

# An Engineering Feat of No Small Magnitude

The History, Hydraulics and Engineering of the Marlette Water System



Today's presentation is about the History, Hydraulics and Engineering of the Marlette Water System.

The system was constructed by the Virginia & Gold Hill Water Company. Over the last 150 years, the system has been upgraded and continues to operate and provide water to the Comstock and Carson City today.

# Virginia City Evening Chronicle

August 2, 1873

"The pouring into this city and Gold Hill of a large stream of water from the Eastern Summit of the Sierra Nevada Mountains at 6:45 last evening, marked an epoch in the history of the Comstock and was the signal for a general jollification and rejoicing of twelve or thirteen thousand people. Bonfires and rockets girdled old Mt. Davidson for hours and cannons continued to roar until a late hour of the night."

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Here is a bit from an article from the August 2, 1873 (150 years ago today) Virginia City Evening Chronicle reporting that the evening before water from the pipeline was greeted in Virginia City by lots of merriment. The flow rate was 153 miners inches or 1,717 gpm (in Nevada, a miners inch is 1/40<sup>th</sup> of a cfs).

Putting the pipe into operation was not without problems. They started filling the pipe July 31 and discovered two leaks, one causing a "200' spirt (sic). The next attempt on August 1 resulted in a bell on the pipe giving way. At risk of getting ahead of myself, I'll say that the static pressure in the pipe exceeded 700 psi along the ridge of Lakeview Hill-the highest pressure pipeline in the world at the time.

Water Supply on the Comstock, Hugh Shamberger.

# Report from near the foot of Lakeview Hill

"As the water came surging down through the great inverted siphon from the elevated mountain spur and began to fill . . . one after another of the blow-off cocks on the crests of the ridges crossed, opened, and allowed the escape of compressed air. Compared with what was heard when these cocks blew off, the blowing of a whale was a mere whisper ... .

As the pipe filled, the progress of the water in it could be traced by the blowing off of the air on top of the ridges through the valley, and at last, to the great joy of the engineer and all concerned the success of the enterprise, the signal fire at the outlet, on the summit of Virginia range, was for the first time lighted showing that the water was flowing through the whole length of the pipe."

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Dan DeQuill was an author, journalist and humorist who was a reporter for the Virginia City Evening Chronicle. He lived near the foot of Lakeview Hill and wrote this article. .

Give a minute to read:

This is great stuff. I've commissioned some pipes, but nothing like this. It must have been exciting as the water traversed the 20 miles, crossing Washoe Valley. They said the sound of the air blowing out of the ARV's was louder than the blowing of a whale. I've never doubted that water would come out the other end of pipes I was involved with, but it is always exciting watching it happen-I can only imagine the delight Herman Schussler (the engineer who designed the system) must have felt when he saw the signal fire lit at on the summit of the Virginia range to announce the water was coming out of the pipe above Bullion Ravine. Remember, the pipe had already sprung a few leaks.

Signal fires. That sounds like way more fun than a text message, phone call or call on the radio saying "It's here."

Water Supply on the Comstock, Hugh Shamberger.

A scenic landscape featuring a large, rusted metal pipe structure in the foreground, set against a backdrop of rolling hills, a valley, and snow-capped mountains under a blue sky with light clouds. The pipe structure is a prominent feature, likely part of a water infrastructure project.

# Agenda

- The Need
- The Early History
- Engineering
- Pipe
- Construction
- Evolution
- Questions

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So here's what I'll talk about. Why this was needed, the early history of the system, the engineering (and the engineer), the pipe, construction, and a bit about how the system has evolved to where we are today. It's fascinating both from an engineering perspective as well as a historical perspective. I'll mainly focus on Pipe #1 (there have been a total of 3).

# Original System

- Virginia & Gold Hill Water Company formed May 12, 1863 via the merger of two companies.
- The supply was streams coming from 7 tunnels.
- Water was in short supply, due to demands from the mines and a growing population.
- Mining activity changed the flow from various tunnels.
- The water company started augmenting the supply with water from the Ophir mine, which was poor quality.

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- Prior to the construction of the pipeline, the water in Virginia City was primarily from streams and drainage from mines. The Virginia Water Company and Gold Hill Water Company merged to form the Virginia Gold Hill Water Company in May 1863.
- They owned or leased streams from 7 tunnels and moved water through flumes and ditches to cisterns. From the cisterns, it was distributed throughout Virginia City and Gold Hill.
- Supply was short, in October 1863, they only had about 0.9 MGD, seemingly a lot for a population of around 2,500 but the mines used a lot of water.
- The main supply was from the Santa Rita Tunnel.
- Mining activity was affecting the flow of water from the tunnels.
- So, the Virginia & Gold Hill Water Company had to augment the supply with water from the Ophir mine, which was poor quality, and people began to complain.

Water Supply on the Comstock, Hugh Shamberger.

# Whiskey Is For Drinking

Notwithstanding the number of physicians who had already hoisted their "shingles," there was much sickness in Virginia, owing chiefly to exposure and dissipation, but in some measure to the deleterious quality of the water. Nothing more was wanting to confirm my original impressions. The water was certainly the worst ever used by man. Filtered through the Comstock Lead, it carried with it much of the plumbago, arsenic, copperas, and other poisonous minerals alleged to exist in that vein. The citizens of Virginia had discovered what they conceived to be an infallible way of "correcting it;" that is to say, it was their practice to mix a spoonful of water in half a tumbler of whisky, and then drink it. The whisky was supposed to neutralize the bad effects of the water.

From "A Peep at Washoe" by John Ross Browne, Harpers New Monthly Magazine December 1860.

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This is part of an article by John Ross Browne who reported the water was said to be the worse ever used by man after filtering through the Comstock Lead. It apparently contained plumbago (graphite which is naturally occurring in this area), arsenic (no surprise) copperas (ferric sulfate, which forms green crystals) and other minerals. Treatment of the water was accomplished by mixing a spoonful of water in half a tumblerful of whisky to neutralize the bad effects of the water.

# Water Is For Fighting Over

- The Santa Rita Tunnel was the main source of water.
- In early January 1867, the supply from the Santa Rita Tunnel was intercepted by work in the Cole Tunnel.
- The Virginia & Gold Hill Water Company had to start getting water from Cole Company.
- The Cole Company didn't renew the water lease in 1870, instead, they started building their own water system.
- The Virginia & Gold Hill Water Company saw that coming so they had been extending the Nevada Tunnel to intercept the water going into the Cole Tunnel, timing it so they would hit the water as their lease expired.
- The water company successfully intercepted the water.
- The Cole Company went to court.

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- Remember the main source of quality water was the Santa Rita Tunnel.
- In early January 1867 two laborers were working in the Cole Tunnel below the Santa Rita Tunnel, when the rock suddenly gave way and the "water gushed out with such force that the men were driven back to the mouth of the tunnel."
- That stopped the flow of water from the Santa Rita Tunnel at once.
- The water company took legal action against the Cole Company and lost. So they had to start leasing water from the Cole Company.
- The Cole Silver Mining Company realizing the value of good quality water didn't renew the lease with the water company and started to build their own water distribution system. Remember, the water from the Cole Tunnel was higher quality.
- The Virginia & Gold Hill Water Company apparently saw that coming so they had been extending the Nevada Tunnel (below the Cole Tunnel) to intercept the water going into the Cole tunnel, timing it so they would hit the water as their lease expired. When they hit water, it stopped flowing out of the Cole Tunnel and began flowing out of the Nevada Tunnel.
- So, the Cole Company went Court to stop the water diversion by the Water Company.
- They insisted that the water company extended the tunnel expressly to take its water; the Virginia and Gold Hill Water Company claimed that its objective was to prospect ledges.

Water Supply on the Comstock, Hugh Shamberger. Pages 3-4  
Comstock Mining and Miners, Eliot Lord Pages 258-262ish

# The Outcome

- In February 1871, the court agreed with the Cole Company and said that the diversion and appropriation of the water by the water company was wrongful.
- That decision was upheld by another judge, Circuit Justice Field.
- The Virginia & Gold Hill Water Company returned the flow to the Cole Silver Mining Company.
- The Cole Company supplied domestic water to the area, but the Virginia & Gold Hill Water Company supplied water to the mills in Gold Canyon-and made more money.

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- The court agreed with the Cole Company and said that the diversion and appropriation of the water by the water company was wrongful.
- That decision was upheld on appeal.
- Following this ruling, the Virginia and Gold Hill Water Company effectually bulkheaded the Nevada Tunnel, causing the water flow out of the Cole Tunnel once more.
- The Cole Company continued to furnish most of the domestic water to the area, but the Virginia and Gold Hill Water Company continued to furnish water from the mine shafts to the mills in Gold Canyon and made more money.
- Somewhere during this time, the rumor may have started that Mark Twain said “Whiskey is for drinking and water is for fighting over”. There is no evidence that he ever said that, nor any that he didn’t. So, in true Virginia City fashion, it’s a great story, which might even be true.

Water Supply on the Comstock, Hugh Shamberger.



# A New Source

- The Virginia & Gold Hill Water Company had long recognized a need for a new source of water for the Comstock.
- One of the first engineers to look at the project to bring water to the Comstock from the Sierras was S.M. Buck who gave an adverse report in 1864.



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- The Virginia & Gold Hill Water Company had long recognized a need for a new source of water for the Comstock
- The thought of getting water from the Sierras was first broached in the early 1850's.
- One of the first engineers to look at the supply was S.M. Buck. In a letter dated July 14, 1864, he said "...to bring water across Washoe Valley at sufficient height to make it available to supply Virginia City would, to say the least, be one of the most arduous undertakings of engineering and mechanical skill in modern or ancient times." He went on to say later in his letter "...it is an undertaking in which no prudent capitalist would ever invest his money; and I hardly need observe that without capital, and that in great abundance, this undertaking could never be accomplished."

Water Supply on the Comstock, Hugh Shamberger

# And A New Set Of Eyes

- Next, came some changes in ownership of water company.
- The new Board of Directors decided to go to the Sierra Nevada for water in August 1871.
- They asked Herman Schüssler to take a look.
- Herman submitted his report in October 1871.
- In May 1872, Herman submitted the specs and requisition for the iron for the pipe and a month later the specs and requisition for the rivets.
- 14 months after Herman's first report, the new system was operating.

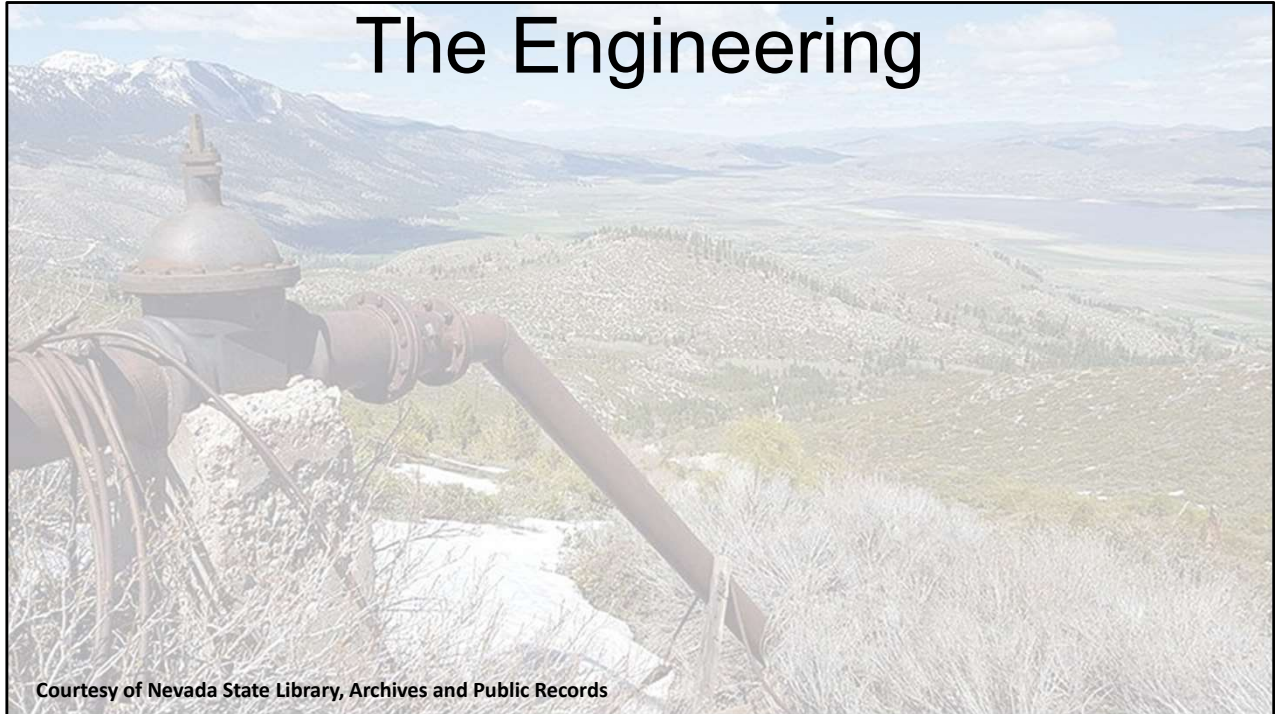
Courtesy of Nevada State Library, Archives and Public Records

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- Then there were some changes in ownership of water company.
- The new Board of Directors decided to go to the Sierra Nevada for water in August 1871. Those directors were Walter Dean, W.S. Hobart, John Skae, John Mackay, James G. Fair, James C. Flood and W.S. O'Brien.
- They contacted Herman Schussler to take a look. Herman was a consulting engineer who was the chief engineer for the Spring Valley Water Works in San Francisco. He had also done work on the Sutro Tunnel so he was familiar with the area.
- Herman submitted his report in October 1871.
- 7 months later, in May of 1872, Herman submitted the specs and requisition for iron for the pipe - 477 long tons of it-a long ton is 2,240 lb. It's interesting, he specified "no salt, salt petre or any other material that would precipitate corrosion to be shipped on the same vessel with the iron." A month later he submitted the specs and requisition for the rivets-952,900 of them.
- 14 months from the date of his initial report, on August 1, 1873-150 years ago yesterday, the new system went into service.

Water Supply on the Comstock, Hugh Shamberger

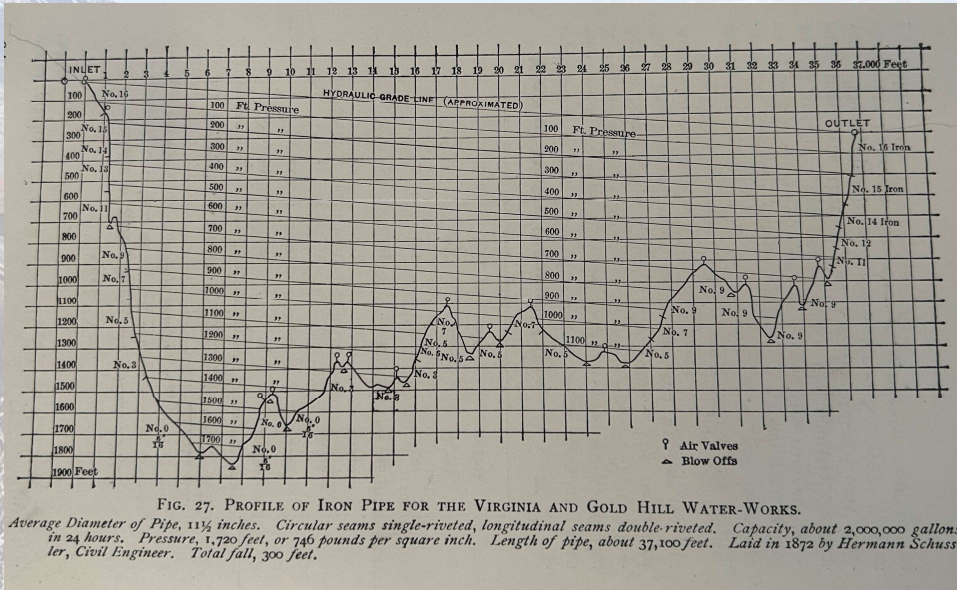
# The Engineering



- The Engineering
- Ultimately, there were 3 pipes, and this photo shows the alignments of all three pipes.
- Schussler did the Number One pipe.
- The water originally came from Dall Creek (now Hobart Creek through flumes and into the pipe.
- The water then went through about 7 miles of pipe to the outlet at 5 mile reservoir, and back into flumes to go into town.
- The pipes went up to this area, I'm not sure why the lines get lighter going west.

Water Supply on the Comstock, Hugh Shamberger P. 4.

# Profile



A Practical Treatise on Hydraulic Mining in California; Augustus Jesse Bowie, 1895.

- This is where it gets good. This is the profile of the pipe.
- This profile is really no different than what we do today.
- The first pipe was 11 ½ " diameter riveted steel pipe, it's 37,100' long.
- The elevation difference from one end to the other was about 300'-remember that number.
- The difference between the high point and the low point was about 1825', so 790 psi static pressure.
- Flow was 2 MGD or 1,390 gpm.
- ARV's were at the high points to let air out and blow offs were at the low points to flush out sediment-just like we do today.
- The hydraulic grade line is shown-a line connecting two points of known pressure.
- The slope of the HGL represents friction loss.
- The vertical distance from the HGL to the pipe gives the pressure. Max pressure when flowing is 1,720' or 745 psi.
- Notes on the profile show the gauge of steel for the pipe based on these pressure lines.
- Wall thicknesses varied from about 1/16" to 5/16".

Water Supply on the Comstock, Hugh Shamberger P. 4.

# Headloss

$$\text{Friction Head Loss (ft)} = \frac{\text{Length(ft)}}{100} 0.2083 \frac{100^{1.852}}{C} \frac{Q(\text{gpm})^{1.852}}{\text{Diameter(in)}^{4.8655}}$$

Courtesy of Henry Darcy of France, and Julius Weisbach of Saxony

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- No presentation is good without some equations.
- Here's the Darcy-Weisbach Equation to determine head loss.
- Julius Weisbach wrote this in 1845 so it might be what Schussler used.

# Headloss

$$\text{Friction Head Loss (ft)} = \frac{\text{Length(ft)}}{100} 0.2083 \frac{100^{1.852}}{C} \frac{Q(\text{gpm})^{1.852}}{\text{Diameter(in)}^{4.8655}}$$

$$\text{Friction Head Loss (ft)} = \frac{37100'}{100} 0.2083 \frac{100^{1.852}}{108} \frac{1389\text{gpm}^{1.852}}{11.5''^{4.8655}} = 306'$$

Courtesy of Henry Darcy of France, and Julius Weisbach of Saxony

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- Plugging in the numbers and knowing riveted steel Pipe has a c factor of 100-110
- The result is about 300' of head loss with a C factor of 108. It nice to know the math still works.

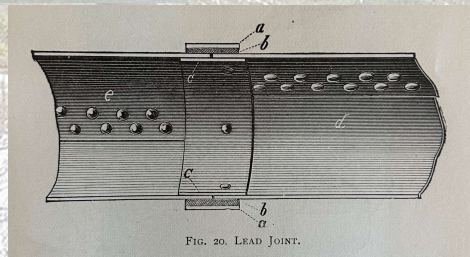
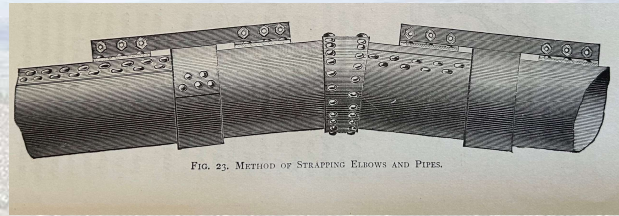
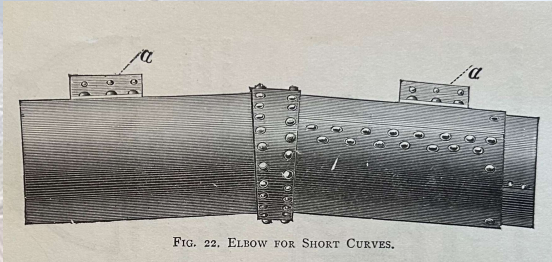
# Velocity

$$Velocity = \frac{Q}{A} = \frac{2 \text{ MGD}}{\pi \left(\frac{11.5''}{2}\right)^2} = 4.29 \text{ ft/s}$$

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- Velocity=Q/A=4.29 ft/s – this meets NAC445A’s max of 8 ft/s and good engineering design of 5 ft/s.
- It’s a little slow for flushing velocities (2.5 ft/s+) so the blow offs were necessary.
- I left out the constants for unit conversion for clarity

# The Pipe



A Practical Treatise on Hydraulic Mining in California; Augustus Jesse Bowie, 1895.

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- The pipe was riveted steel pipe and roughly 3' sections were riveted together to make 23' sticks.
- The pipe was double riveted longitudinally and the couplers were single riveted-but they did have restraints.
- The thick walled pipe was made in San Francisco by Risdon Iron Works.
- Some of the thinner pipe was rolled onsite from plates.
- The joints were restrained.
- Like I said earlier, wall thicknesses varied from 1/16" to 5/16".
- The pipe was buried about 4' deep.
- The joints were a bit different than we do today. The bells if you will were internal.
- No longer use lead joints.



# The ARV's and Blowoffs

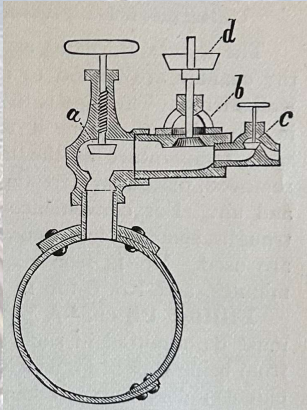


FIG. 26. SELF-ACTING AIR-VALVE.

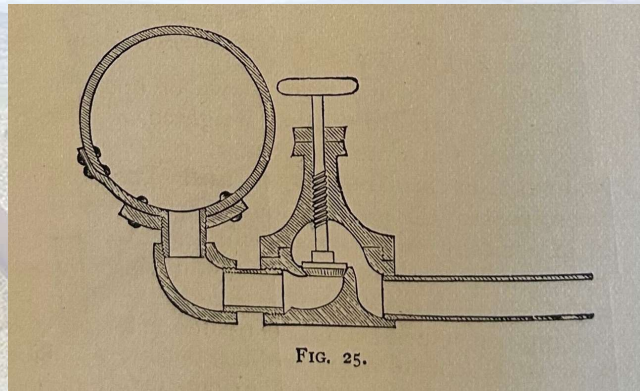


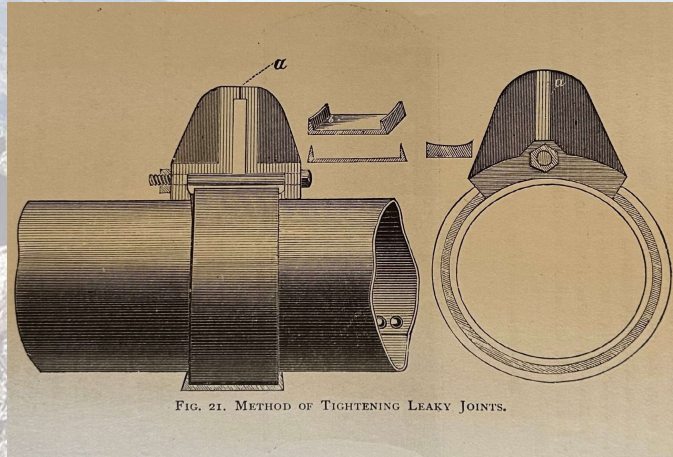
FIG. 25.

A Practical Treatise on Hydraulic Mining in California; Augustus Jesse Bowie, 1895.

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- The ARV's work on the same principle as the ones we use today, with a float that falls to open a valve to release air.
- Valves on blowoffs were globe valves.
- These diagrams also show how the longitudinal seams worked.
- Today, we tend to use circumferential taps where these taps rely on the tensile strength of the rivets.

# Joint Retrofits



A Practical Treatise on Hydraulic Mining in California; Augustus Jesse Bowie, 1895.

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- After they pressured up the pipe, they discovered a number of joints leaked.
- They dug up lots of joints and installed lots of clamps to tighten up the lead in the joints.

# Evolution

- While all this is going on, Virginia City was booming.
- In July 1873, as Pipe #1 is coming online, the water company superintendent J.B. Overton was working on the next pipeline.
- 5 Mile Reservoir was being built, and was completed in early 1874.
- By early May 1875 a second water pipe was being laid across Washoe Valley in order to increase the available supply by another 2 million gallons per day.

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- The evolution of the system after Pipe 1.
- Virginia City was really booming at this time.
- Construction of 5 Mile Reservoir started in August 1873 and was completed in early 1874 with a capacity of 5-7 MG.
- Virginia City's population was over 20,000. (1875 Nevada census was 19,000 it is believed to be closer to 25,000 due to miscounting.
- Captain J.B. Overton was hired as the Superintendent in late February 1872 and took over responsibility of developing additional supply.
- The second pipe which was designed by Superintendent Overton, was ten-inches in diameter, with lap welded seams and threaded joints, rather than the riveted style used on the first pipe.
- The second pipeline is the one being used today. About 5 miles of the #2 Pipe is still in use.

Water Supply on the Comstock Shamberger

# Added Supply

- In late 1875, work started on a tunnel to bring water from Marlette Lake into the basin.
- Marlette Lake water first arrived in Virginia City about July 1, 1877.
- A third pipeline would also be designed and laid by Superintendent Overton by late July 1887.
- With the completion of the third pipeline, the system consisted of 3 reservoirs, over 21 miles of pipeline, over 46 miles of covered flume and the tunnel which was nearly 4,000 feet in length.

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- Superintendent Overton was also planning for the excavation a nearly 4,000-foot-long tunnel to bring water from the Tahoe Basin. The tunnel was necessary to provide a route for water from Marlette Lake to contribute to the water system supply. In January 1876 it was reported that 1,200 feet of the tunnel had been completed, and about 65 feet of progress was being made per week.
- The tunnel was completed May of 1877.
- Marlette Lake Water first arrived in Virginia City through the third pipe about July 1, 1877.
- With the completion of the third pipeline, the system consisted of 3 reservoirs, over 21 miles of pipeline, over 46 miles of covered flume and the tunnel which was nearly 4,000 feet in length.
- I didn't find anything which told how much the system produced at this point, but reports in the 1900's say the system could produce 7 mgd.

# The Lakeview House

- The white house on Lakeview Hill was built around 1873.
- Captain Overton maintained quarters there but never lived there.
- There were pressure gauges in the house to monitor the system.
- The house also had a Dodds Sigmoidal Water motor connected to a generator to provide lights for the house and exterior lights for evening passers by.



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- The Lakeview House
- No discussion of this water system would be complete without mentioning the Lakeview House, which still sits at the top of Lakeview Hill.
- It was built about 1873.
- Captain Overton maintained quarters there but never lived there, but other company employees assigned to monitor the system lived there with their families.
- Rumor has it that the pipes passed directly under the house.
- There were pressure gauges in the house to monitor the system- they read 0-1000 psi.
- The house also had a Dodds Sigmoidal Water motor which was an improved Pelton Wheel. The Dodds cup design is better for high heads.
- It was connected to a generator to provide lights for the house and exterior lights for evening passers by.
- On the night the system was tested, July 31, 1873, many of the key players celebrated the completion of the project in this house.

<https://www.911metallurgist.com/water-wheel/>

# Subsequent Owners

- In 1957 the Curtiss Wright Corporation bought the supply system, along with about 95% of the land in Storey County.
- They deeded all it's rights in the water system to a subsidiary, the Marlette Lake Company.
- The missile testing contract Curtis Wright was hoping for never materialized.

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- Subsequent Owners.
- In 1957 the Curtiss Wright Corporation bought the system, upstream of 5 mile reservoir, along with about 95% of the land in Storey County. They deeded all it's rights in the water system to a subsidiary, the Marlette Lake Company.
- They were planning a large missile testing program under a government contract, which never materialized.
- I can't help but wonder how our area would be different had they got that contract.
- The distribution system continued to be operated by the Virginia City Water Company, which was formed in 1933 and assumed ownership and operation of the entire system from The Virginia and Gold Hill Water Company. The Virginia City Water Company had two superintendents, James Leonard 1905 to 1959, and his son Hobart Leonard 1959 to 1974. In March 1974 the Virginia City Water Company sold the local distribution system to Storey County.

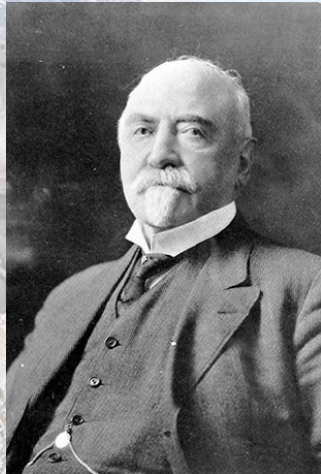
# Subsequent Owners

- The Marlette Lake Company approached the State offering to sell in Feb 1963.
- Edward Kruse, Superintendent of Buildings and Grounds was in favor of that and spearheaded the purchase.
- The deal closed in June 1963.
- The state still operates the system today supplying raw water to Virginia City and Carson City.

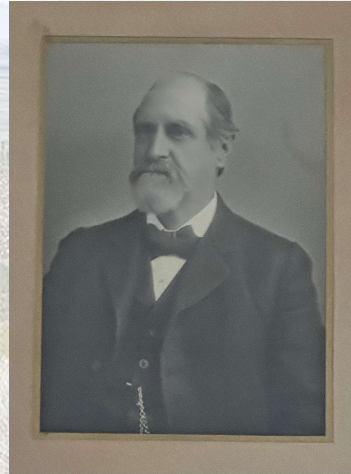
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- The Marlette Lake Company approached the State offering to sell in Feb 1963.
- Edward Kruse, Superintendent of Buildings and Grounds for the State at that time was in favor of that and spearheaded the purchase.
- I believe the granddaughter of Mr. Kruse is with us today, Kari Ward, can you stand up?
- The deal closed in June 1963 and included 5,378 acres of land, The purchase was approved by the NV Legislature for \$1.65 Million.
- The state still operates the system today supplying raw water to Virginia City and Carson City.
- The tunnel has collapsed, so water is pumped over the ridge to run down to Hobart Reservoir.

# Final Thoughts



Herman Schüssler



Captain John Bear Overton

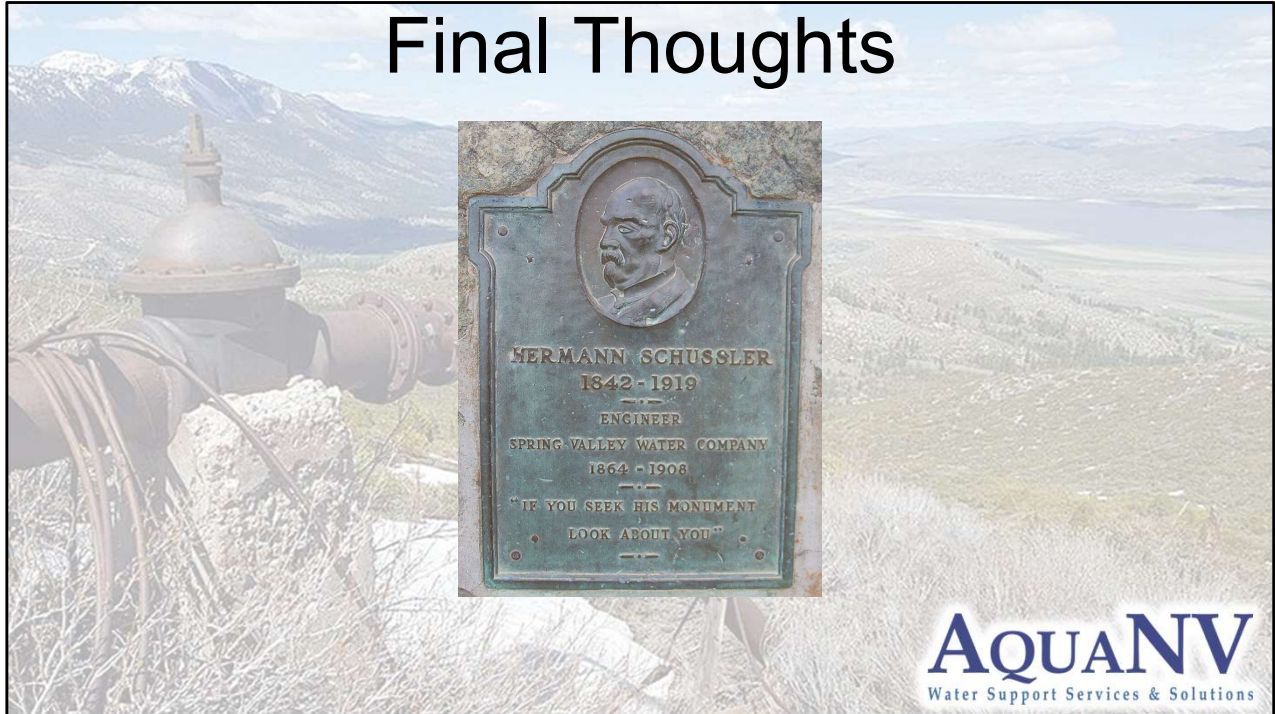
Courtesy of the Historic Fourth Ward School Museum & Archives, Leonard Collection.

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- No talk at an event like this would be complete without some retrospective thoughts.
- On the left is one of the two pictures of Herman Schussler, obviously as a much older man-he was 29 when he started on this project.
- As I prepared this, I wondered why Herman was able to tackle and complete a project others said was impossible- and came up with some thoughts.
- Schussler had experience on high pressure pipelines from Spring Valley to build on.
- Herman didn't let an assumed budget stand in his way. S.M. Buck said nobody will pay that much so the project won't work. Herman just brought his experience to the table, did his job and designed and constructed the pipeline.
- The Water Company Board understood the need and decided it was worth it to build the pipe - and made the Comstock what it was.
- Captain John Bear Overton was superintendent of the water system from 1873 until 1905. He tends to get less recognition but actually delivered more capacity to Virginia City and arguably did more for the system. He did have the advantage of knowing it could work, where Schussler was breaking new ground.



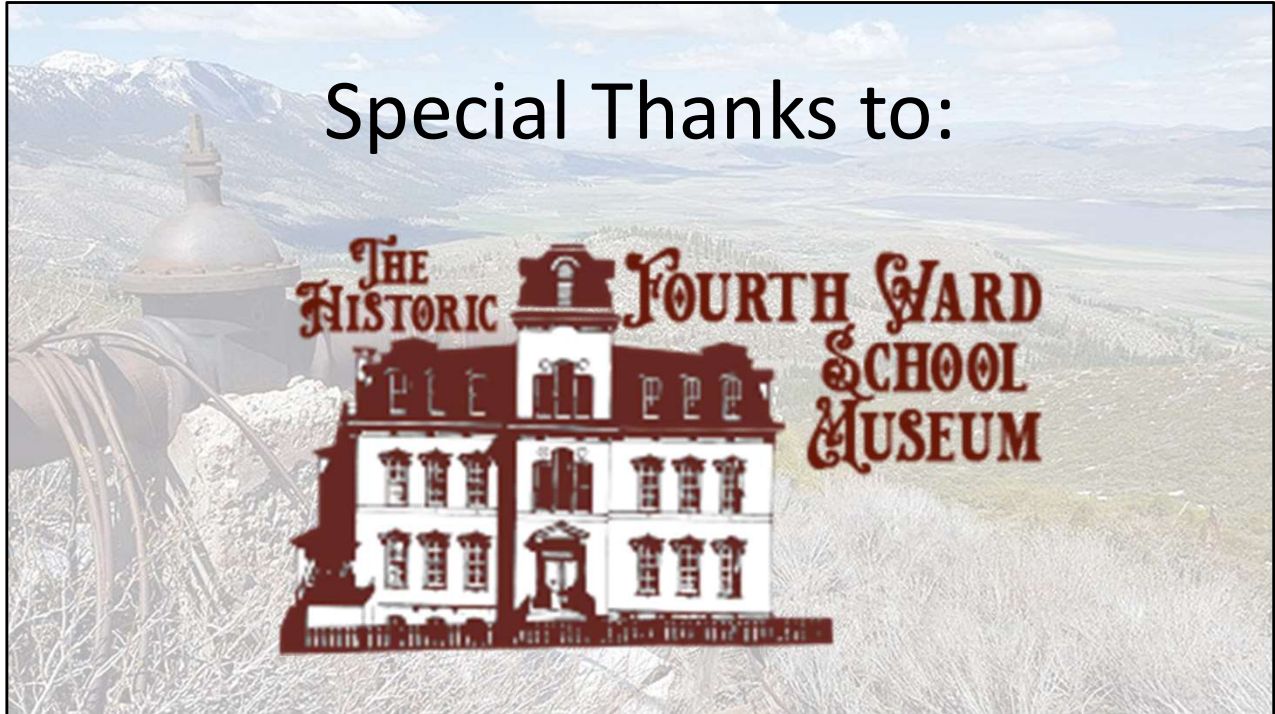
# Final Thoughts



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- I also came across a photo of this across this plaque, located at the Crystal Springs Reservoir honoring Herman Schussler. “If you seek his monument look about you”. I don’t think engineers build monuments to themselves, but our work becomes our legacy. Herman just did his job - that speaks for itself.

## Special Thanks to:



- I'd like to give thanks to the Historic Fourth Ward School Museum which has an exhibit on this system in their changing gallery, it will be there through this year and possibly into 2024.
- The exhibit includes a bunch more information on the system, its history, the people and workers, and has many artifacts - a piece of Pipe #1, a piece of a flume, the pressure gauges and the Dodds Sigmoidal Water Motor from the Lakeview House, in addition to objects from the Water Company and personal effects from the Leonard family-and lots of photographs

# Questions?

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