Boulder Dam – 1937

[Music]

[Opening Credits]

Narrator: For untold centuries, the turbid waters of the Colorado River battered their way through the forbidding canyons of its 1,700 mile course, traversing the arid Southwest, for the most part little known except to the native Indians and the few parties of intrepid explorers. Draining a vast region of mountain and desert, entering seven of the largest western states, it poured its waters southward into the Gulf of California, carrying into its delta a tremendous volume of silt and periodically overflowing the prosperous towns and rich agricultural districts near its mouth with devastating floods.

From the time of its discovery, it remained a challenge to engineers who sought to control it until the enactment in 1928 of the Boulder Canyon Project Act, authorizing the construction of Boulder Dam. In Black Canyon, where the Colorado River forms the boundary between Nevada and Arizona in the very heart of the great desert of the Southwest, the United States Department of the Interior, through its Bureau of Reclamation, was directed to proceed with the construction of this mightiest of dams.

Highways were pushed across the desert, railroad lines thrust their ribbons of steel through the sagebrush and cactus, and transmission lines for construction power were brought hundreds of miles across the heat-stricken wastelands of the southern Nevada desert. Every section of the country was called upon to contribute to the staggering quantity and wide diversity of material required: thousands of tons of steel; millions of barrels of cement, machinery, gasoline, and oil by the thousands of gallons; tools; building materials – all these and much more were concentrated at the site of operations in an endless stream. The engineering forces completed their surveys, working under the most hazardous conditions, and every state in the Union furnished its quota of laborers and artisans.

In what had once been an uninhabited, waterless desert supporting only a sparse and hospitable growth of chaparral and cactus, the beautiful little town of Boulder City was built within the short space of fifteen months to house the army of 5,000 men to be employed. Here was no construction camp such as was known in the early days of the West. Instead, Boulder City was developed as a model town, furnishing every facility and convenience to its inhabitants. Four churches, a modern fully-equipped school, and various civic organizations met the cultural requirements of the community, while a theater and several clubs furnished recreation. A thriving business section developed along the principal streets, while pleasant homes surrounded by gardens faced the broad tree-line residential avenues of this modern, spotless town.

The buildings housing the offices of the Bureau of Reclamation and the civic administration, which operated directly under the federal government, were set in the midst of pleasant parks which were welcome havens of rest after the day's labors in a country where the summer temperature often reaches 125 degrees above zero. In the business section of the town, arcades formed a protection against the tropic sun. Lovely flower gardens bloomed in marked contrast with the surrounding desert. Lining street after street, the white cottages of the married workmen recalled to mind the military camps of 1918, while single men were housed in air-cooled dormitories each accommodating 176 occupants. Under conditions which would have gained the wholehearted approval of any modern housewife, tons of food were prepared and served daily in the sanitary, electrically-equipped kitchens.

A corps of cooks and waiters was able to feed as many as 1300 men at one setting of the tables. Menus were varied, and the food was of excellent quality.

As Boulder City was about seven miles distant from the dam site, it was necessary to provide transportation for the workmen to and from the job. This was accomplished by a fleet of passenger motor trucks, some of them carrying as many as 160 men. A twenty-four hour day was divided into three shifts of eight hours each for all classes of labor. The Fourth of July, Labor Day, and Christmas were the only holidays observed once the rapid tempo of the ambitious construction schedule was established and underway toward the marking of a record-breaking achievement in American engineering history.

It was in March 1931 that Six Companies, Incorporated of San Francisco, California was awarded the general contract for the construction of the project including Boulder Dam and its appurtenant works, and by early summer of the same year, preliminary construction work was in full swing in Black Canyon. During this early period of construction, before roads had been built into the depths of the gorge, man and materials were forced to take to boats or travel the catwalks, often swung between the sheer walls of the canyon at dizzy heights above the muddy waters of the world's most dangerous river.

It was not long before roads and rail lines had penetrated into the very lowest reaches of the canyon. To provide these arteries of transportation, thousands of tons of virgin rock were blasted from the age-old walls of the gorge. Thus the first thunders of man's determination to conquer the Colorado River reverberated between the sheer cliffs of the canyon, which heretofore had known only the hot silence of the desert and the roar of the river's angry floods.

The boring of four diversion tunnels to carry the stream around the dam site during construction, two on each side of the river, fifty-six feet in diameter and averaging 4,000 feet in length, constituted the first major construction operation. The drilling jumbos used on this job were mounted on motor trucks to facilitate handling and were capable of driving from twenty-four to thirty powder holes into the heading simultaneously by means of drifter drills. The tunnels were excavated through the rock simultaneously from four headings: one at either end and two boring in opposite directions from a river level auxiliary tunnel located about midway on the main bore. A pioneer drift was drilled at top line, and closely followed by the excavation for the complete fifty-six foot bore. Thousands of tons of drilled steel were used in this work and the sharpening shops were kept working at top speed night and day to maintain a steady supply.

After the powder holes had been drilled and the rock blasted, power shovels and trucks moved into the tunnels for the purpose of removing the shattered material. An unbroken parade of heavy duty trucks, each handling from eight to ten tons of rock, labored up over the steep roads cut into the canyon walls to dispose of the material in the gulches adjacent to the dam site. This phase of the task, which entailed the excavation and the handling of over one and a half million cubic yards of material, was completed within a period of thirteen months and was considered the most grueling portion of the work for both men and machinery.

After the tunnels had been excavated, they were lined with concrete three feet in thickness. Due to the unprecedented size of the bores, special equipment was designed to facilitate this task. The tunnels were lined in segmental sections, the invert or base being the first in which the concrete was placed. A gantry crane operating through the tunnel itself handled the concrete throughout this operation. The side walls were next lined behind movable steel forms, which traveled through the excavated section on rails laid from portal to portal. The top arch was placed with the use of a concrete gun operated by compressed air. To prepare the canyon walls to receive the abutments of the dam, and to remove loose and dangerous rock from the face of the cliffs overhanging the site, many tons of rock were torn away and hurled into the depths of the canyon in a series of spectacular blasts which occurred almost daily during the period from commencement of operations at the dam site to the time when actual building of the dam began about two years later.

To reach their positions on the canyon walls, the men engaged in the work of drilling and handling explosives for these huge blasts traveled in cages or skips, swung on cables, at heights of hundreds of feet over the river. To the casual observer, this dizzy sky ride must have seemed thrilling indeed, but to the workmen themselves it became a matter of course and all a part of the day's job. The first step in preparing for the blast was the drilling of powder holes into the rock of the canyon wall. For this purpose the jack hammer drill, operated by a single man, was generally used. The holes were then loaded with dynamite and the blast set off, shattering the air with its detonation and shaking the very earth with its force.

After the blast, acrobatic workmen, known in construction camp parlance as high scalers, swarmed over the … [face of the cliff to remove the] … fragments of rock shattered and loosened by the upheaval of the explosion. Only in this manner could the walls be successfully cleared of debris. Swinging in bosun's chairs from the canyon's rim, these daredevils were protected in their hazardous work by hard helmets, safety ropes, and other safety appliances.

[In November 1932] … preparations were made to divert the river through the tunnels. A small blast opened a breach in a temporary dike … [which had held the river] … in check at the entrance to one of the tubes, opening the way for the free passage of the water into the fifty foot concrete lined bore. A temporary dam of earth and rock was quickly thrown across the stream, deflecting the entire flow. Within twenty-four hours, the Colorado River, under control for the first time in its history, was flowing around and past the dam site through the huge diversion tubes.

An all-time record was set in placing the more than one million cubic yards of material required for the construction of the two coffer dams, in themselves barriers of no mean proportions. The earth fills were compacted to an elevation well above the high water mark to prevent the flow of the river from entering the scene of operations during the construction of the dam and power plant. After the completion of the coffer dams, the site was unwatered and the fleet of power shovels and trucks put to work on the excavation of the riverbed material to provide foundations for the structures. This excavation was carried to a point 135 feet below the old river level, necessitating the handling of more than two million yards of rock, earth, and sand. Here again the stamina of both man and machinery was put to a severe test in transporting the waste from the very lowest depths of the gorge.

As the cleanup of the dam site progressed, the ancient bed of the Colorado River was laid bare. Here geologists were able to read the story of what had happened ages ago when the chasm now called Black Canyon had been carved out of the primal rock by the rush of water from a great inland sea and the Colorado River was settling into its present bed.

To ensure the greatest possible stability for the foundation of the dam, meticulous care was exercised in preparing the rock surfaces for the reception of the first concrete. Sand and gravel for the four and one-half million cubic yards of concrete required for the construction of the dam and its appurtenant works were obtained from a detrital deposit located on the Arizona side of the river some twelve miles upstream from the dam site. Here the raw material was excavated by dragline and hauled by train to the gravel screening and washing plant, which was the largest of its kind ever built, being capable of producing 20,000 tons of crushed, screened, graded, and washed materials every twenty-four hours. Arriving at the plant, the raw material was dumped into hoppers, from which it was conveyed into the plant over endless belts. Here it passed through the various stages of screening, by which it became suitable aggregate material for the manufacture of concrete of a quality meeting the most rigidly uniform requirements. Oversized cobbles, that is those measuring more than nine inches in one dimension, were first screened out, then crushed and returned to the plant for regrading along with raw material.

The screening plant itself consisted of four towers of similar design, each equipped with screening apparatus and each separating out gravel of a different given size from the mass of raw material reaching the unit over the conveyor belts. An endless stream of raw, pit-run gravel passed over the screens and the selected material carried to the stockpiles over the conveyor belts, each of the four sizes being stocked separately, ready at hand when needed at the mixing plants. A clarifier tank provided six million gallons of clear water daily for washing gravel and sand.

Raw material for concrete manufacture which fell into the size classified as sand was graded a second time into three sizes after the very fine and undesirable sand had been discarded. The three selected sands were then recombined into a uniform mixture to meet specifications for the concrete to be used in the dam and the appurtenant structures of the project. The sand was then stored awaiting the requirements of the construction program. As the graded materials were called for, conveyor belts loaded the sand and gravel into railroad cars for transportation to the concrete mixing plants located at the dam site several miles distant.

Concrete was mixed in two plants: one located in the bottom of the canyon upstream from the dam and the other on the canyon rim on the Nevada side immediately over the dam site, both equipped with the most advanced machinery for concrete manufacture. Upon arrival at the concrete mixing plant, sand and gravel of the various sizes were stored in separate bins. A railroad system of sizable proportions was required to maintain a steady flow of material from the gravel pit to the screening plant, and from the screening plant to the concrete mixing plants. Bulk cement was unloaded from railroad cars by means of a pneumatic pump and conveyed into the bins of the blending plant where cements from several production sources and of varying physical and chemical characteristics were combined into a uniform product. This was necessary because of the requirement for standardization in concrete work ability, strength, texture, color and other properties.

Following the progress of concrete manufacture through its successive stages, we see the several ingredients entering the concrete mixing plant where they were combined scientifically and under rigid inspection into a finished product. With a maximum capacity of twenty-four cubic yards of concrete every three and one-half minutes, the high level mixing plant at Boulder Dam represented the ultimate in plant installations of its kind.

Here automatic equipment not only controlled the apportionment of the concrete ingredients, but in addition maintained a graphic record of every plant operation. From his post on the control deck of the mixing plant, an operator was able to direct the entire mixing cycle from the initial weighing of the ingredients on through the complete mixing process. The human element was almost completely eliminated as the mechanical equipment was capable of automatically selecting, measuring, weighing, and recording the proper materials in the precise amounts required for the production of a given mix, to which the recording dials had previously been adjusted and set.

Here also we find the production line conveyor belt speeding up the process by carrying the component parts from the measuring and weighing hoppers into the batching bins, from which the materials were dumped into the four cubic yard capacity rotary mixers. Water was added in controlled amounts, and the entire mass thoroughly agitated as the last step in the economical and efficient manufacture of a concrete strong enough to withstand the enormous pressure to which the dam would be subjected.

From the mixing plant, concrete was dispatched to all sections of the works and, because of the widely varying conditions prevailing, various types of containers and methods of transportation were involved. Motor trucks and electric trains were utilized as carriers and containers varied from the eight cubic yard capacity bottom dump buckets to the four cubic yard capacity transit mixers. The latter were used on long hauls when it was necessary to agitate the concrete in transportation to prevent segregation of the mix. However, the major portion of the concrete handled on the project was carried in the eight cubic yard buckets and transported from the mixing plants by electric train. A system of nine aerial cableways, spanning the canyon from rim to rim and anchored at either end to movable towers, was utilized to carry the concrete and other materials from the points of train or truck delivery to the dam and other structures on the project.

It was on June 6, 1933 that the first bucket of concrete was placed in the very lowest of the dam forms, 135 feet below the level where a few months previously had flowed the unchallenged Colorado River. What was to become the highest dam in the world began to rise from the impregnable rock of its foundation. As bucket after bucket of concrete was dumped into the forms, the plan of the structure became apparent and soon extended along its full 660 feet dimension of thickness at the base. Throughout the lower levels of the structure, concrete was placed from a trestle anchored to the Nevada wall of the canyon. The concrete was poured in keyed, or interlocking, columns, the design of which became more noticeable as the five foot layers, or lifts, in which the concrete was placed rose from level to level. As the work of placing progressed, the crews became expert in the handling of the equipment and record-breaking daily pours were made only to be surpassed by later achievements on this same structure.

The transit mixers were transported on trucks from the bed of which they could be removed and handled on the overhead cableways. These were used in the placement of concrete in the confined forms along the abutments, where the eight cubic yard buckets could not be handled. Selecting at random one bucket from among the hundreds of thousands that traveled from the canyon rim over the cableways and down into the dam forms, we see the typical operation, from the time the bucket is picked up on the cableway on the canyon rim, swung out into midair over the gorge hundreds of feet above the forms, its tremendous weight of twenty-two tons riding easily and gracefully over the cable as it is lowered into the forms with an ease and certainty seemingly out of proportion to its great bulk and tonnage. As the bucket descends, suspended at the end of hundreds of feet of cable strands, it is received at the forms. The safety locks unlatched, the signal given, and eight more cubic yards of concrete added to the dam’s bulk. Concrete was compacted into the forms by mechanical vibrations, the application of which ensured dense compression against adjacent surfaces.

Workmen were carried from the canyon rim to the dam forms by way of the inclined skidway, or monkey slide as it was called, which operated through the Nevada abutment excavation.

Boulder Dam laborers represented a fair cross section of the American working class, and many stayed on the job during the entire period of construction. With an ambitious progress schedule to meet, and with work going forward under all conditions at all seasons of the year without cessation, rain or shine both day and night, within a year less four days, two million of the three and one-quarter million cubic yards of the dam's total volume had been placed in the forms. And Boulder Dam had risen to an impressive height, already having taken its place as one of the wonders of the West and a tourist attraction of prime importance.

Meanwhile, progress had been made in the erection of the structures appurtenant to the dam itself. The construction of the power plant, a U-shaped structure at the downstream toe of the dam, had been in progress for some months, and as its substructures assumed form it gave some hint of the beauty it was later to possess.

The intake towers, two on each side of the canyon wall immediately upstream from the dam, were in course of construction and from a maze of reinforcing steel rapidly rising toward the uppermost rim of the canyon. These structures were later to serve as giant inlet valves for the outlet conduits and power penstock systems. And the placing of the seats for the mammoth cylinder gates was an important phase in their construction.

Located at the ultimate high water storage level of the reservoir, the two spillways, designed to act as overflow controls in the open bypass system, were located one on each side of the river upstream from the dam and within the reservoir area. Work on their construction progressed simultaneously with that of the dam itself.

One of the most interesting and spectacular phases of the work was the fabrication and installation of the huge steel penstock pipes forming the conduits for the power and pressure outlet systems. This work was performed by the Babcock & Wilcox Company of New York City, who erected a modern steel fabrication mill near the dam site to facilitate the undertaking. As the pipe units to be fabricated were of unprecedented size and weight, it was necessary to design, build, and install special machinery solely for this task. Provisions were made to manufacture pipe ranging in diameter from eight and one-half to thirty feet from steel plate varying in thickness from five-eighths of an inch to two and three-quarters inches. As it was impossible to ship units of this size across country by rail, steel plate was brought from eastern rolling mills, and the entire process of manufacture including rolling and assembling was initiated and completed at the Boulder Dam plant.

First step in the fabrication process, after the plates had been laid out to dimension, was the shaping of the edges to ensure the precision and accuracy of later steps in their manufacture. This work was done on a planing machine capable of handling a strip of steel fifty feet in length. The plates were then given an initial bend on a giant press operating at a pressure of 3,000 tons. This initial bending was necessary to avoid damaging the rolls when the plates in the next step of fabrication were rolled into circular form.

The plates, entering into the manufacture of the thirty foot diameter penstock pipe, were fabricated through the initial steps of manufacture in eleven foot widths. These plates were two and three-quarters inches in thickness and were rolled into circular form by being passed through forty inch vertical rolls until the desired degree of curvature had been obtained. One such plate represented a segment equal to one-third of the complete circumference of a finished pipe. Having been rolled to the correct degree of curvature, the three curved plates were joined to form a single ring thirty feet in diameter and eleven feet long. Two such rings were then joined end to end to form a shop unit twenty-two feet long. All joints were made by electric welding and in forming the longitudinal joints an automatic welding machine, traveling on a chassis supported in line over the joint, was used.

As these pipe units were of a size never before assembled, it became necessary to design and build special machinery to accomplish many phases of the work. This was especially true in the fabrication of mitered rings to be later assembled into bend sections. The general usage of electric cutting and welding was applied not only to pipe sections but to the manufacture of other fabricated units as well. A complete shop unit weighed from 150 to 184 tons depending upon its design determined by its ultimate use upon installation in the power penstock system. Circumferential joints were made by rotating the rings, making up a shop unit beneath an electric welding machine suspended above the line of the joint to be welded. Every foot of welded joint was subjected to searching examination by X-ray and recorded on photographic film which exposed even the slightest imperfections in the continuity of the weld. Samples of typically welded joints were subjected to severely rigid laboratory tests calculated to produce a condition of strain far in excess of that to be born by the joint under actual usage. The discovery of even the slightest imperfection was sufficient cause for the rejection of a complete unit.

In marked contrast to the meticulous care and precision exercised throughout every phase of their manufacture was the actual size and weight of the pipe unit themselves. Heavy duty rigging of special design was required to handle the sections through the shop and high capacity cranes were required to move them step by step through the progressive phases of their manufacture. To equalize the terrific internal strains introduced into the plates by bending and the additional temperature strains incurred during welding, individual pipe sections were subjected to a temperature of 1400 degrees Fahrenheit in a gigantic annealing furnace. This temperature was induced not by the application of flame itself but through the circulation of superheated gas. Shop processes were carried only as far as the production of the unit section. As these sections were to be joined to form a continuous penstock, provision was made to accurately accomplish this conjunction in the tunnels. To guarantee a satisfactorily tight field joint, the ends of the sections were machined on a mammoth vertical lathe operating across the thirty foot diameter of the pipe. After a final inspection, the pipe section was ready for installation. A modern streamlined train passing through one of the huge tubes affords an interesting gauge for the comparative size of the unit.

The job of transporting the pipe section from the plant to the dam site was in itself a tremendous undertaking, and to accomplish this work a special road trailer capable of carrying 200 tons was designed and built. Caterpillar tractors furnished the motor power as the trailer itself was not equipped with the means of locomotion. During handling, the confirmation of the pipe section was maintained by rigid internal bracing. The movement of the heavy trucks was controlled by air brakes and power steering apparatus with which the trailer itself was equipped. Upon arrival at the canyon rim, directly over the dam site the unit was maneuvered into position for lowering into the canyon.

To perform this task and to handle other heavy equipment, a permanent 200 ton capacity cableway had been swung over the gorge, its six three and a half inch track cables securely anchored into the rock of the canyon wall. The cableway was manipulated from a control tower overhanging the canyon, from which the operator commanded a full view of all its movements. The heavy hoisting machinery controlled by synchronized motors was the largest and most powerful of its kind ever built, as were also the track cables themselves which spanned the canyon a distance of 1256 feet at an elevation of 700 feet above the river from the head tower located on the Nevada side. … [Over the track] … cables traveled the carriage, to which the hoisting and traveling cables were played. A specially designed heavy duty rig, which became known to the workmen as the moonbeam because of its peculiar shape and from which the pipe sections were suspended, was used in lowering the huge tubes into the low levels of the canyon while cradled in a sling of heavy steel cable. After all lashings were secure, the pipe section was lifted from the trailer to begin its slow and carefully controlled movement over the cableway riding from the rim out into space, suspended 700 feet above its ultimate position.

When the cable carriage, with this tremendous weight of steel, had been maneuvered into location over the intended landing far below, the hoisting cables were slowly played out and the pipe lowered under absolute control into the canyon. Here a second specially designed car waited at the portal of the access tunnel to relieve the cableway of its burden and carry the pipe section underground to become a part of the extensive conduit system penetrating the cliffs on both sides of the canyon.

With the workmen laboring in the tunnels far underground, the gargantuan task of placing the penstock pipes in position to form continuous conduits between the intake towers and the powerhouse and outlet works was accomplished. The separate units were hoisted into location with the aid of cables and once placed into position were joined with pressure pins to form a continuous pipe.

While work on the appurtenant features of the Boulder Canyon project was in progress, an uninterrupted stream of concrete had been pouring into the forms of the dam from both mixing plants. Progress was curtailed only by the limitations of sound engineering and construction practice. Day by day, week after week, the top workings of the structure approached its full height of 730 feet, far above the crest of any other dam yet built by man, or likely to be built for years to come. Schedules established at the outset of the work were left far behind as the concrete of the dam narrowed toward its crest and the structure widened between its abutments, approaching the very top rims of the canyon walls.

In June 1935 the dam structure itself stood completed, two and one-half years in advance of the time originally designated. In September of the same year, President Franklin Delano Roosevelt, voicing high praise for both designers and builders, dedicated Boulder Dam to the progress of the nation. As final construction work was completed, the impressive beauty of the structure became apparent. The roadway traversing its 1300 foot crest forms a magnificent link in a transcontinental highway.

The reservoir filling behind the dam was named Lake Mead in memory of Doctor Elwood Mead, late Commissioner of Reclamation, whose life work culminated in the building of Boulder Dam. The largest artificial body of water in the world, it extends upstream 115 miles and to the lower reaches of the Grand Canyon with a shoreline of 550 miles opening on vistas unglimpsed by man until invaded by the gradually rising waters of the reservoir.

Equipped with cylindrical gates which function as giant valves, the four intake towers serve as inlets to the four steel penstocks supplying water to the turbines and outlet valves. Perched on shelves hewn into the canyon walls, they tower 403 feet to an elevation above the crest of the dam and the rim of the canyon.

With a combined capacity of 400,000 cubic feet of water per second, the two spillways, located one on each side of the canyon upstream from the dam, will serve as high level controls once the water of the reservoir has risen to its maximum storage elevation. Each spillway is equipped with four 100 foot drum gates acting through a vertical dimension of sixteen feet. Water flowing over the lowered gates into the spillway basin plunges 600 feet down through the tunnels to reenter the river downstream from the dam.

The Boulder Dam power plant is built in two wings, one alone each side of the canyon wall at the downstream toe of the dam. The first generator was placed in operation on September 11, 1936. Equipped with seventeen generating units, with capacities ranging from 40,000 to 82,500 kilovolt amperes, this, the world's largest power plant, is capable of generating 1,835,000 horsepower of electrical energy when operating at its rated capacity. The transmission lines carrying Boulder Dam power radiate in a network from the dam with the major lines serving the Los Angeles metropolitan area. From the takeoff structure located on the roof of the powerhouse, the lines are taken up over the rim of the canyon into the switchyard above where the most highly specialized and modern developments in the power transmission field are to be found. From the switchyard, the lines travel out across the desert bringing light to the homes and cities and power to the factories of the great Southwest.

From Parker Dam, 150 miles to the south, the Colorado River Aqueduct supplies the city of Los Angeles with the domestic and industrial water supply. While from the Imperial Dam, 300 miles to the south, the All-American Canal diverts water from the Colorado River into the rich agricultural districts of the Imperial Valley.

And so Boulder Dam stands today, a modern colossus, shouldering the rock ribbed walls of Black Canyon, standing and controlling the floods, and bending the will of a hitherto ungovernable stream, the Colorado River, to perform the fruitful tasks of a civilization rapidly invading the limits of its last frontier.

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