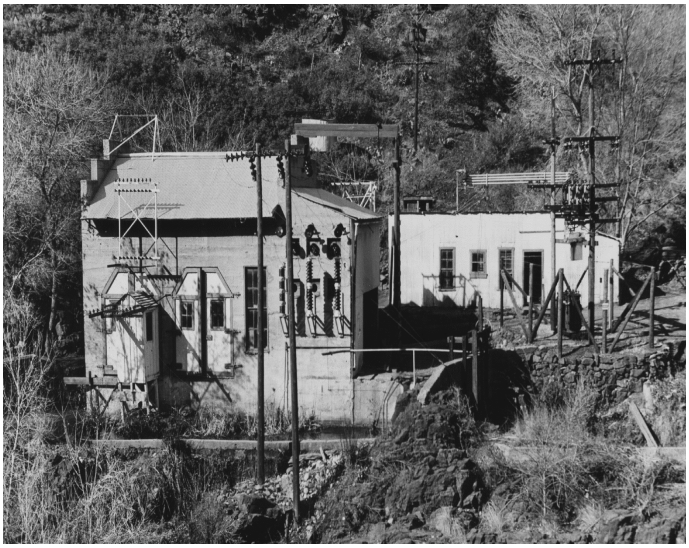
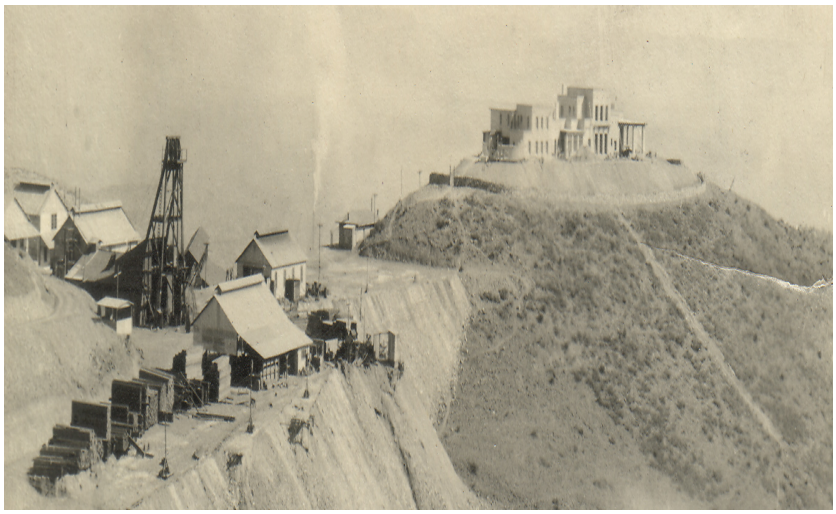


# How Water Changed the Face of Power in Central Arizona



# HOW WATER CHANGED THE FACE

# OF POWER

# IN CENTRAL ARIZONA

by

Tim Coons

Presented at

The Arizona Centennial Conference

at The Pointe Hilton Cliffs Tapatio Resort

Phoenix, Arizona

April 20, 2012

# HOW WATER CHANGED THE FACE OF POWER IN CENTRAL ARIZONA

This is a brief look at the turn of the century mining boom in Yavapai County and the obstacles The Arizona Power Company had to overcome to meet the challenge of providing adequate and reliable electricity.

In 1876, prospectors staked claims, and built a mill site on what would become the largest and richest mine on the eastern slope of the Black Mountains in the central territory of Arizona.

About the same time, Yavapai County cattleman Lew Turner ran across and made note of some springs along the base of the Mogollon Rim that gushed from unknown subterranean depths. The creek that was formed by these springs covered sticks, stones and roots with mineral deposits making them look like fossils, so the creek was named Fossil Creek.

In 1882, Frederick Tritle--lawyer, businessman, investor, and governor of Arizona territory, helped organize the United Verde Copper Company and was named vice president. The operation, which had been purchased from the prospectors, was named Jerome. After a successful two-year run, the mine closed when copper prices were depressed. The operation was sold to U. S. Senator William Andrews Clark and was back in full swing by the fall of 1888.

The generation and transmission of electricity by hydro and steam power started to play an increasing role in mining and industry and Lew Turner realized the struggling mines around Jerome and the Bradshaw Mountains, south of Prescott, offered a ready market.

In 1902, Turner gathered three associates and formed the Arizona Power Company, or APCO, with the goal of diverting Fossil Creek and building two hydroelectric plants.

Feasibility studies revealed 43 cubic feet of water per second at 72º F, winter and summer, dry season or wet. Measurements were taken three times daily, and after two years the effort was abandoned after the same figures were repeated the entire time, varied only by rainfall.

Also revealed was a static head of 1,600 feet, or 693 pounds per square inch, over a distance of ten miles, with a drop of 1,575 feet without any sizeable waterfalls.

In an article titled Harnessing the Water Power of Fossil Creek, Terry Munderloh conveyed the thoughts of an early surveyor for the power company: (The springs were) "about four miles up the roughest canyon there is in Arizona. The rock formation in the canyon is mostly limestone rocks with ledges formed by the flowing water and is as sharp as broken glass. The hillsides are covered with catclaw, mesquite and cactus, with one or more rattlesnakes in each one."

One of the three original APCO associates was Iva E. Tutt. Born to an engineer father, she grew up to prefer the world of cogs and pulleys to dolls with pretty clothes. After the sale of her electric light plant in Long Beach, California, she decided to join the Fossil Creek project in the Arizona desert. In that day, it was unheard of for a woman to be an engineer, much less one who was attracted to a harsh environment where few men and no other woman had been.

She took a survey party right to the head of Fossil Creek, paid attention to every detail, and came back with design plans for the work. Mrs. Tutt was generally given

credit for coming up with the basic framework for the water diversion system for Fossil Creek.

In an interview by the *Jerome Mining News* in June, 1903, she stated, "Does it cost me nothing to make these engineering trips, gone for weeks from sight and sound of civilization, with four camp and mess wagons, a buckboard, a train of burros, a cook, four (servants), a couple of engineers and a gang of thirteen men, keeping to the saddle for nearly 200 miles over mountain trails, coming back black and blue from head to foot from falling among the rocks and being pummeled by branches through which we forced our way? And oh, tired to death? Success means sacrifice."

Together with her feminine charm and elegant clothes, the kind that made women jealous and men overly attentive, she convinced the Arizona legislature to exempt APCO from taxation for a period of years, saving thousands of dollars.

Without adequate connections in the financial market, the infant company faltered until Francis Vielé and Raymond S. Masson joined the project in 1907. The pair of well-credentialed hydraulic engineers were able to attract investors from New York, Boston and London.

Senator Clark, owner of the United Verde Copper Company, quickly realized the advantage of cheaper hydroelectric power over the coal and oil he was having to import 1,500 miles over harsh and difficult terrain and signed a contract for more than a third of the generating capacity of Fossil Creek on March 19, 1907.

With financing and a contract secured, APCO reorganized as TAPCO (The Arizona Power Company) in April, 1908.

The location of the project was desolate, rugged and remote. The only access was on foot or by horseback. A road sufficient to handle heavily loaded horse-drawn wagons had to be constructed from the nearest railroad siding at Blue Bell, two miles south of Mayer.

By May of 1908, 250 men armed with picks, shovels, pry-bars and dynamite traversed steep mountains, high desert plateaus, canyons and washes to build the 50-mile road to the power-house site on the Verde River and beyond to the intake.

In a letter to financial partner F. W. Stehr dated July 21, 1908, R. S. Masson offered an explanation for his failure to submit his monthly cost estimates for construction expenses on time: Fearing a loss of roughly _ of the work force to the 4th of July celebration, which the majority of the men saw as an opportunity to get roaring drunk and not come back, Masson organized a little celebration on the job site. It was announced three weeks in advance, and the men "took to it nicely." A grand barbeque with two heads of beef and twenty five kegs of beer cost almost $1 per man for a total of about $300.

An unintended consequence was that many of the foremen and superintendents, who would have stayed without the booze, partied with the laborers and were chased off the job, "with the result that I was short about ten important men on the various crews the following day."

The drop from the rim of the Verde Mountains to the Verde River was approximately 3,300 feet over a straight line distance of about four miles. Grades of 15% were being scaled and descended by teamsters using 26 mules with a single

wagon for the heaviest loads. On sharp turns, the lead team would be out of sight of the driver requiring a rider on one of the lead mules to maintain control.

At the height of construction, as many as 600 men, 450 mules and 150 wagons were contracted to build the road, transport tons of material and equipment, build the water diversion system and the Childs Hydroelectric Plant.

The intake to the water diversion system started below the future site of the Irving Plant, where Fossil Creek, according to R. S. Masson, "flowed over a wide spreading, black volcanic rock ledge. No dam was needed and the entire intake was formed by blasting a channel in this rock to a point where its level came under the stream."

The system was 7.2 miles long, alternately included several different features as dictated by topography, and was engineered to convey water at a constant decline for controlled speed and pressure. Among those features were open trough-style wooden flume, and reinforced concrete flume built on "benches" cut into the hillsides. An inverted siphon of riveted steel pipe, transported flume water across a deep canyon and back into the flume on the other side.

Water entered the siphon under gravity and exited at the other end under atmospheric pressure at a slightly lower elevation than it entered the siphon.

Seven tunnels through rock totaled 1.7 miles. A dry lake bed, later named Stehr Lake, was used to form a 27.5 acre storage reservoir with a capacity of 287 acre feet of water, or 93_ million gallons, enough to run the Childs plant for three days in the event of emergency repairs to the system upstream.

Reinforced concrete pipe pre-cast on site in three foot sections lead to a 36 foot high, 30 foot in diameter concrete stand pipe. This open circular pipe served as a

junction between Stehr Lake and the high pressure steel pipe leading to the Childs plant. The high pressure steel pipe, or penstock, at the upper end was riveted pipe made in Pennsylvania and the lower section that entered the plant was produced by the Krupp Gun Works in Germany. There was no one making pipe in the U. S. at the time that could withstand the pressure. Water plunged down the final descent into the Childs plant, situated on the edge of the Verde River, at 470 static pounds per square inch.

By the end of 1909, Childs was generating 2,700 horsepower and 1,600 of that was delivered to the United Verde Copper Company.

A reflection by R. S. Masson after completion of all construction, including the Childs Plant reads: "It is worthy to note that in the entire course of construction there was not a single accident involving serious injury or loss of life. This is remarkable in view of the very large amounts of powder used in blasting. Every pound of material used in the construction was hauled by teams a distance of from two to fifty miles; the total amount being 50 million pounds."

Three major events in 1914 affected The Arizona Power Company's ability to keep up with the increased demand for power. First, the development of new ore deposits, and, settling ground beneath the United Verde Smelter prompted them to build a new and larger smelter below Jerome in Clarkdale. Second, the discovery of bonanza size and quality copper ore deposits at the United Verde Extension (or UVX) mine owned by James S. Douglas, set off another growth explosion. Third, the start of WWI caused the demand and price of copper to go up.

The Childs Power Plant was running at capacity, so construction of the Irving Hydroelectric Plant between Fossil Springs and Childs was started in May, 1915.

The addition of the Irving Plant on Fossil Creek necessitated a dam just below Fossil Springs, and a new 3.9 mile water diversion system. The new system included Hess half-round steel flume supported on wood timbers; one tunnel through rock, and inverted siphon; and a sandbox or surge box to prevent debris from entering the riveted steel penstock and to regulate and direct water flow. A static flow of 204 pounds per square inch was enough to power one low pressure water wheel and generator and produce 2,100 horsepower. The topographic gradient from the springs to Childs allowed for an average drop of one foot per 1,000 feet.

By the time the Irving Plant went on line in April, 1916, it was evident again that additional power would be required. The potential of Fossil Creek had been maximized, so the planning of an auxiliary steam generating plant was commenced immediately. Under the supervision of R. S. Masson, The Arizona Power Company's chief engineer, contractor Charles C. Moore and Company of San Francisco started construction of a modern steam plant called "Tapco" on February 1, 1917. The new steam plant was located out of convenience to their largest customer, The United Verde Copper Company, about three miles north of Clarkdale on a large bend in the Verde River.

Four boilers equipped to burn California crude oil produced steam at 250 pounds pressure and 150 degrees superheat which passed directly into the turbine, and then into a large condenser.

A 4,600 foot concrete gravity flume delivered water from the Verde River to cool the condenser. In a memo from Charles F. Turtan, he noted that about 8,000 gallons per minute (12,904 acre feet per year) were pumped into the flume when the plant was

operating. When the pumps were not operating, there was a gravity flow into the flume of about 1,350 gallons per minute (2,178 acre feet per year).

The new plant went online September 17, 1917 and made another 10,000 horsepower available for distribution, more than doubling the combined capacity of the Childs and Irving hydro plants.

In an official test at full load conducted for three days in November, 1917, the Tapco steam plant developed 335 kilowatt hours per barrel of oil, a result which at that time had never been achieved by any other similar size plant in the world.

The use of river water to cool the condenser gave the Tapco plant a performance advantage. In a comparison with Tapco, two other nearly identical steams plants built in Arizona in the same time frame used recirculating ponds to cool their condensers and never reached the same efficiency or economy.

Together with its hydro plants, auxiliary steam plant, and transmission lines, The Arizona Power Company was prepared to meet the energy demands of Yavapai County.

In 1920, the Central Arizona Light and Power Company built a transmission line from The Arizona Power Company grid to the south, and supplied 70% of the power needs of the Phoenix area.

Although The Arizona Power Company was originally organized to supply power to the mining operations in Yavapai County, by 1932, it had expanded to provide power to the mines and town of Wickenburg, and the towns of Seligman, Ashfork and Flagstaff.

The Arizona Power Company also assisted the Salt River Valley Water Users Association from the mid-1920's to the early 1930's when a drought left their reservoirs empty and curtailed their ability to generate electricity or provide irrigation water.

By 1938, all the ore of value at the United Verde Extension mine had been processed. By the time it closed that year, it had produced over $100,000,000 in copper, gold and silver and paid $55,000,000 in dividends.

The United Verde mine worked itself out of profitable ore in 1953 after the production of 2.5 billion pounds of copper, 50 million ounces of silver, a million ounces of gold, and several million pounds of zinc with a gross value of over half a billion dollars.

While the Childs and Irving hydro plants continued their steady, dependable, low maintenance production, the Tapco steam plant was near the end of its production life by June, 1950. It ran for three months in 1953 for summer peak load and was retired for good after a seven day run in September, 1958.

Engineers and investors that were drawn in by the prospects of harnessing a wild and unique source of water to produce electricity had no idea that their efforts would still be productive over 100 years later had it not been for the decision to return that water source back to its natural course.

Completion of the Childs, Irving and Tapco power plants, all in less than ten years, was a credit to the leadership of The Arizona Power Company. This was a herculean effort that produced engineering marvels and changed the course of Arizona history.

BIBLIOGRAPHY

Alston, Elmer
2011 Personal conversation
Retired Arizona Public Service Company operator at Childs and Irving Power Plants

Arizona Public Service
1990 *Childs-Irving: A History*. Brochure

Arizona Public Service Archives
Historic Photograph Collection

Bridgwater, Malcolm M.
1950 Memo from Arizona Public Service Archives
Vice President and General Superintendent of The Arizona Power Company

Hawley, J. E.
1991 *An Unusual Road*

Historic American Engineering Record
2004 No. AZ-65 and AZ-65-A
*Childs-Irving Hydroelectric Project*

Jerome Mining News
June 8, 1903
*Mrs. Iva E. Tutt, The Electrician*

Jerome State Park
Historic Photograph Collection

Johnson, A. C.
Reports and notes from his papers. Courtesy of Sharlot Hall Museum Archives
Accountant and Treasurer of The Arizona Power Company.

Masson, Raymond S.
1908 Letter to F. W. Stehr -- The Arizona Power Company Letterhead
Arizona Public Service Archives

Masson, Raymond S.
August 11 & 18, 1910
*The Hydroelectric Generating System of The Arizona Power Company*
Reprinted from *Electrical World*

Munderloh, Terry
2007 *Harnessing the Water Power of Fossil Creek*

Turtan, Charles F.
May 31, 1967
Memo from Arizona Public Service Archives

Weymouth, C. R.
June 16-19, 1919
*Economy of Certain Arizona Steam-Electrical Power Plants Using Oil Fuel*
A report presented to the American Society of Mechanical Engineers, Detroit, Michigan. Weymouth was chief engineer for Chas. C. Moore & Co., builder of steam-electrical power plants.

Witte, Bob, Sr.
1971 Memo from Arizona Public Service Archives
Former APS employee

Young, Herbert V.
1964 *Ghosts of Cleopatra Hill -- Men and Legends of Old Jerome*

## Biography

Tim Coons is a 42-year Arizona resident who just completed his 39th year at Arizona Public Service Company. He and his wife, Jennie, live in Cottonwood, and have two daughters and ten grandchildren.