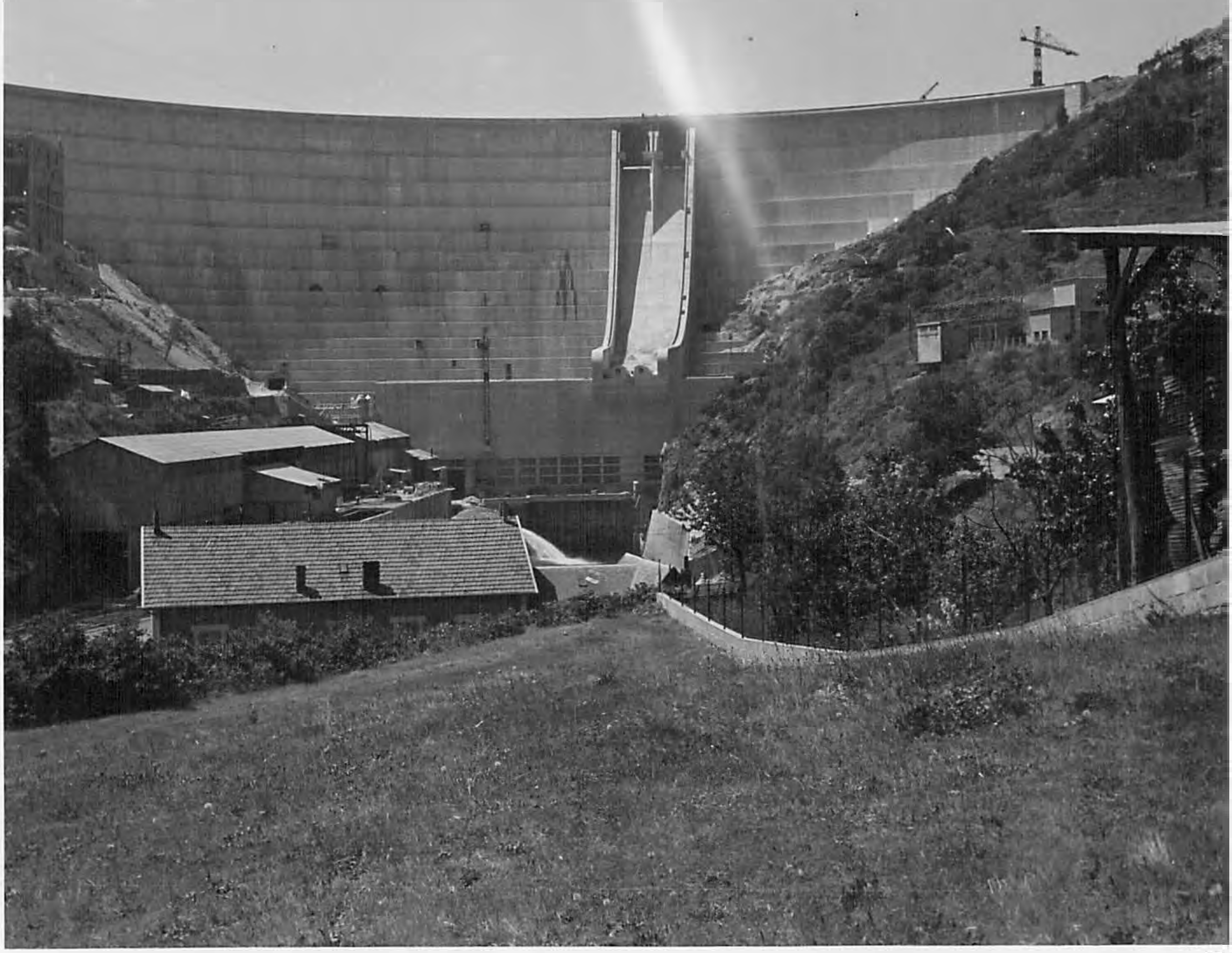
Slides 29 and 30: BIN EL OUIDANE DAM on the OUED ABID in the ATLAS Mountains of Morocco. This is a concrete arch dam and will be 462 feet high, when completed. It will provide water storage to irrigate an area of approximately 500,000 acres in the valley of the OUM ER RBIA as well as the development of a large block of power.

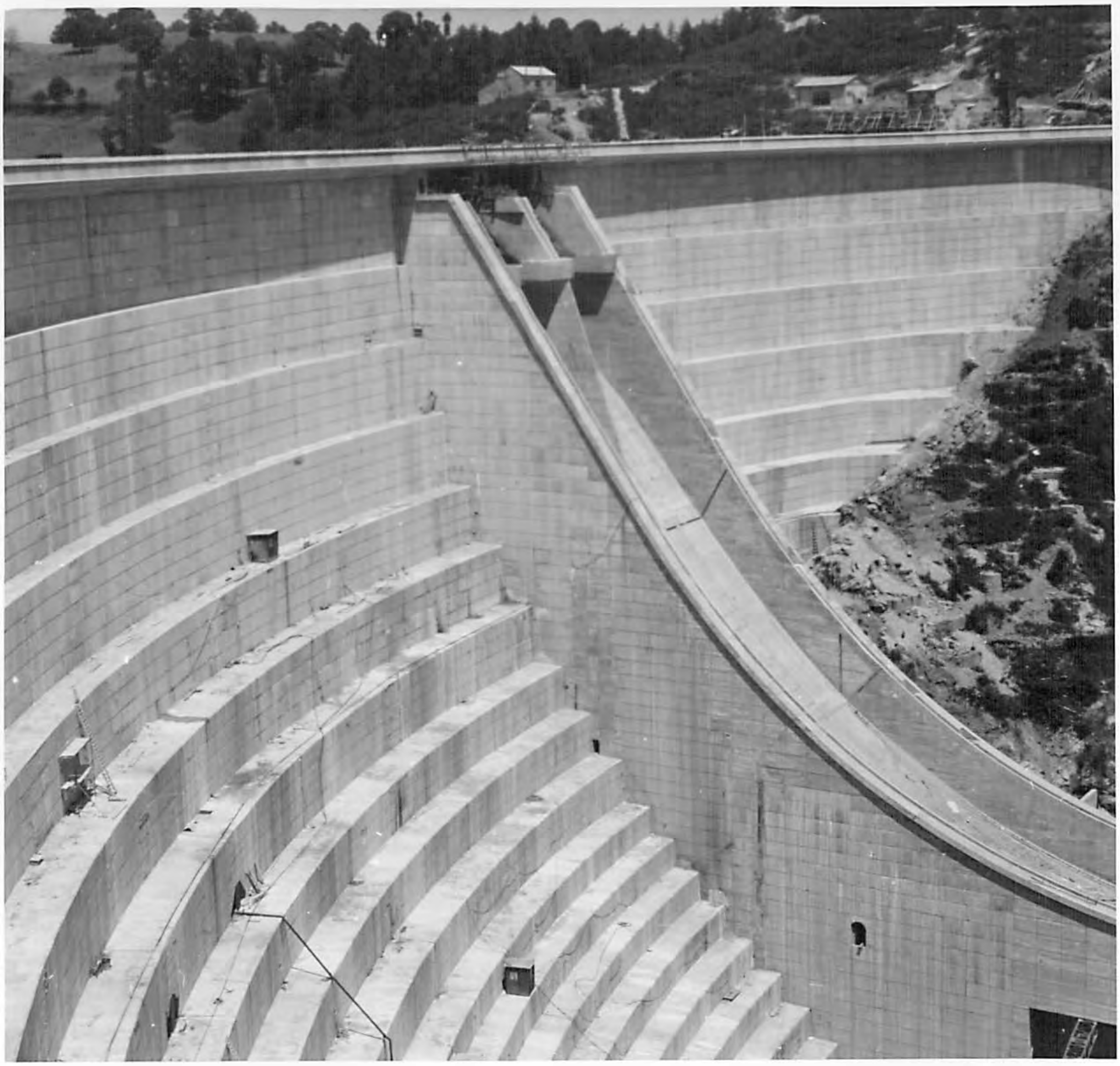


Slide 31: One of the outstanding differences in European and United States practice is the manner in which the discharge from the flood spillways of the dams is handled. In some instances stilling pools similar in design to ours are constructed, but in the majority of cases a simple ski jump is installed to throw the water away from the structure and obtain a maximum of energy dissipation in the air. A beautiful example of this type of treatment of a flood spillway is at L'AIGLE DAM on the DORDOGNE RIVER in the MASSIF CENTRAL region of France. Here the twin spillways pass the water over the top of the power plant and throw it into the stream bed below. The shape of the lips on the spillways spreads the jets over the river bed, and the energy is dissipated. This dam is 297 feet high and is 907.5 feet long at the crest. The spillways each handle a maximum discharge of 70,000 cfs (total 140,000 cfs) over the roof of the power plant. Each spillway is controlled by two radial gates, each 39.6 feet wide and 39.3 feet high. The concrete wall to the left of the roadway leading to plant is in reality a stormproof tunnel that provides access to the power plant when the spillway is discharging. Access may also be gained by an inclined elevator and a stairway from the top of the dam.

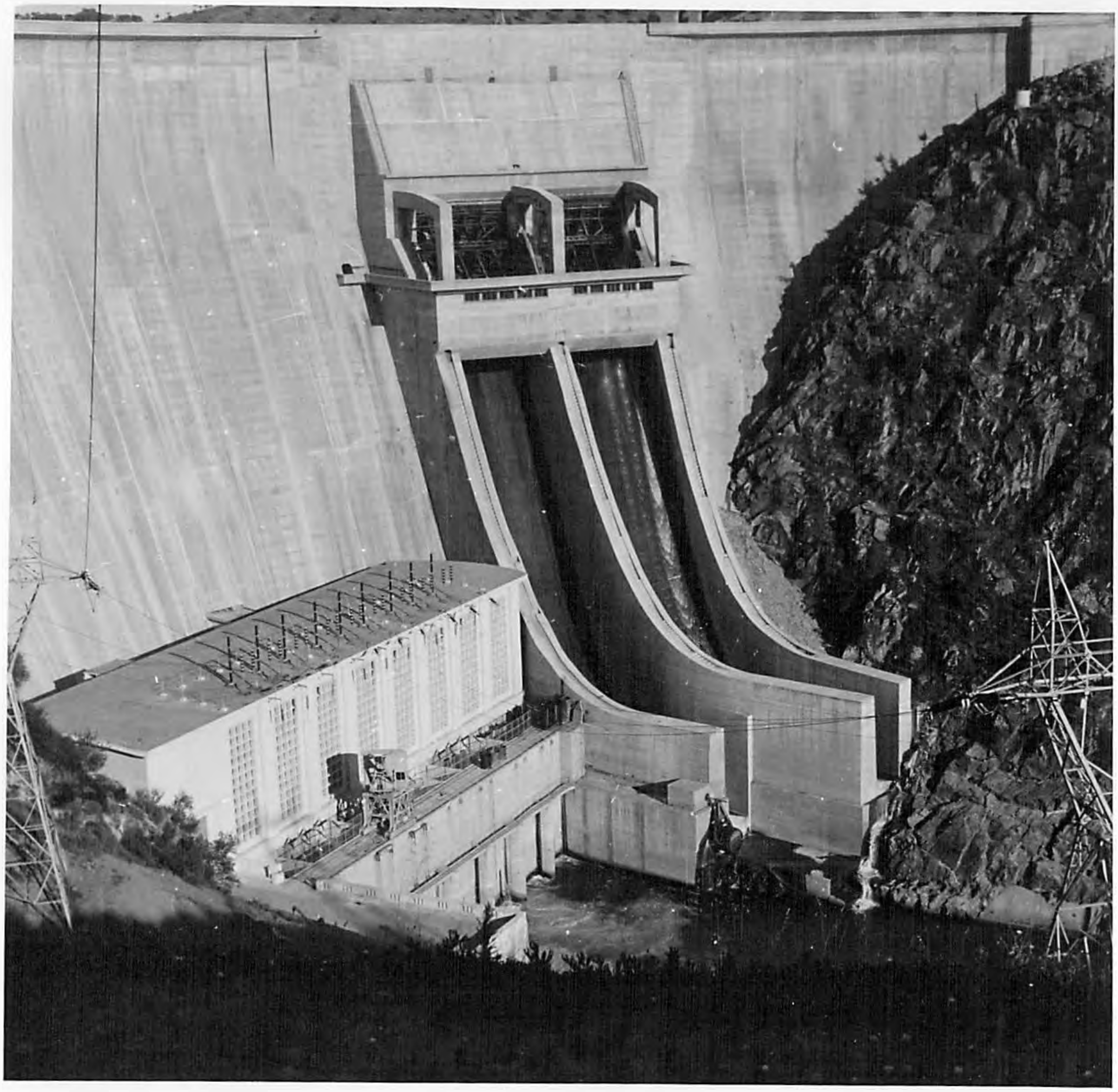


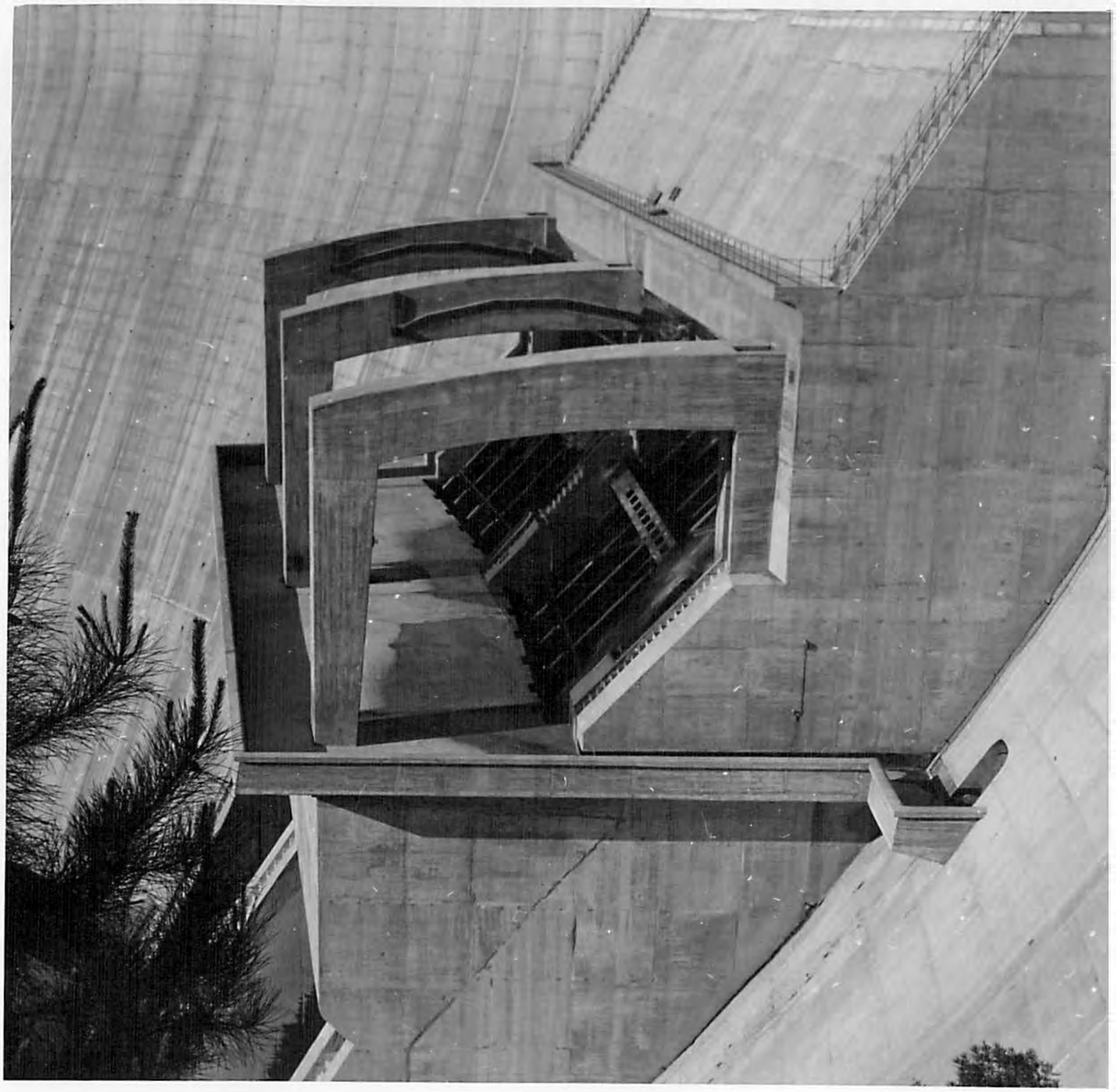
Slides 32 and 33: Another example of a flood spillway that is carried over the roof of the power plant. This is BORT LES ORGUES Dam, also on the DORDOGNE RIVER, upstream from L'AIGLE. This dam is 395 feet high and has a crest length of 1,247 feet. It contains 660,000 cubic meters of concrete. The maximum discharge of the spillway will be 42,000 cfs. Two low level outlets will provide an additional release capacity of 14,600 cfs. The power plant will generate 350 million kwhr per year.





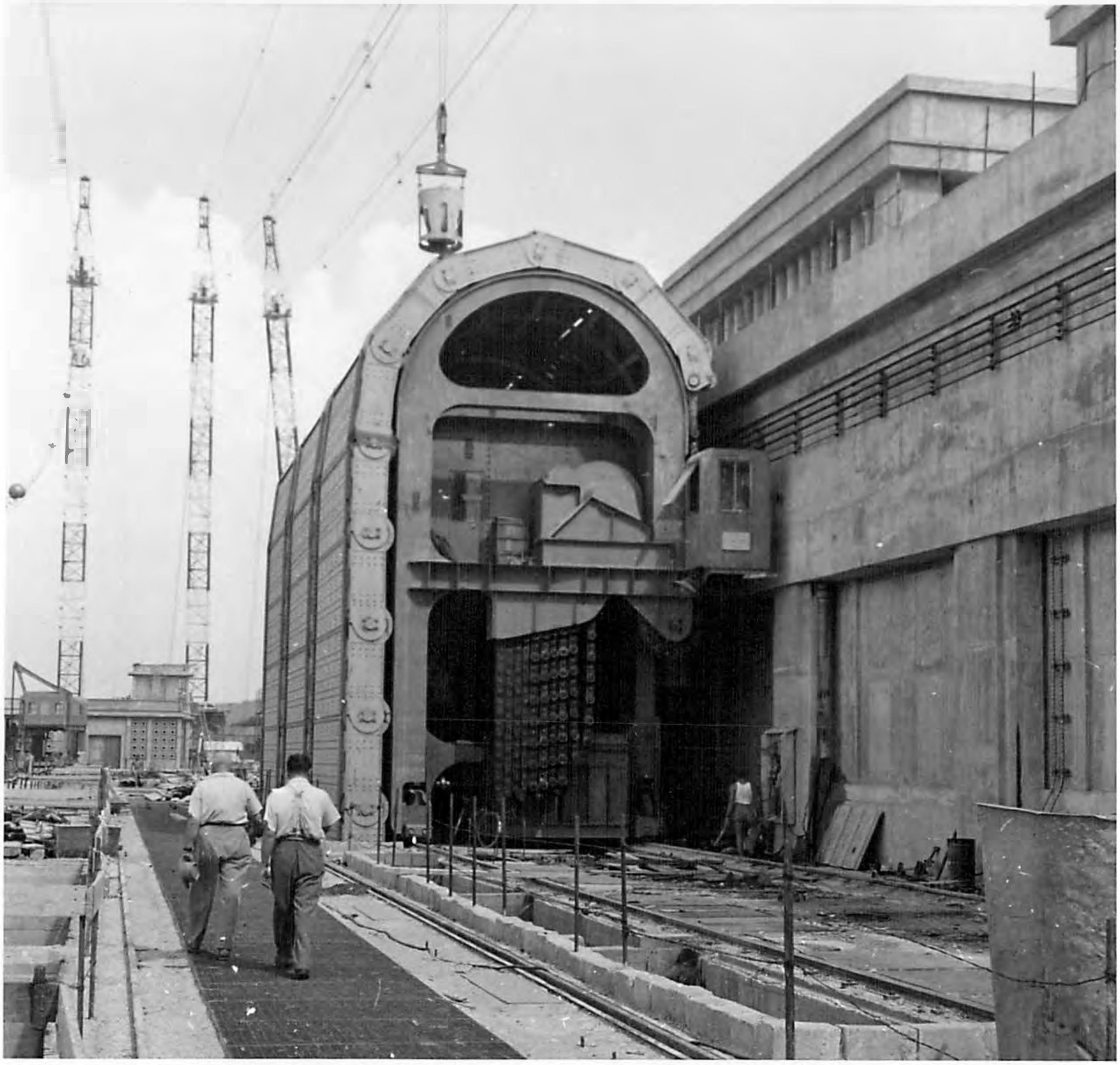
Slides 34, 35, and 36: Another treatment of a flood spillway may be found at CASTELO DO BODE Dam on the RIO ZEZERE northeast of LISBON, PORTUGAL. This dam has a total height of 379.5 feet and has a crest length of 1,155 feet. The flood spillway is equipped with two top seal radial gates, each 46.2 x 26.4 feet under a head of 98 feet. Each gate will discharge 71,750 cfs or a total, for the spillway, of 143,500 cfs. Here again the water from the spillway is released at the bottom of the fall after being directed downstream away from the structure.





Slide 37: In closing this brief talk I want to touch on just a few things that I think should be given further consideration by our designers. I mentioned at the beginning that steel is in very short supply in Europe. One means of conserving the available quantities is the saving effected in the design of penstocks. These sections of penstock for the AFOURER POWER PLANT in Morocco were fabricated in GRENOBLE, FRANCE, and shipped across the MEDITERRANEAN to the point of use. The tubes are 8.6 feet internal diameter; are designed for a maximum static pressure of 776 feet of water; and will carry 840 cfs. The penstock is fabricated of a relatively thin shell of steel and then wound with heavy cable under considerable stress. This method of fabrication is stated to effect a saving of from 1/4 to 1/3 of the steel that would be necessary to form a solid cylinder designed for an equal pressure.

Slide 38: This stop log type gate is used at the ANDRE BLONDEL POWER PLANT in the DONZERE-MONDRAGON CANAL off the RHONE RIVER in FRANCE. This gate is used to close any one of the six entrances to the power units in the plant. The penstocks are each provided with stop log slots at the entrance. This emergency gate can be used to stop the flow in any one of the penstocks in case of failure of wicket gates. It is moved from one position to another on the crane which rolls on rails. Another interesting item in this picture are the single tower cableways used in the construction of the plant. The towers may be leaned to displace the cables up- or downstream. Note that the right tower is leaning in the picture.



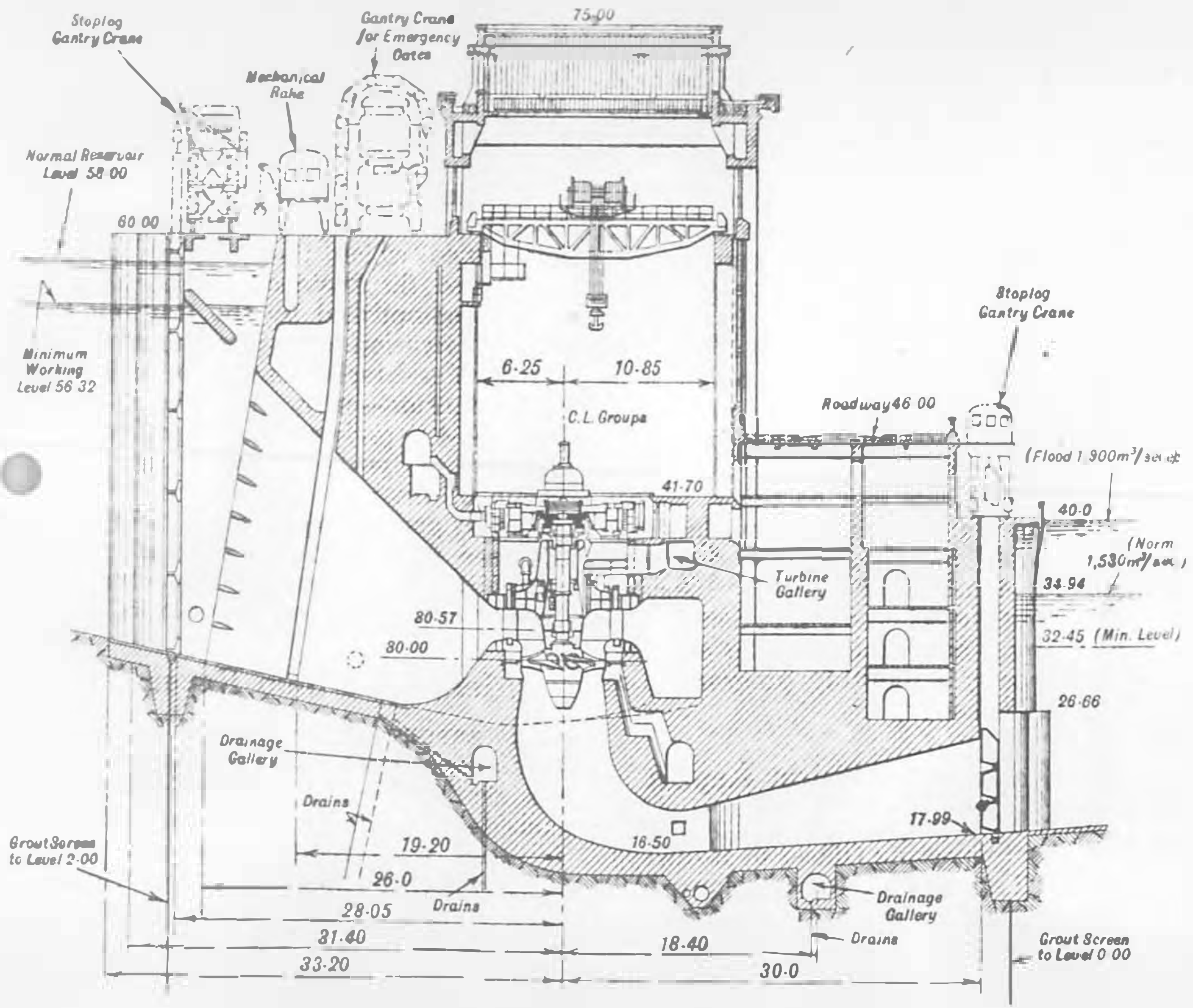


FIG. 26—CROSS SECTION OF POWER STATION

Slides 39 and 40: Extensive work has been done throughout Europe on the protection of sea walls along the coasts and the entrances to ports and harbors. These views show a means of protection developed by NEYRPIC known as TETRAPODS. This installation is at the entrance for the condenser cooling water for ROCHES NOIRES STEAM POWER PLANT at CASABLANCA, MOROCCO. Each TETRAPOD weighs 15 tons.

I have not completed my thinking on all of these items, but at present these seem to be some of the developments that we might look into. No doubt there are many others, but in the limited time I have only attempted to point out a few which I think might be of interest to you.

Before I close, I cannot help mentioning the extensive work that is being done in Holland toward the reclamation of land areas that lie below sea level. The reclamation of this land from the sea is something that is wonderful to watch. The tenacity of the Dutch people who have taken this land away from the sea and have lived on it for a number of years, and in some areas for centuries, indicates an attribute that is certainly admirable.

- Thank you -