CHAPTER IV.—PLACER MINES.

TOPOGRAPHICAL.

POSITION RELATIVE TO SOURCES OF WATER SUPPLY.—This is a decisive question with regard to mines worked by the hydraulic method, for which an abundant water supply is as essential to successful results as is the possession of an auriferous gravel deposit. Drift mines require much less water, but it is none the less a necessity. As it frequently happens that erosion has left the gravel beds at elevations far above the existing drainage system in their immediate vicinity, and sometimes in isolated positions, as at Cherokee and many other places in California, the introduction of artificial water channels becomes a problem of great difficulty, to meet which capital and engineering skill are taxed to their fullest extent. The section on mining ditches contains illustrations of the nature of the work already accomplished in this direction.

POSITION RELATIVE TO LINES OF COMMUNICATION.—The more important placers are in portions of the country which, as a rule, are more accessible and thickly settled than the quartz-mining districts, and are often found in immediate proximity to fertile agricultural land, to which population was originally attracted by the existence of mines. Hence, the prices of food and other necessaries of life are comparatively low. Placer mines, too, do not require nearly so large an amount of material as do quartz mines and mills. Beyond the light iron pipes, hose, tools, quicksilver, and occasionally powder for bank-blasting, the amount of supplies to be brought as freight is usually very small, except in cases where mines are opened by extensive tunnel enterprises. The question of freight charges is therefore one of minor importance, except in certain remote districts in Idaho, Montana, and Dakota, or the Skagit country in Washington.

ALTITUDE REFERRED TO SEA-LEVEL.—The secondary nature of gravel deposits in itself implies a lower average altitude than that of quartz veins, from which they are derived, though exceptions are met with in the case of veins unrelated to the drift matter or whose croppings have been largely cut down by erosion, possibly also where the conditions have been reversed by earth movements. The placer mines reported upon are at an average elevation of over 3,400 feet above sea-level, and those of California alone are at an elevation of about 2,600 feet. The large number of shallow alluvial placers on the foot-hills and on the edges of the Sacramento and San Joaquin valleys, not on the lines of ancient river channels but re-deposits from the latter, are at less altitudes than the average stated, while the beach sands, which are not included in this computation, form the lowest group. The great drifts of the ancient rivers are in places from 1,500 to 2,000 feet above the present drainage system. The order of succession of the deposits in point of time as well as of altitude is: first, the original quartz veins; second, the drift accumulated in the ancient river channels; third, the shallow alluvial placers, a re-deposit or second concentration from the earlier drifts. Above the zone of the ancient rivers, in places, are found deposits of wash from the quartz croppings of recent origin; and, on the other hand, below the old river beds occasional accumulations of gravel are found, which are not re-deposits from the latter, but are formed by the disintegration of veins which reach the surface at a less elevation than that of the ancient channels.

Placers are sometimes by erosion left at the summits of hills or mountains, but this is the exception, not the rule, though some very important deposits occur on the crests of the foot-hills.

Alma township, in Park county, Colorado, contains the highest placer reported. Its elevation is stated at 10,000 feet.

Tables are annexed showing the results, in reference to altitude, reached from an examination of 174 working placer mines.

TABLE LX.—ALTITUDE OF PLACER MINES, BY DISTRICTS.

State, county, and district.	No. of mines reported.	Average altitude.
ARIZONA.		
APACHE CO.		
Greenlee Gold Mountain	1	4,000
CALIFORNIA.		
BUTTE CO.		
Cherokee Flat	1	1,116
Magalia, or Dog Town	1	2,650
Morris Ravine	1	900
Oroville	1	185
DEL NORTE CO.		
Indian Creek	7	1,796
PLACER CO.		
Dutch Flat	1	3,500
Gold Run	1	3,400
Iowa Hill	1	2,850
Michigan Bluffs	2	3,540
PLUMAS CO.		
Moonlight Mountain	1	5,433
Seneca	2	4,142
....	3	3,753
SISKIYOU CO.		
Galena Hill	1	2,500
Humbug	2	2,850
Indian Creek	3	2,683
McAdams Creek	7	2,707
Oro Fino	1	2,300
Sawyer's Bar	1	2,200
Sciad Valley	2	1,407
Scott Valley	1	3,200
Yreka	8	2,831
STANISLAUS CO.		
La Grange	1	260
COLORADO.		
CHAFFEE CO.		
Hope	1	8,600
CLEAR CREEK CO.		
Grass Valley	1	7,600
Jackson	1	7,500
LAKE CO.		
California	2	9,975
LA PLATA CO.		
California	1	8,400
PARK CO.		
Alma township	1	10,000
SUMMIT CO.		
Bevan	1	9,700
Spaulding	1	9,200
....	1	9,800
DAKOTA.		
CUSTER CO.		
Battle Creek	1	4,400
LAWRENCE CO.		
Bear Gulch	1	*a* 6,000
PENNINGTON CO.		
Confederate	2	4,075
Cañon	3	4,800
Jenny and Strawberry	1	5,500
Rockerville	1	5,500
Ruby	1	4,000
GEORGIA.		
CHEROKEE CO.		
Fifteenth and Second	1	881
HALL CO.		
8!0 G. M., Ninth and Twelfth	1	1,400
LUMPKIN CO.		
Twelfth	3	1,602
Twelfth and First	2	1,530
Thirteenth	1	1,430
UNION CO.		
Tenth and First	1	3,000
WHITE CO.		
Third	1	2,060
Fourth	1	*a* 2,000
IDAHO.		
ALTURAS CO.		
Elk Creek, or Hardscrabble	1	5,700
BOISÉ CO.		
Boston	1	5,300
Moore's Creek	3	5,008
Pioneer	2	5,725
MONTANA.		
BEAVER HEAD CO.		
Bannock	2	5,000
DEER LODGE CO.		
Gold Hill	1	5,480
Henderson Gulch	1	*a* 5,600
Independence	1	*a* 5,800
McClellan Gulch	2	*a* 6,100
Nelson	1	*a* 4,500
Summit Valley	1	*a* 5,700
LEWIS AND CLARKE CO.		
Last Chance	1	*a* 4,200
MEAGHER CO.		
German	1	4,400
Thompson Gulch	3	6,300
NORTH CAROLINA.		
MONTGOMERY CO.		
Eldorado	1	440
....	1	780
OREGON.		
BAKER CO.		
Amelia	1	4,000
Blue Cañon	2	3,050
Chicken Creek	2	3,250
Humboldt Basin	1	4,500
Mormon Basin	1	5,000
Pocahontas	3	4,333
Rye Valley	1	3,000
Shasta	3	3,500
Sumter	1	4,000
Wilson Creek	1	3,000
DOUGLAS CO.		
Big Bend Cow Creek	4	1,181
Cañonville	2	580
Green Mountain	2	2,000
GRANT CO.		
Cañon City	2	4,200
Elk Creek	1	4,200
Granite	2	6,350
Marysville	5	4,800
Rock Creek	2	3,880
Trail Creek	1	7,000
JACKSON CO.		
Applegate	2	2,000
Ashland	1	1,850
Coyote Creek	2	1,350
Farris Gulch	1	1,600
Fort Lane	1	1,700
Forty-nine	2	2,350
Sam's Valley	1	1,760
Sterling	2	2,425
Uniontown	2	1,600
Wolf Creek	1	1,500
JOSEPHINE CO.		
Althouse	2	1,500
Cañon Creek	1	1,600
Grass Creek	2	1,500
Josephine	1	1,600
Murphy	1	1,600
Silver Creek	1	1,900
Waldo	2	1,550
Yank	2	1,050
....	1	800
WASCO CO.		
Ochoco	1	3,800
SOUTH CAROLINA.		
CHESTERFIELD CO.		
....	1	650
UTAH.		
SALT LAKE CO.		
West Mountain	1	6,000
WASHINGTON.		
YAKIMA CO.		
Swank	1	2,000

a Estimated.

TABLE LXI.—POSITION OF PLACER MINES IN ZONES OF ALTITUDE.

tate or territory.	Total number of mines reported.	Under 500 feet.	Over 500 feet and under 1,000 feet.	Over 1,000 feet and under 1,500 feet.	Over 1,500 feet and under 2,000 feet.	Over 2,000 feet and under 2,500 feet.	Over 2,500 feet and under 3,000 feet.	Over 3,000 feet and under 3,500 feet.	Over 3,500 feet and under 4,000 feet.	Over 4,000 feet and under 4,500 feet.	Over 4,500 feet and under 5,000 feet.	Over 5,000 feet and under 5,500 feet.	Over 5,500 feet and under 6,000 feet.	Over 6,000 feet and under 6,500 feet.	Over 6,500 feet and under 7,000 feet.	Over 7,000 feet and under 7,500 feet.	Over 7,500 feet and under 8,000 feet.	Over 8,000 feet and under 8,500 feet.	Over 8,500 feet and under 9,000 feet.	Over 9,000 feet and under 9,500 feet.	Over 9,500 feet and under 10,000 feet.	10,000 feet.
The United States..	174	3	8	17	25	15	20	11	12	14	13	9	7	7	1	2	2	1	1	1	3	2
Arizona	1									1												
California	49	2	1	5	5	5	19	4	5	1	1	1										
Colorado	10																2	1	1	1	3	2
Dakota	10									4	2	1	2	1								
Georgia	11		1	4	3	2		1														
Idaho	7										2	3	1	1								
Montana	14									2	1	3	4	3		1						
North Carolina	2	1	1																			
Oregon	67		4	8	17	7	1	6	7	6	7	1		1	1	1						
South Carolina	1		1																			
Utah	1													1								
Washington	1					1																

TABLE LXII.—RANGE AND MEAN OF ALTITUDES OF PLACER MINES REPORTED ON.

State or territory.	Highest.	Lowest.	Intermediate.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*
The United States	10,000	185	5,092	3,447
Arizona	4,000	4,000	4,000	4,000
California	*a* 5,433	*b* 185	2,809	2,612
Colorado	10,000	7,500	8,750	9,075
Dakota	*c* 6,000	*c* 4,000	5,000	4,795
Georgia	3,000	881	1,940	1,694
Idaho	*d* 5,700	4,800	5,250	5,354
Montana	*c* 7,000	4,200	5,600	5,484
North Carolina	780	440	610	610
Oregon	7,000	*b* 560	3,780	2,780
South Carolina	650	650	650	650
Utah	6,000	6,000	6,000	6,000
Washington	2,000	2,000	2,000	2,000

a Small placers in the Bodie district not included.
b Does not include black sand littoral deposits.
c Estimated.
d Small placers in Alturas and Lemhi counties 9,000 feet.

GEOLOGICAL.

FORM OF THE SURFACE OF GRAVEL DEPOSITS.—The topographical features of the auriferous alluvions vary widely with the nature and origin of the deposits and according to geological events succeeding the period of deposition. Deep placers are often left by erosion at the crests of hills in forms which from a distance give no indication of their existence, and may be cut through transversely by modern streams in such a manner that the original channel is only traceable by detached patches, which are not always clearly related. If covered by volcanic flows, and then subjected to erosion on a large scale, the deposit may assume the form of a table-mountain. Many blind leads, workable by drifting, doubtless exist which have not yet been discovered, owing to the completeness with which they have been covered over.

The shallow placers of wash from neighboring quartz croppings or formed from ancient channel deposits by more recent agencies are usually deposited in the gulches and creek beds as bars or irregularly rounded accumulations, or are spread thinly over the surface as a light wash on smooth slopes. A shallow, quite uniform loam is commonly found on the surface, supporting in places a vegetation which masks the character of the underlying deposit.

Prospectors are guided in their search by the indications found in creek beds, and in localities where the development of the mines has progressed to some extent they are enabled to locate the position of hidden deposits by their relationship to known channels.

DIMENSIONS OF THE CHANNELS.—The ancient channels are remarkable not only for the enormous carrying force shown by the frequent huge accumulations of bowlders, but also for their extent. In California these channels represent rivers, and not glacial courses—a point which is quite satisfactorily established—and indicate an extinct fluvial system much greater than that now existing, and consequently a greater rainfall than the present. In Arizona and New Mexico gravel deposits of considerable size are found in regions where the water supply is now entirely insufficient for successful working. The course of the channels, too, is often at variance with that of existing streams, though the drainage system as a whole retains the same general character.

The deposit on which the Spring Valley mine, at Cherokee, California, is located is 9 miles long and from 1 to 2 miles wide. On the Spring Valley ground the gravel reaches 400 feet in depth and averages 200 feet. The Bonanza mine, at Mokelumne Hill, is on a channel 500 feet wide, traceable for 10 miles. The Wingate and Bunker Hill mines, in Del Norte county, are on a deposit from one-half to three-quarters of a mile in width, which is claimed to be traceable for 150 miles. The "blue lead" at the Gold Run mine, Placer county, is from 200 to 1,000 feet wide and in places 450 feet deep, and averages 350 feet deep; at the Polar Star the pay channel, 300 feet wide, is nearly as deep, while the Paragon mine has a deposit 800 feet wide, averaging 400 feet in depth, and in places is 600 feet deep. The channel at the Orion mine, in the same county, is said to be 2,000 feet wide, with a maximum depth of 180 feet, averaging 100 feet. In Plumas county the lead worked by the Plumas Mining and Water Company, half a mile wide, is 70 feet deep on an average and 120 feet in spots. In Stanislaus county the La Grange mine is on a deposit traceable for a mile in width and having a maximum depth at that mine of 300 feet. A lead running through Yuba county, traced from San Juan to Laporte, is 27 miles long, and at the Weed's Point mine, Galena Hill, is 600 feet wide, with an average depth of 75 feet. At Columbia Hill, Nevada county, the deposit has been estimated at between 600 and 620 feet in depth. Other places in California show examples of similarly vast alluvions, those known as "deep placers" ranging between 100 and 600 feet, with possibly still greater depths, though it cannot be stated that a greater depth than 200 feet is a frequent occurrence.

Boisé basin, in Idaho, furnishes another example of great magnitude. Here a deposit 3 miles wide and 4 miles long is worked. It is traceable in patches for a full length of 14 miles, and is certainly not less than 30 square miles in area. The depth ranges from a few inches only to possibly 250 feet, and, however formed, the deposit is immeasurably disproportionate to any existing motive force. In this territory and in Montana and Dakota many placers occur in places apparently unrelated to the present drainage system of an extent altogether out of proportion to the transporting power of the present streams.

Kind and order of deposits recognized in gravel.—The most common occurrence in deep placers is: At the surface (or immediately underlying a loam stratum or a volcanic capping) a fine wash, containing few bowlders, or even pebbles. This may be quite uniform throughout, or may consist of many strata of varying coarseness and alternations of sand, fine gravel, and clay seams. The lower portion, on the other hand, contains bowlders, of which the largest are commonly near and on bed-rock. This sizing of material, observable in beds which are considered unquestionably of fluvial origin, is the natural result of the change of grade of the channel as the latter gradually becomes filled. Each successive layer formed was equivalent to a lessening of the grade and a diminished carrying power, and consequently involved a further deposition of lighter particles. In addition to this cause, variations in the amount of water flowing at different times of the year leave their traces, freshets depositing a coarser detritus than the sluggish flow during the dry season. A similar lamination, corresponding to the seasons, is shown in some tailings deposits, where, the cause and effect being recent, the connection is readily traced.

The typical formation indicated is susceptible of many variations without departure from its leading features, but sometimes the divergence is so wide as to indicate the action of exceptional causes. Particularly is this the case where, in gravel beds apparently belonging to the same system, the higher contain heavy bowlders, while the lower are made up of strata of fine material, indicating a very slow current, or even perhaps a lacustrine deposit. Here the most natural supposition is that the bowlders were brought down by exceptional freshets.

As a rule, the shallow alluvial placers and river beds do not show the same regularity as the deep leads, and often no stratification is perceptible.

Lava-cap.—Very many of the deep placers of California are overlaid wholly or in part by a capping of volcanic rock. This is usually a basalt, and all such cappings are locally known as "basalt". The lithological character of the rock has not been minutely studied as yet, but the occurrence of augite-andesite is suspected. The flow varies in depth from a few feet to a thickness of several hundred feet, extending over large areas, and sometimes for considerable distances is quite uniform in thickness.

A number of placer mines are so situated that, a portion being overlaid by lava while another part of the gravel is exposed, they are worked both by the hydraulic method and by drifting. If the whole ground is heavily capped, there is, of course, no alternative, and drifting is resorted to if the gravel is sufficiently rich.

Occurrence of water and quicksand.—At the lowest depths of the old channels seepage water sometimes accumulates, and precaution is necessary when the deposit is tapped from beneath by an upraise from a tunnel. The accumulation of water sometimes gives rise to quicksands, which are extremely troublesome.

Bed-rock.—In California this is commonly slate, shale, or schist, but sometimes it is granite or sandstone, and more rarely limestone. The slates, etc., are of various colors (brown, blue, green, or black), and are usually soft (talcose or chloritic), but a fine-grained siliceous blue or black slate also occurs, which is rather hard. The granite is soft and decomposed, and slacks rapidly on exposure. In Oregon, Colorado, and Montana similar rocks occur.

In Idaho the common bed-rock is a highly decomposed granite, which is firm when first uncovered, but soon disintegrates on exposure to the air. In Dakota slate prevails, as also granite and sandstone. In the southern gold belt of Georgia, North Carolina, and South Carolina the bed-rock is usually a soft, decomposed mica-schist, which is highly siliceous, and often contains stringers of quartz, though a hard slate is also met with. In this portion of the country the "bed-rock" itself is mined. The disintegration of the surface by decomposition and weathering gives rise to a loose material which may be "hydraulicked", but which is not usually of the same character as the western gravel deposits, the latter often occurring at considerable distance from their origin.

The form of the surface of the bed-rock is a matter of considerable importance in working. A rough, uneven bed increases the labor of cleaning up, and if very irregular may suddenly leave the sluices "out of grade" at points where the pay is richest. In drift mines operations are facilitated by a regularity in the formation, while the drainage and extraction of ore are obstructed by a reverse condition.

False bed-rocks.—Strata of indurated clay, or of dead gravel cement, occur frequently in gravel deposits, forming what are known as false bed-rocks. Sometimes it happens that below such a stratum the deposit, consisting of "dead wash", is too poor to pay for washing, or that the grade will not admit of deeper working; in such cases the seam is treated as a working bed-rock, and the tougher and more uniform it is the better. A number of profitable mines are operated on this plan, working off only the top pay streak down to a false bed-rock; but in more numerous cases, where it is desirable to "bottom" the entire deposit for the sake of winning the richer gravel on the true bed-rock and the gold lying in the crevices of the latter, the occurrence of the false bed-rocks is a great hinderance. Some clays are so tenacious as to yield but slowly to the pipe, and often blasting has to be resorted to, thus increasing the expense.

Change in the deposit at the water-level.—In deep placers the upper strata of gravel and bowlders, when subject to the action of the atmosphere, are commonly reddish or yellowish in color. This is due to the peroxidation of the iron in the quartz. Below the water-level a deposit of blue gravel occurs. This, on prolonged exposure to the air, also changes color. In many famous mines the blue gravel, being the deeper and therefore presumably the richer, is the paying portion of the deposit; hence the popularity of "blue leads", which, indeed, have proved highly remunerative. In them, however, the color is not in itself an indication of richness beyond the fact that it points to a position protected from the air; that is, a comparatively deep one. Red gravel, too, occurs in depth. It is hardly necessary to add that changes in the position of the water-level may have obscured the color line.

Occurrence of gold.—The manner in which gold particles are distributed in gravel has been made a subject of close study by thoughtful miners, for upon a knowledge of the exact location of the paying portion of the mass often depends the method of working. Careful experiments should be made by panning; and the result of actual workings, when the product from different layers can be segregated in separate clean-ups, should be noted. The matter is one for serious consideration, and all the more so because of the present uncertainty as to the laws determining the occurrence of the "pay".

In a great majority of cases where the character of the deposit has been definitively established the preponderance of gold is found on and near bed-rock. In the deep beds of the ancient "leads" of California this generalization almost invariably holds good. Mr. Augustus J. Bowie, jr., (a) speaking of these deposits, after quoting several instances in point, remarks:

> Experience has proved that the quantity of gold found in "top-gravel" is insufficient to warrant any large investment based solely on its value. Under exceptional conditions and circumstances the upper strata have in some cases yielded handsome returns, but on the whole the general results have been anything but fortunate. It is therefore a well-established fact that the pay-dirt is obtained not from the washings of the entire bank, but chiefly from that stratum or those strata which are in most cases within 8 or 10 feet of the bed-rock.

It has certainly been shown by the workings of the more important deep placer mines of California, where, indeed, the most of the recorded observations have been made, that the lowest strata are the richest. For mines worked by the hydraulic method this often means a removal of large masses of barren, nearly barren, or unprofitable matter, in order to wash the paying portion, and with banks of great height often demands costly preliminary operations, as tunnels or deep cuts, before the deposit can be bottomed. On the contrary, in mines capped by lava, where drifting is in any event the only mode of working, the concentration of the gold in a thin stratum on the bed-rock is an advantage, as a correspondingly small amount of gravel has to be excavated in order to secure the bulk of the "pay".

In the shallow placers, however, the gold is apt to be more evenly disseminated throughout the deposit, and is sometimes found chiefly at the top. Deeper deposits also occur, containing strata of clay or barren cement false bed-rocks, in which the surface gravel is auriferous, while below the pay and false bed-rock there may be a deep body of "dead wash".

In river beds the gold, instead of settling in the deeper pools, is found chiefly on the bars, but pockets also form in crevices of the bed. The bed-rock itself, especially if decomposed and porous or of upturned slates, often contains gold to a depth of 2 or 3 feet. This is the case in many of the old channels, and in those worked by

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a Hydraulic Mining in California, *Transactions of American Institute of American Engineers*, vol. vi, p. 31.

drifting it is commonly the practice to mine the bed-rock to a certain depth, while in hydraulic mines the bed-rock, if auriferous, is piped off according to its softness. As stated, hollows and crevices in the bed are usually the richest spots; but there is sometimes an exception to this in the case of large and deep pot-holes, which are found to be filled with barren wash, while the pay stratum continues uniform above them. It has been observed in some localities that where sand strata or clay seams come in the pay ceases beneath, but such observations can be only of local validity. In many of the wide extinct channels the pay is confined to a comparatively narrow path, usually at the middle and lowest portion.

The gold of the placers is by no means exclusively in the form of grains, scales, nuggets, etc. It is also found attached to its original quartz matrix in varying proportions, from pieces which could almost be termed nuggets, but which have sufficient gangue in them to materially affect their specific gravity, up to quartz bowlders, which contain gold disseminated with the same fineness and occasionally in the same proportion as the average free-gold milling ores from veins, in much of which no gold is ordinarily visible to the eye. The cement mills connected with some drift claims afford a means of partially saving this gold, but in hydraulic mines the fine gold contained in the unexposed portions of quartz gravel and bowlders is lost. Large bowlders have been found of a grade sufficient to warrant their crushing in ordinary gold stamp-mills.

Grass-root gold.—Where the gravel comes to the surface, and, less frequently, where the upper stratum consists of loam containing more or less fine quartz wash, grass-root gold is often found. It is said to be met with more frequently in shallow than in deep placers, but an insufficient number of observations is recorded to admit of a safe generalization. If it occurs in hollows, it is not always an indication that the whole of the upper gravel is to be considered more or less auriferous, for it may have been simply the result of a local secondary wash. The gold found at the surface usually consists of very light, thin scales, not so readily saved as the more granular and heavier particles of the lower strata, but in a few cases quite coarse gold has been detected. It has been suggested that the finely divided metal usually known as "grass-root gold" has been precipitated by vegetable matter from solution in iron salts or other solvents, but it is not certain that any but mechanical influences have affected the distribution of the metal in the gravel deposits.

Rusty gold.—A portion of the placer gold exists in a state such as to render its amalgamation difficult or impossible. Such gold is called by miners "rusty". The cause is supposed to be a coating of silica cemented by sesquioxide of iron, the latter due to the decomposition of pyrite associated with the gold in the original matrix, or, according to another theory, to be a partial oxidation of the base metals alloyed with the gold. Vein gold is also said to exist in a similar condition. In the laboratory this film may be removed by digesting the rusty gold with chlorhydric acid and subsequent rubbing, or by brightening the surface mechanically by filing and scraping, when the refractory gold at once becomes facile. Certain improvements in quartz-crushing machinery aim to do this on the large scale for vein gold, but the attrition in placer washing is insufficient to render the rusty gold wholly susceptible to the influence of quicksilver. Specific gravity, therefore, rather than amalgamation, determines the saving of such of this gold as is caught.

Alloys of placer gold.—Nearly the whole of the metal alloyed with gold is silver. A little copper and iron also occur in association. In the bullion, after melting, are sometimes found, in addition to these metals, traces of lead, zinc, antimony, arsenic, and tin. Much of the base metal entering into the alloy is undoubtedly due to the concentration of metallic refuse of various kinds in the process of washing. Thus the presence of lead is accounted for by the miners, and probably correctly, by the fact that the shot which may have been fired into a gravel bank by sportsmen are, owing to the high specific gravity, caught by the appliances designed to save the gold. It is stated that, even after careful retorting and melting, minute traces of quicksilver remain in the gold.

Mineralogy of the "washings".—An enumeration by Professor Silliman of the minerals of the Cherokee Flat washings embraced gold, platinum, iridosmine, diamonds, zircon, topaz, quartz in several varieties, chromite, magnetite, limonite, rutile, pyrite, garnets, epidote, and almadine.

Platinum.—This metal occurs much more frequently and in larger quantities than is commonly supposed, as is also possibly the case with other metals of the same group, such as iridosmine, etc. Search is very seldom made for it, and it would be apt to escape the gold-saving appliances, most of which depend upon amalgamation. It is found, if at all, in small grains associated with the black sand in the sluices.

Among the localities in California reported as showing the presence of platinum are the Spring Valley, Magalia, and Morris Ravine mines, in Butte county; the Bunker Hill, Del Norte, and Happy Camp mines, in Del Norte county; the Weed's Point mine, in Yuba county; the Lincoln, Hart & Henry, Oak Grove, Fort Goff creek, and Thompson creek mines, and in the placers on the south fork of the Salmon river, in Siskiyou county; the La Grange mine, in Stanislaus county; and Chapman & Fisher's, the Gribble, Slattery, and Wiltshire mines, in Trinity county. In Colorado traces are found in the Cash Creek placer, in Chaffee county, and in the L. H. Arthur and Edward mines, in Clear Creek county. In Oregon small quantities have been detected at upper Grass creek and Evans creek, in Jackson county, and at Sunken creek, Josephine creek, Silver creek, Galin creek, Desselles & Co.'s, and the Blue Gravel mines, in Josephine county.

The quantities reported as found are very small, being from a fraction of an ounce to a few ounces per clean-up, and in most cases are saved merely as a curiosity. In the absence of systematic tests, it would be premature to predict positively that the saving of platinum is likely to become an important adjunct to the gold placer-mining industry; but it seems reasonable to suppose that such a possibility exists, and that in some of the many localities where platinum is known to occur future experiments may lead to important economic results. With the improvement of appliances designed to save "rusty" gold by specific gravity alone—such, for instance, as a system based on retaining a larger bulk of black sand and other heavy material in the sluices and under-currents and subjecting it to a second treatment by mechanical concentrators—probably larger quantities of platinum will be found.

DIAMONDS.—The occasional occurrence of diamonds in the auriferous gravels of California has long been known, but the finds have thus far been of small importance. In 1864 a diamond valued at $250, from the Spring Valley mine, Butte county, was cut in Boston, and subsequently several were tested in Amsterdam and Paris and pronounced diamonds of the first water, though of small size. In the census year one valued at $80 was found in the same mine. Small diamonds have also been found in the Morris Ravine mine, in the same county. At the Lyon drift mine, at Placerville, El Dorado county, several small diamonds of average brilliancy and not discolored were saved.

The specific gravity of the diamond (3.53) is too low to resist with any certainty the rush of water in the sluices, and of those caught by the riffles few are recognized. It would be well if the men engaged in cleaning up the sluices were to familiarize themselves with the crystallographic and other physical properties of the diamond and its appearance in the native, uncut form; for, as Mr. W. A. Goodyear, of the California state geological survey, wrote in 1871, "though it may not pay to hunt for diamonds, yet it always pays to pick them up when you do happen to see them."

RUBIES AND GARNETS.—At the Bonanza mine, Calaveras county, and the La Grange mine, Stanislaus county, California, both rubies and garnets are reported to have been found. The occurrence of garnets had previously been noted in many of the gravel deposits. It is quite possible that the supposed rubies were also garnets, as it is not known that corundum in any form has been identified by conclusive tests.

STREAM TIN.—Specimens of stream tin have been found in the alluvions of the Middle fork of the Feather river, in Plumas county, California, and in some quantity and widely distributed in the placers of the granitic regions of Idaho, Dakota, and Montana. The ore very frequently escapes recognition, and no systematic search for paying deposits is known to have been made.

INVESTMENT AND OWNERSHIP.

CAPITAL STOCK OF PLACER MINING COMPANIES.—The nominal capital stock of the mining corporations has but little significance. The placer properties are usually capitalized at much less amounts than has been the custom with deep mines, though for no apparent reason, unless, indeed, the fact that the stock of the former is less apt to be found upon the lists of the mining boards and is not so frequently used as a vehicle for speculation. But even thus the nominal capital has often little relation to the amount of money invested or the actual value of the properties. The present Spring Valley Hydraulic Gold Mining Company, for instance, has a nominal capital stock of only $200,000, in 200,000 shares of $1 each, though when placed upon the market the shares brought $10 each. In this case the incorporation was effected under the laws of the state of New York, the purpose of the low capitalization being to insure individual stockholders against any possible personal liability or assessments. Thirty-six placer mining companies reported have a nominal capital of $35,115,000, or an average of $975,417, and the average par value of the shares of $34,815,000 of this amount is $14 68.

There are a large number of claims held by unincorporated companies, each consisting of a few individuals. The ownership of these is often divided into a small number of shares, commonly the same number as that of the original holders, but each share of correspondingly higher value.

CAPITAL ACTUALLY INVESTED IN PLACER MINING.—This cannot be definitely ascertained or even approximately estimated. In the case of the State of California *versus* the Gold Run Mining Company the statement was made that the capital invested in mining in California is about $160,000,000, of which $100,000,000 is in gravel mining. Referring to this testimony Lieutenant-Colonel Mendell (*a*) remarks:

> This appears to be a generalized opinion, based upon a partial knowledge of investments. It is not based upon detailed information, and is not claimed to be more than an approximation. So far as it applies to gravel mining, the amount is probably in excess. Perhaps it is quite as well for the purposes of this report to be able to say that invested capital is large as to be able to give the specific amount. This kind of information for a majority of mining properties is quite out of the question

For the following-named companies Lieutenant-Colonel Mendell (*b*) gives the several amounts, including in each case presumably the cost of ditches, reservoirs, etc.:

a Mining Débris in California Rivers, p. 17. *b Mining Débris in California Rivers*, p. 18.

TABLE LXIII.—CAPITAL INVESTED IN LEADING HYDRAULIC MINES.

Name of company.	Amount.
Total	$16,283,434 77
Excelsior, of Smartsville	2,857,106 55
North Bloomfield and Milton	4,070,321 02
Gold Run	433,335 00
Blue Tent	755,000 00
El Dorado Deep Gravel	1,008,011 60
Eureka Lake (approximate)	2,500,000 00
South Yuba	2,000,000 00
Spring Valley	2,000,000 00
La Grange (about)	650,000 00

WORKING CAPITAL.—Returns from only 10 hydraulic mines, giving amount of working capital, were received. The total for these few reporting mines is stated at $1,495,000.

LOCALITY OF OWNERSHIP.—Of the placer mines reported upon with reference to ownership, 88 per cent. are held in the state or territory where they are located and 12 per cent. are controlled by capital from other parts of the country. Nearly one-half of the investments in placer property by capitalists living in non-mining states have been made in New York city. The accompanying table shows the manner in which the ownership of the more important placer mines is distributed:

TABLE LXIV.—LOCALITY OF OWNERSHIP OF PLACER MINES.

State or territory in which mines are located.	Total number of mines with ownership specified.	Owned in state or territory where located.	Owned in other states or territories than those in which the mines are located.												
			Total.	California.	District of Columbia.	Illinois.	Indiana.	Massachusetts.	Minnesota.	Missouri.	New Hampshire.	New Mexico.	New York.	Ohio.	Pennsylvania.
Total	237	209	28	3	1	2	2	2	1	1	1	1	11	1	2
Arizona	2	1	1									1			
California	112	105	7				2	1			1		3		
Colorado	11	7	4			1		1		1			1		
Dakota	10	7	3						1				2		
Georgia	11	4	7			1							4	1	1
Idaho	7	7													
Montana	14	14													
North Carolina	3	1	2		1										1
Oregon	65	62	3	3											
South Carolina	1	1													
Utah	1		1										1		

EXTENT OF CLAIMS.—The river bar claims of the first years of placer mining, which were worked by single miners or small parties, were often but 20 feet in length and of the same width as the channel. This, in some districts where the virgin ground was very rich, was the recognized extent of a location, though in others the unit was somewhat greater, and in certain localities reached 200 or 300 feet, measured on the length of the deposit. (*a*) Occasionally the ground was located in square areas, as, for instance, in plots 100 by 100 feet. Great differences existed in the local regulations of the various camps, though the tendency in all was to keep the size of individual claims within narrow limits; but the extensive equipment and development of a modern hydraulic mine of importance demands a large area of workable gravel, in order to offset the preliminary expenses and give the mine any permanence. When it is considered that a single company, by means of the powerful hydraulic rig of to-day, may wash upward of 3,000,000 cubic yards of gravel in a single season, (*b*) it will be seen that to insure continuity of work considerable extent is necessary. Even with deep banks the acres melt away rapidly before the hydraulic nozzles.

a The shallow placers near Bodie, Mono county, California, worked on a small scale during the census year, are by the local regulations held as follows: (A) Flat claims, 250 feet square; (B) hill-side claims, 200 feet front, extending back to the summit of the hill; (C) gulch claims, 50 feet each side of run of water.

b The North Bloomfield Gravel Mining Company, No. 8 claim, in a run of 342 days in 1876, washed 2,919,700 cubic yards. The bank was 260 feet deep.

Many of the more important mines in California comprise tracts of over 500 acres each. The Spring Valley, 1,215 acres, and Morris Ravine, 1,300 acres, in Butte county; Happy Camp, 507 acres, in Del Norte county; Liberty Hill, 554½ acres, and North Bloomfield, 1,585 acres, in Nevada county; Gold Run, 500 acres, in Placer county; North Fork, 800 acres, and Plumas, 1,355 acres, in Plumas county; Dry Creek, 1,332 acres, in Shasta county; La Grange, 1,200 acres, in Stanislaus county; Buckeye, 1,700 acres, Lewiston, 640 acres, Weaver Creek, 600 acres, in Trinity county; and the Golden Rock, 640 acres, in Tuolumne county, are examples of mines of this class. A still larger number are between 200 and 500 acres in size. In Colorado, Idaho, and Dakota the ground is held in large blocks. One mine, the Castle Creek, in Pennington county, Dakota, consists of 88 claims of 300 feet each in length, with a width equal to that of the deposit.

Some of the drift mines of Sierra county, California, are of great extent. The Bald Mountain mine embraces 7,500 linear feet of the channel, of which 4,000 feet have been worked; the Union, 2,400 feet; Hawkeye, 800 feet; Pittsburgh, 860 feet; Monumental, 1,040 feet; and Empire, 1,560 feet. Mr. W. A. Skidmore states that the working life of a mine of this class has a duration of from ten to twenty years, according to length of its location on the channel.

In working river beds by the dam and fluming method it is necessary to drain considerable lengths of the streams to render the enterprise profitable. Dams and tunnels or flumes are sometimes so favorably located as to lay bare the river beds for miles.

NATURE OF TITLE.—In the early history of placer camps the claims, as is the case with quartz veins, are first held by virtue of location or discovery. This constitutes what is called a "miner's title". In the next stage there is a large proportion of consolidated ownership still resting upon the original "miner's title", the property being acquired by purchase of individual locations. Finally, the large and valuable tracts of auriferous ground which are worked by corporate capital or by strong firms are often for greater security covered by United States patents. The trouble and expense incurred in procuring a patent usually prevent the original locators from thus securing their title, and it is generally not until the ground has changed hands at least once that the patent is applied for. As the mines reported upon are properties developed to a considerable extent, the proportion patented is much larger than would be the case if all the placer mines, large and small together, the newly-discovered and the long-worked, were considered. Table LXV, therefore, represents only the nature of the titles of the more important mines.

TABLE LXV.—PLACER MINES—NATURE OF TITLE.

Nature of title.	Total, according to nature of title.	Arizona.	California.	Colorado.	Dakota.	Georgia.	Idaho.	Montana.	North Carolina.	Oregon.	South Carolina.	Utah.
Total by States and Territories	204	2	85	11	11	10	7	14	3	50	1	1
Patented	40	....	26	4	....	....	....	6	....	4	....	....
Partly patented	17	....	10	3	....	....	....	1	....	3	....	....
Patent applied for	11	....	6	1	1	....	....	....	....	3	....	....
Location or discovery	29	2	5	1	1	....	....	3	....	17	....	....
Purchase or part purchased	42	....	10	....	1	....	5	....	....	25	....	1
Quit-claim deed	1	....	....	1	....	....	....	....	....	....	....	....
Warrantee deed	2	....	....	....	....	2	....	....	....	....	....	....
Fee-simple	10	....	....	....	....	7	....	....	2	....	1	....
Lease	1	....	....	....	....	....	....	....	1	....	....	....
Unspecified	51	....	28	1	8	1	2	4	....	7	....	....

PROPERTY OWNED IN CONNECTION WITH PLACER MINES.—In the case of mines worked by the hydraulic method this may embrace (in addition to the mining claims) water rights, ditches, flumes, pipes, reservoirs, etc.; office, shops, and buildings for lodging the men and storing tools and material; the working plant of the mine, such as feed pipes, distributers, nozzles, derricks, sluices, and tools; supplies, such as quicksilver, iron, steel, lumber, powder, fuse, etc.; horses, wagons, barns, and feed; right of way for tailings, or land held for the dump, sometimes including brush and earth dams for impounding the tailings. The Spring Valley Company owns and operates a telegraph line from Cherokee to Oroville, 12 miles, with complete outfit. A saw-mill, for furnishing lumber used in sluices, flumes, etc., is occasionally an adjunct. Altogether, the equipment of a large hydraulic mine involves a very considerable outlay beyond the simple ownership of mining ground. Drift mines yielding cement gravel sometimes are equipped with stamp batteries for coarsely crushing the cement before sluicing it.

TECHNICAL METHODS EMPLOYED.

HYDRAULIC MINING.

ORIGIN OF HYDRAULIC MINING.—From the rediscovery of gold in California in 1848 the primitive pan, rocker, long-tom, and short sluice were the appliances used in earth washings up to the spring of 1852, when a miner, whose name is not remembered, introduced the first hydraulic apparatus(*a*) at his claim at Yankee Jim, Placer county, California. Mr. Waldeyer says:

> This machine was very simple. From a small ditch on the hill-side a flume was built toward the ravine, where the mine was opened; the flume gained height above the ground as the ravine was approached, until finally a "head" or vertical height of 40 feet was reached. At this point the water was discharged into a barrel, from the bottom of which depended a hose, about 6 inches in diameter, made of common cowhide, and ending in a tin tube about 4 feet long, the latter tapering down to a final opening or nozzle of 1 inch. This was the first hydraulic apparatus in California, simple in design, dwarfish in size, yet destined to grow out of its insignificance into a giant powerful enough to move mountains from their foundations. The news spread among the miners, the wonderful practicability of the new invention was at once acknowledged, and, wherever circumstances permitted, a "hydraulic", the name adopted for the novel apparatus, was "rigged".

THE DUMP.—Without the means of getting rid of the tailings the hydraulic miner is helpless. The possession of "pay gravel" and water are not alone sufficient. A place must be provided at a lower grade for the vast masses which are moved from their original position. These, after being broken up, occupy more space than when in the bank. After the natural dump-room is exhausted by choking, and the sluices have been extended as far as the grade will permit, then resort is had to tunneling. Some placers, indeed, especially those in ancient channels bounded by rim-rock higher than the bottom of the gravel, can only be opened in the first instance by expensive open cuts or by long tunnels, in such a manner that the lowest or richest portion may be made available. To secure a proper dump is often a matter of greater difficulty than to bring water upon the ground.

TUNNELS AND CUTS.—Very long tunnels or cuts are often required to open deep placers to the bed-rock, and with some mines the preliminary work necessary to thus bottom the claim forms the chief item of expense. The open cuts, if in moderately loose earth, are sometimes made by the use of the hydraulic nozzle, which is an efficient and cheap means of excavation if the conditions are favorable. If the cuts are made in rock, blasting is resorted to. The operation of driving the long bed-rock tunnels is prosecuted as in vein-mining. The ground is, however, apt to be softer than the average country rock of vein mines, allowing more rapid progress; but more careful timbering is, for the same reason, usually required. The grade of these tunnels being adapted to the sluicing of heavy material, is necessarily much steeper than would suffice for simple drainage.

By far the majority of hydraulic mines are opened by cuts alone. About one-fifth of the mines reported on have tunnels, and of the latter class several have auxiliary cuts in addition to the tunnels.

In planning a tunnel designed to open a gravel channel great care is necessary to locate it at such a depth that its face at the middle or lowest part of the channel shall remain in bed-rock, and to provide against inequalities in the surface of the bed-rock it is usual to allow a considerable margin in depth, ranging from 40 to 75 feet below the top of the bed-rock at the point of connection by chimney. Careful surveys are therefore first made and liberal allowance is made for irregularities, in order that all of the deposit may be bottomed. A want of care in this respect has caused heavy loss in several instances, the money spent in driving the tunnel being thrown away if by bad calculation the latter has been run out of grade.

Some examples of tunnels in placer mines are given in the accompanying list.

TABLE LXVI.—TUNNELS IN PLACER MINES.

CALIFORNIA.

Name.	Locality.	Length.	Width.	Height.	Average grade.
		Feet.	*Feet.*	*Feet.*	*Feet per 100.*
American	Below San Juan	3,900			6.25
Babb	Timbuctoo	1,200			3.80
Bed-Rock	Below Sweetland	2,600			5.25
Blue Gravel	Sucker Flat	1,100			4.50
Blue Point	do	2,250			4.16
Bonanza	Mokelumne Hill	200	4	6	6.25
Boston	Wolsey's Flat	1,600			7.25
Buckeye	Buckeye district	1,500	7	7½	
Deer Creek	Mooney's Flat	2,200			3.40
Del Norte	Del Norte county	600	3	6	5.56
Dry Creek	Igo	300			2.78
Duryea	Mokelumne Hill	250	6	4½	5.56
English Mine	Badger Hill	1,400			7.00
Enterprise	Sucker Flat	1,200			4.16
Evans & Bartlett	Red Hill	300			4.17

a Paper on Hydraulic Mining in California, by Mr. Charles Waldeyer, in *Report of Mining Commissioner*, 1872, p. 390.

TABLE LXVI.—TUNNELS IN PLACER MINES—Continued.

Name.	Locality.	Length.	Width.	Height.	Average grade.
CALIFORNIA—Continued.					
		Feet.	*Feet.*	*Feet.*	*Feet per 100.*
Farrel	Columbia Hill	2,200	....	....	3.50
French Corral	French Corral	3,500	....	....	4.66
Gold Run	Gold Run	2,500	10	12	4.02
Hidden Treasure	Michigan Bluff	2,700	6½	5	1.32
La Grange	La Grange	*a* 1,300	6½	4	2.02
Lyon Gravel (*b*)	Placerville	1,300	6	5	1.04
Mammoth	Red Hill	360	8	6	6.25
Manzanita	Sweetland	1,740	....	....	4.16
North Bloomfield	Humbug Cañon	8,000	....	....	4.50
Orion	Iowa Hill	600	8	6	5.56
Pactolus	Timbuctoo	1,700	....	....	4.16
Paragon (*b*)	Bath	2,000	5½	5 to 6	1.04
Penobscot	Mokelumne Hill	200	3	6½	4.86
Pittsburgh	Sucker Flat	900	....	....	4.16
Polar Star	Dutch Flat	600	9	9	6.94
Rose's Bar	Timbuctoo	1,000	....	....	4.16
Spring Valley	Cherokee Flat	1,400	6	6½	2.01 to 4.02
Do	do	400	6	6½	2.01 to 4.02
Sunnyside	Seneca	750	5	6½	0.61
Sweetland Creek	Sweetland	2,200	....	....	4.66
Van Emmons	Michigan Bluff	*c* 1,800	4½	8	9.03
Weed's Point	Galena Hill	600	4 to 5½	6	4.51
COLORADO.					
L. H. Arthur	Grass Valley district	350	4	5	Level.
Do	do	400	4	5	Level.
Rob Roy	Spaulding district	50	5 to 6	4	0.42
Do	do	67	5 to 6	4	0.42
DAKOTA.					
Castle Creek (*b*)	Cañon district	550	10	12	2.43
Fort Meade	Ruby district	625	10	12	2.43
Last Chance Bar (*b*)	Cañon district	1,300	4	5	....
McKay & Ross	Cape Horn district	200	5	7	4.02
GEORGIA.					
Findley	Lumpkin county	270	4	6	....
Griscom	do	600	6½	6	8.33
MONTANA.					
Charles Pryse (*b*)	McClellan Gulch	1 mile	5	5	0.01
OREGON.					
Blue Gravel	Yauk district	200	8	10	6.25

a Five. *b* Drift mines. *c* Two.

CHIMNEYS.—These are connections between the tunnel and the surface, and are usually made by raising from the tunnel, though sometimes the tunnel is driven to connect with a prospecting shaft, in which case the latter becomes the working chimney. The proper location for the chimney is at the point where the bed-rock is lowest, or near the middle of the channel. When all the ground controlled by one chimney has been worked off, it sometimes is possible to extend the tunnel and open a new chimney, thus developing a further territory.

As regards the form of the chimney a diversity of practice exists. More commonly it is a vertical opening, the gravel being dropped upon a rock pavement in a single fall. Some engineers prefer a chimney built in steps, which break the fall, and from the lowest step, which is shallower than the others, the wash flows directly into the head of the sluice. A third variety is a simple inclined chute.

In making an upraise from the tunnel through the gravel precaution is taken against a rush of water and quicksand, which is liable to occur when the channel is tapped, and the timbering needs to be substantial. As the surface about the mouth of the chimney is washed away the timbers are removed, set by set, until a permanent level has been reached, and the wash from the face of the bank is led to the chimney by shallow cuts. Careful watching is also required in the first washings to prevent choking, as the work of clearing away an accumulation of this kind from below is difficult and dangerous.

POWER DRILLS.—Excavations in the gravel itself are usually made without difficulty, except as regards timbering. Sometimes, however, power drills, such as the Burleigh or the Ingersoll, driven by compressed air, are employed in making cuts or in tunneling, and greatly expedite matters.

BLASTING.—In tunneling, the mode of blasting is similar to that in vogue in vein-mining. The explosive, commonly a nitro-glycerine powder (Giant, Hercules, or Vulcan) of No. 2 grade, is tamped in drill holes and fired by caps and time-fuse. To break up large bowlders holes are drilled and from one-half a stick to two sticks of a nitro-glycerine powder is fired in the usual way. A stump is destroyed by boring a hole and exploding in it a part of a cartridge. Small quantities of the high explosives are also used in breaking up patches of cement, as required.

Bank-blasting on the large scale is an operation requiring judgment and experience on the part of the hydraulic miner. The conditions, such as height of bank and tenacity of ground, vary so greatly that the quantities of powder used and the precise method of disposing it are matters for calculation in particular cases rather than subject to any general rule. An inquiry addressed to superintendents to ascertain the average amount of ground loosened per unit (100 pounds of black powder) developed such a wide range of experience or of opinion that no useful result would be gained by particularizing the replies. The subject is worthy of more careful investigation than has yet been made, and it would be well if the details connected with the use of heavy charges in gravel were always published in full.

A slow-burning explosive, such as black or Judson powder, is found to give the best results in bank-blasting. As regards quantity, it is usual to allow a liberal margin above the amount theoretically sufficient, for the additional expense is of less importance than would be a failure of the blast. The usual method of disposing the powder is to run a small and short drift into the bank at or near bed-rock, and from it two cross-drifts parallel to the face of the bank, in the form of a simple T. The powder is placed in the cross-drifts, and after charging and laying the wire connections the main drift is tamped. Sometimes a more complicated system of cross-drifts is adopted, and short galleries, called "lifters", are also added, being driven from the extremities and center of the cross-drifts toward the face of the bank. These modifications are used where the bank is not very deep. The bank-blasts are usually exploded by a frictional electrical apparatus.

In blasting extremely high banks, instead of attempting to shatter the whole mass from the bottom upward by direct action of the explosive, cross-drifts are driven parallel with the face of the bank, and at such distance that the strip of ground between them and the face can be blown out, thus allowing the upper part of the bank to fall by its own weight. Very large blasts have been fired in some of the gravel mines of California. At the Spring Valley mine the blasts range up to 25,000 pounds of black powder. At the Blue Point mine a blast of 2,000 kegs (50,000 pounds) of powder was fired, and a charge of 1,700 kegs was exploded in the Enterprise mine. Bank-blasting not only facilitates the work of the nozzles and renders it possible to "hydraulic" tough ground, which would be otherwise piped off with difficulty or even altogether unworkable, by breaking up the cement, pipe-clay, etc., but it also serves the very important purpose of disintegrating the gravel and freeing the gold particles. The more thoroughly the ground is shattered the better its condition for sluicing. In blasting bottom cement and bed-rock the powder is disposed in a system of small transverse galleries, or in single charges in bottle-shaped excavations, the necks of which are tamped with earth.

Most hydraulic mines, including those which do not need regular bank-blasting, consume at times small quantities of high explosives, which are conveniently used in wet ground and require little care in tamping. The total amount of powder thus absorbed is considerable, but for individual mines this item of expense is generally not a heavy one. In mines where bank-blasting on the large scale is practiced the cost of explosives, on the contrary, is a leading consideration, taken in connection with the labor and loss of time involved in preparing for each blast.

FEED PIPES.—The pipes conveying the water from the pressure-box to the distributer and nozzles are made of wrought iron if the fall is considerable, though doubled or three-ply canvas hose, if carefully made, can be used advantageously with small volumes of water at pressures of 75 feet, and is sometimes employed with still greater fall. The iron pipe is made in lengths, the longitudinal seams are riveted, and the joints connected by simple insertion, by lugs and wire or by riveting. The upper end of the pipe connects with the pressure-box by means of a tapering, funnel-shaped section of sheet iron. The permanent pipes are supplied with air-valves, and are braced with frame-work and weighted to prevent shifting. The aggregate length of such pipes in use is certainly not less than the total extent of the piping on ditch lines; and though no figures are at hand for an accurate estimate, there are probably in the neighborhood of 200 miles of feed pipes in the hydraulic mines.

The pressure of water used varies greatly in different mines, ranging from very moderate falls to heads of upward of 400 feet, according to the elevation at which water can be brought upon the ground and the capacity of the rig. The variations in this respect, and the dimensions of feed pipes on some of the hydraulic mines, are shown in the accompanying list, to which is appended for reference a table of the thickness and weight per square foot of wrought iron of the numbers commonly used, according to United States and Birmingham gauges.

TABLE LXVII.—FEED PIPES IN HYDRAULIC MINES.

ARIZONA.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
YAVAPAI.		*Feet.*		*Feet.*	*Inches.*	
	Jackson		1			

CALIFORNIA.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
BUTTE.						
Cherokee Flat	Spring Valley	311	3		15 and 22	$\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{6}$ inches.
Morris Ravine	Morris Ravine	160	2		11 and 22	No. 14.
Oroville	Oroville	35	6		One, 30; Five, 14	Main $\frac{1}{4}$ inch. Small $\frac{1}{16}$ inch.
CALAVERAS.						
Mokelumne Hill	Bonanza	100	1		11	No. 14 and 18, United States gauge.
Do	Duryea				11	No. 14 and 16, United States gauge.
Do	Eureka	400	2		11 and 13	No. 14 and 16, United States gauge.
Do	Mammoth	150			11	No. 16, Birmingham gauge.
Do	Penobscot	250			11	No. 16, Birmingham gauge.
DEL NORTE.						
	Bunker Hill	240		2, 300	11	No. 16.
	China Creek	225	2	2, 680	11 and 15	No. 16.
	Del Norte	100 to 175	3	4, 000	11, 15, and 10	No. 16.
	Happy Camp	125 to 200	2	3. 100	11 to 24	No. 16.
	Muc-a-muc	90	1	1, 100	11 to 15	No. 16.
	Wingate	260	1	1, 200	15	No. 16.
PLACER.						
Dutch Flat	Polar Star	450	2		Tapering from 4 feet to 11 inches.	No. 14 and 16.
Gold Run	Gold Run	400	3		Tapering from 5 feet to 10 inches.	No. 14, Birmingham gauge.
Iowa Hill	Orion	440	1		15 to 22	Nos. 18 to 12.
Michigan Bluff	Van Emmons	200	2		11	Nos. 18 to 16, Birmingham gauge.
PLUMAS.						
Seneca	North Fork	75	1		16	$\frac{1}{8}$ inch.
	Black Hawk	50	1		11	$\frac{1}{8}$ inch.
	Hungarian Hill	180	4		15 and 22	$\frac{1}{4}$ and $\frac{1}{8}$ inch.
	Plumas M. and W. Co	350	5		15 and 22	Nos. 16, 14, 12.
SHASTA.						
Igo	Dry Creek	175		8, 800	15, 19, and 30	$\frac{1}{8}$ inch.
SISKIYOU.						
Callahan's Ranch	A. B. C. (*a*)	175	7	1, 200		Nos. 18, 20, 22.
Indian Creek	Bay City	200 to 300	1	1, 000	8	No. 20.
Do	Coyote Gulch (*a*)	184	2	900	6	No. 18.
McAdams Creek	Hiyou	150 to 200	1	800	6	No. 20.
Do	Oak Grove		1		7	No. 16.
Oro Fino	John Young	200	1	2, 000	6	Nos. 20 and 24.
Sciad Valley	Fort Goff Creek	275	1	866	11 to 15	No. 16.
Do	Thompson Creek	65	1	800	15	No. 16.
STANISLAUS.						
La Grange	La Grange	20 to 125			Main, 22; others, 15 to 36	
TRINITY.						
Buckeye	Buckeye	300		2, 073	11 to 15	
Cañon Creek	Berger			1, 500	9 and 11	
Do	Wilt			1, 500	9 and 11	
Douglas	Smith's Flat			2, 000	20	No. 16.
Indian Creek	Johnston	200		2, 700	15 and 22	
Junction City	Lewiston	175 and 275		1, 800	13 and 15	No. 18.
Minersville	Digger Creek			900	11 and 13	
Red Hill	Evans & Bartlett			2, 000	11	No. 18.
Do	Mammoth	160		1, 700	15 and 22	Nos. 14 and 16.
Do	McKenna	200		2, 100	7 and 15	No. 16.
Taylor's Flat	Trinity			700	15	Nos. 14 and 16.
Weaver	Garden Gulch			2, 000	15	
Do	Harvey Bros	230		1, 900	13 and 15	Nos. 16 and 18.
Do	Holman & Mahon			2, 100	15, 16, and 18	
Do	Hupp & Murry	210		2, 400	13 and 15	Nos. 16 and 18.
Do	Mable's Bench			1, 350	6, 7, and 15	
Do	Rule Bros	100		1, 200	13	Nos. 16 and 18.
Do	Weaver Creek			600	15	
	Center Placer	250		1, 400	13	No. 16.
	Chapman & Fisher			3, 000	15	No. 16.
	Gribble			2, 000	7 and 11	
	Hager & Haas			1, 500	14	
	Slattery			700	15 and 18	No. 16.
	Trinity	270		4, 500	15	Nos. 14 and 16.
	Wiltshire			1, 600	13 and 15	
YUBA.						
Galena Hill	Wood's Point	95	2		11 to 15	Nos. 16 and 18.

a Galvanized sheet iron.

TABLE LXVII.—FEED PIPES IN HYDRAULIC MINES—Continued.

COLORADO.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
CLEAR CREEK.		*Feet.*		*Feet.*	*Inches.*	
Grass Valley	L. H. Arthur (*a*)	60			6	1/8-inch.
Jackson	Edward	80	1		8 to 24	No. 18.
LAKE.						
California	Oro M. D. and F. Co	140			8 to 30	No. 14.
LA PLATA.						
California	Parrot City	75		1,200	12 to 20	1/8-inch.
PARK.						
Alma township	Alma	80	2		16 to 22	No. 20.
ROUTT.						
Hahn's Peak	Hahn's Peak	225	1		15	1/16-inch.
SUMMIT.						
Spaulding	Rob Roy	85			18	
Do	Sisler	75			7 to 16	3/32-inch.

DAKOTA.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
PENNINGTON.						
Confederate	Stockade (*a*)	25			6	
Rockerville	Black Hills Placer Company	200			9 to 28	1/8- and 3/8-inch.

GEORGIA.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
HALL.						
810 G. M	Glade (*b*)	156		900	6	1/8-inch.
LUMPKIN.						
Twelfth	Battle Branch	150	1		9	No. 16, wire-gauge.
Do	Findley (*b*)		1		4	No. 16, wire-gauge.
Do	Griscom	80			6	No. 24, wire-gauge.
Twelfth and First	Chicago and Georgia	75	1		9	
Do	Hand and Barlow	105	1	520	6 to 16	
Thirteenth	Cleveland, or Bugg's Branch	50	1		4	1/16-inch.
UNION.						
Tenth and First	Coosa (*c*)	110	1		6	
WHITE.						
Third	Nacoochee (*a*)	40	2		6	1/8-inch.
Fourth	Forest Spring	60	1		6	

IDAHO.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
ALTURAS.						
Elk Creek	Hardscrabble (*b*)	75 to 125	1		7	
BOISÉ.						
Boston	R. W. Spencer	70	2	1,240	6 to 8	
Moore's Creek	Crepisculla (*b*)	60 to 100			6	
Do	Noble, Lower & Mann	114		920	7 to 11	Nos. 18 and 20.
Do	Thorn Creek	75 to 100	2		7	
Pioneer	Hon. Ben. Wilson	70		7,000	7 and 11	Nos. 18 and 20.
Do	Stevenson & Noble	150 and 200			11 to 20	Nos. 16 and 18.

MONTANA.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
BEAVER HEAD.						
Bannock	Bannock (*b*)	40			6	1/8 inch.
Do	White Bar (*b*)	20 to 75			6	1/8 inch.
DEER LODGE.						
Gold Hill	Squaw Gulch	180	4		11 and 15	1/16 inch.
Henderson Gulch	Butler & Anderson	125	1		6	1/32 inch.
Independence	Oro Fino	60	1	1,500	6 and 7	Nos. 18 and 20.
Nelson	Pioneer (*a*)	110 to 150	1		8	1/16 inch.
Summit Valley	Noyes & Upton	50	1		6	No. 20.
LEWIS AND CLARKE.						
Last Chance	W. A. Cheesman (*a*)	45 to 60	4		2 to 6	Nos. 22 and 24.
MEAGHER.						
German	Diamond Flume and Hydraulic	200	1		11	1/16 inch.
Thompson Gulch	California	60 to 75	1		6	1/32 inch.
Do	Morgan Bar	60	1		7	1/32 inch.
Do	Tubbs & Ramsey	75	1		6	1/32 inch.

a Canvas. *b* Galvanized sheet iron. *c* Rubber.

TABLE LXVII.—FEED PIPES IN HYDRAULIC MINES—Continued.

NORTH CAROLINA.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
		Feet.		*Feet.*	*Inches.*	
MONTGOMERY.						
Eldorado	Beaver Dam	25	1		5	¼ inch.
	San Christian (*a*)	40	8		3	
POLK.						
	Cochrane	50	1		5	No. 20, Birmingham gauge.

OREGON.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
BAKER.						
Blue Cañon	Littlefield & Duckworth	60	1		6	1/32 inch.
Do	Marysville	80	1		13	1/16 inch.
Chicken Creek	J. N. Osborne & Co (*b*)	80	1		7	1/16 inch.
Do	Porter (*b*)	80	1		7	1/16 inch.
Humboldt Basin	Colt & Co	60, 80 & 175	3		7	No. 20.
Mormon Basin	Rogers & Copeland	70	1		7	1/16 inch.
Pocahontas	Baisly	300	1		11	1/16 inch.
Do	Baisly & Daly	300	1		11	1/16 inch.
Do	Lew Cooper & Co	130	1		6	1/16 inch.
Do	Neversweat	125	1		6	1/20 inch.
Do	Salmon Creek	300	2		11 and 13	Nos. 18 and 16.
Rye Valley	Powers & Co	90, 100 & 140	5		8	1/16 inch.
Shasta	Ah Moon	100			6	1/16 inch.
Do	Campbell	146		800	8	No. 20.
Do	Steiger's French Gulch	100	1		7	1/16 inch.
Do	Stephenson	65	1		8	No. 20.
Sumter	Sumter	75				
Willow Creek	W. Boswell	70	1		7 to 9	1/20 inch.
DOUGLAS.						
Big Bend Cow Creek	J. Fuller	200		700	11	3/64 inch.
Do	D. A. Levens	120		800	7 to 11	3/64 inch.
Do	Merriam & Anderson	100	1	1,400	7 to 10	1/16 inch.
Do	Salmon	175		1,000	15	No. 16.
Cañonville	Catchings	45	1		11	No. 18.
Do	McWilliams & Ash	160	1	800	11	3/64 inch.
Green Mountain	Chas. Dwelley	200	1	800	5	1/16 inch.
Do	M. T. Dyer & Son	125	2	750	5 and 7	1/16 inch.
GRANT.						
Cañon City	Sproul (*b*)	75	1		7	1/16 inch.
Granite	Borne & Lucas (*b*)	45	1		7½	1/16 inch.
Do	Kopp & Johnson	130	1		12	1/16 inch.
Marysville	Cannon & Co	200	1		11	1/16 inch.
Do	Thompson	140 to 230	2		11	1/16 inch.
Rock Creek	Erickson Owens	150	1		7	
Do	Lasswell & Co	200	1		7	
Trail Creek	Trail Creek	130	1		13	1/16 inch.
JACKSON.						
Applegate	Grand Applegate	130	1		15	1/16 inch.
Do	Squaw Lake	327	1	1,000	15 to 22	1/16 inch.
Ashland	Anderson & McCall	60	1		11	1/16 inch.
Coyote Creek	Marshall's (*b*)	40		300	8	1/8-inch.
Do	Wm. Ruble	200		700	11	3/64-inch.
Farris Gulch	Farris Gulch	300	2	1,200	7	3/64-inch.
Forty-nine	Davenport	100		1,120	11 to 22	3/64-inch.
Do	Forty-nine	150		1,100	6 to 10	3/64-inch.
Sam's Valley	Hays & McGruder	80	1	500	11	No. 16.
Sterling	Saltmarsh	80	1		6	No. 20.
Do	Sterling	330	2		16 and 22	1/16-inch.
Uniontown	Chapel & Co	800	1		15	No. 16.
Do	Gin Lin	250	2		15	1/16-inch.
Wolf Creek	Gross Bros	100	1	600	11	3/64-inch.
JOSEPHINE.						
Grass Creek	Goff, Triplett & Chapin	150	1	630	7 to 11	3/64-inch.
Do	Steam Beer	150	1	1,400	11	3/64-inch.
Waldo	Desselles & Co	300	2	2,800	6 to 11	Nos. 16 and 18.
Do	Waldo	150	1	900	13 to 22	3/64-inch.
Yank	Blue Gravel	160	3	1,050	16	No. 16.
Do	Josephine	180	2	1,500	11	No. 16.
WASCO.						
Ochoco	Wickaiser & Co	50 to 200	2		6	No. 20.

SOUTH CAROLINA.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
CHESTERFIELD.						
	Brewer (*c*)	65	2	1,700	5	No. 22.

UTAH.

County and district.	Mine.	Head pressure.	No. in use.	Length.	Diameter.	Thickness.
SALT LAKE.						
West Mountain	Argonaut	100			10	1/32-inch.

a Rubber. *b* Canvas. *c* Galvanized sheet iron.

TABLE LXVIII.—THICKNESS AND WEIGHT OF WROUGHT IRON.

[United States gauge and Birmingham gauge compared.]

UNITED STATES GAUGE.			BIRMINGHAM GAUGE.		
No. of gauge.	Thickness.	Weight per square foot.	No. of gauge.	Thickness.	Weight per square foot.
	Inch.	*Pounds.*		*Inch.*	*Pounds.*
10......	0.101890	4.0884	10......	0.134	5.3767
11......	0.090742	3.6410	11......	0.120	4.8150
12......	0.080808	3.2424	12.	0.109	4.3736
13......	0.071961	2.8874	13......	0.095	3.8119
14......	0.064084	2.5714	14......	0.083	3.3304
15......	0.057068	2.2899	15......	0.072	2.8890
16......	0.050820	2.0392	16......	0.065	2.6081
17......	0.045257	1.8159	17......	0.058	2.3272
18......	0.040303	1.6172	18......	0.049	1.9661
19......	0.035890	1.4400	19......	0.042	1.6852
20......	0.031961	1.2824	20......	0.035	1.4044
21......	0.028462	1.1420	21......	0.032	1.2840
22......	0.025347	1.0170	22......	0.028	1.1235
23......	0.022571	0.9057	23......	0.025	1.0031
24......	0.020100	0.8065	24......	0.022	0.8827
25......	0.017900	0.7182	25......	0.020	0.8025

NOZZLES.—The size and power of hydraulic nozzles have steadily increased from their first introduction, and with the higher heads of water larger apertures have come into use. Thus, while a few years ago an 8-inch nozzle was the largest size employed, and then only in a very few mines, machines throwing streams up to 11 inches in diameter have since been introduced, with the probabilities of a still greater increase.

The number of nozzles in use upon a claim varies from one to fifteen. It is very frequently the practice to direct two streams upon a single point of the bank, thus obtaining a cross-fire. At most of the larger mines work is prosecuted at several different parts of the claim, and, as some companies operate several scattered claims, a number of nozzles are often employed by a single ownership.

The larger hydraulic nozzles of the "Little Giant" type are deflected by levers and counterpoised. The small brass hand nozzles, of no particular pattern, ranging from 1½ to 4 inches in diameter, are conveniently slung from a movable tripod and directed by hand. Such nozzles are usually connected by a tapering galvanized iron sleeve to a length of canvas hose and have no joints.

The number and the sizes of nozzles used at some of the hydraulic mines are given in the accompanying table. The heads or pressures of water, in feet, are stated in Table LXVII.

TABLE LXIX.—HYDRAULIC NOZZLES.

ARIZONA.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
				Inches.	*Feet.*
YAVAPAI.					
......	Jackson	1	1	3	......

CALIFORNIA.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
BUTTE.					
Cherokee Flat	Spring Valley	14	2	4 to 8	......
Morris Ravine	Morris Ravine	3	One 1; one 2.	4 to 6	......
Oroville	Oroville	1	1	......	......
CALAVERAS.					
Mokelumne Hill	Bonanza	1	1	......	100
Do	Duryea	1	1	......	175
Do	Eureka	2	1	......	150
Do	Mammoth	1	1	......	150
Do	Penobscot	3	1	......	150
DEL NORTE.					
......	Bunker Hill	1	1	4 and 4½	150
......	China Creek	2	1	4 and 4½	150
......	Del Norte	3	1	4 and 4½	100 to 150
......	Happy Camp	2	1	4½	100 to 275
......	Muc-a-muc	1	1	4 and 4½	85
......	Wingate	1	1	3½ and 4	150
PLACER.					
Dutch Flat	Polar Star	2	1	......	120
Gold Run	Gold Run	4	1	......	125
Iowa Hill	Orion	1	1	......	200
Michigan Bluff	Van Emmons	2	1	......	......

TABLE LXIX.—HYDRAULIC NOZZLES—Continued.

CALIFORNIA—Continued.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
				Inches.	*Feet.*
PLUMAS.					
Seneca	North Fork	1	1	4	50
	Black Hawk	1	1	1½ and 2½	30
	Hungarian Hill	4	1	6	150
	Plumas M. and W	5	1	6½ and 7	150
SHASTA.					
Igo	Dry Creek	3	1	4½ and 5½	
SISKIYOU.					
Callahan's Ranch	A. B. C	2	1	2 and 2½	60
Galena Hill					
Indian Creek	Bay City	1	1	1½ and 2	30
Do	Coyote Creek	2	1	1½ and 1¾	40 to 60
McAdams Gulch	Hiyou	1	1	1½ and 2	20
Do	Oak Grove	1	1	2 1/16	
Oro Fino	John Young	1	1	2	30
Sciad Valley	Fort Goff Creek	1	1	4½	
Do	Thompson Creek	1	1	4½	30 to 45
STANISLAUS.					
La Grange	La Grange	12	3	4 to 11	150
TRINITY.					
Buckeye	Buckeye	2	1	2	
Cañon Creek	Wilt		1	3	
Douglas	Smith's Flat	1	1		
Indian Creek	Johnston	2	2	6 to 8	
Minersville	Digger Creek				
Red Hill	Evans & Bartlett	1	1	4	
Do	Mammoth			6	210
Do	McKenna		3		
Taylor's Flat	Trinity	1	1		
Weaver	Garden Gulch	2	2		
Do	Harvey Bros	2	2	4	
Do	Holman & Mahon	2	1	4	
Do	Hupp & Murray	2	2	4	
Do	Mabie's Bench	1	1		
Do	Rule Bros	1	1	4	
Do	Weaver Creek	1	1		
	Center Placer	1	1	3	
	Chapman & Fisher	3	3		
	Gribbles	2	1		
	Hager & Haas		1		
	Slattery	2	1	4 and 5	
	Trinity	2	2		
	Wiltshire	2	1		

COLORADO.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
CLEAR CREEK.					
Grass Valley	L. H. Arthur	1	1	2	
Jackson	Edward's	2	2		60
LAKE.					
California	Oro M. D. and F. Co	2	2	3	160
LA PLATA.					
California	Parrot City		1	3	
PARK.					
Alma township	Alma	2	1	4 to 6	100
ROUTT.					
Hahn's Peak	Hahn's Peak M. Co	2	2	3 to 5½	60 to 100
SUMMIT.					
Spaulding	Rob Roy	1	1		105
	Sisler	1	1	1½	60

DAKOTA.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
PENNINGTON.					
Confederate	Stockade	1	1	2	50
Rockerville	Black Hills P. M. Co	1	1	1½	175

TABLE LXIX.—HYDRAULIC NOZZLES—Continued.

GEORGIA.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
				Inches.	*Feet.*
HALL.					
810 G. M.	Glade	3	1	1½ to 2½	75 to 100
LUMPKIN.					
Twelfth	Battle Branch	1	1	....	30 to 80
Do	Findley	1	1	....	10 to 30
Do	Griscom	1	1	¾	25
Twelfth and First	Chicago and Georgia	1	1	2	35
Do	Hand & Barlow	1	1	....	100
Thirteenth	Cleveland & Bugg's Branch	1	1	....	15
UNION.					
Tenth and First	Coosa	1	1	....	80
WHITE.					
Third	Nacoochee	2	1	2	30
Fourth	Forest Spring	1	1	1½	50

IDAHO.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
ALTURAS.					
Elk Creek	Hardscrabble	2	1	2 and 2½	25 to 50
BOISÉ.					
Boston	R. W. Spencer	4	1	1 to 2½	....
Moore's Creek	Crepisculla	2	1	2½ to 3	25
Do	Noble, Lower & Mann	1	1	....	20 to 30
Do	Thorn Creek Company	2	1	2½	50
Pioneer	Hon. Ben. Wilson	13	1	3½ and 4	20 and 40
Do	Stevenson & Noble	2	1	4 and 5	....

MONTANA.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
BEAVER HEAD.					
Bannock	Bannock D. and M. Co	1	1	....	40 to 50
Do	White Bar	1	1	....	30
DEER LODGE.					
Gold Hill	Squaw Gulch	3	1	3, 4, and 6	130
Henderson Gulch	Butler & Anderson	1	1	2	100
Independence	Oro Fino	1	1	1½	50
Nelson	Pioneer	4	2	2	50
Summit Valley	Noyes & Upten	1	1	2	40
LEWIS AND CLARKE.					
Last Chance	W. A. Cheesman	2	1	2	5
MEAGHER.					
German	Diamond F. and H. Co	1	1	3½ to 6	150
Thompson Gulch	California	1	1	1½	25
Do	Morgan Bar	1	1	1½	15 to 20
Do	Tubbs & Ramsey	1	1	....	30

NORTH CAROLINA.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
MONTGOMERY.					
Eldorado	Beaver Dam	3	1	1 to 2	150
....	San Christian	1	1	2 to 3	14
POLK.					
....	Cochrane	1	1	2	10

OREGON.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
BAKER.					
Blue Cañon	Littlefield & Duckworth	1	1	2 to 3	25
Do	Marysville	1	1	4	50
Chicken Creek	J. N. Osborne & Co	1	1	2	15
Do	Porter	1	1	2	....
Humboldt Basin	Colt & Co	3	1	2	100
Mormon Basin	Rogers & Copeland	1	1	2	20
Pocahontas	Baisly	3	1	2, 2½, and 3	150
Do	Baisly & Daly	1	1	2½	50
Do	Lew Cooper & Co	1	1	1½	30
Do	Neversweat	8	1	1¼, 1½, and 2	30
Do	Salmon Creek	2	1	2 and 4	125
Rye Valley	Powers & Co	5	1	2½	30
Shasta	Ah Moon	1	1	1½ and 2	30
Do	Campbell	....	....	3	70
Do	Steiger's French Gulch	1	1	2	70
Do	Stevenson's	1	1	3	80
Sumter	Sumter	....	....	2	30
Willow Creek	Bosswell	1	1	2½	40

TABLE LXIX.—HYDRAULIC NOZZLES—Continued.

OREGON—Continued.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
DOUGLAS.				*Inches.*	*Feet.*
Big Bend Cow Creek	D. A. Levens	1	1	2	25
Do	J. Fuller	1	1	2	75
Do	Merriam & Anderson	1	1	2 to 2½	75
Do	Salmon	1	1	3, 4, and 6	200
Cañonville	Catchings	1	1	3 and 4	45
Do	McWilliams & Ash	1	1	4 and 4½	180
Green Mountain	Charles Dwelley	1	1	1¼ and 2	40
Do	Dyer & Sons	2	1	1½ and 2	30
GRANT.					
Cañon City	Sproul	1	1	3	....
Granite	Borne & Lucas	....	1	2	40
Do	Klopp & Johnson	1	1	4 to 7	60
Marysville	Cannon & Co	1	1	3	150
Do	Hillis	....	....	3	50
Do	Thompson	2	1	2¼ and 3	50
Rock Creek	Erickson & Owens	....	1	2½	50
Do	Lasswell & Co	....	1	2½	30
Trail Creek	Trail Creek	1	1	3½	50
JACKSON.					
Applegate	Grand Applegate	1	1	3	150
Do	Squaw Lake	1	1	6	60
Ashland	Anderson & McCall	1	1	3	30
Coyote Creek	Marshall	1	1	2½	20
Do	Wm. Ruble	1	1	3 to 4	60
Farris Gulch	Farris Gulch	2	1	2	50
Forty-nine	Davenport	1	1	3	30
Do	Forty-nine	1	1	2	40
Sam's Valley	Hays & McGruder	1	1	2	....
Sterling	Saltmarsh & Co.	1	1	1¼	20
Do	Sterling	3	2	6	225
Uniontown	Chapel & Co	1	1	5	150
Do	Gin Lin	2	1	5	150
Wolf Creek	Gross Bros	1	1	3	60
JOSEPHINE.					
Grass Creek	Goff, Triplett & Chapin	1	1	1¾	75
Do	Steam Beer	1	1	3	50
Waldo	Desselles & Co	2	1	1¾ and 2½	36
Do	Waldo	1	1	3 to 3½	40
Yank	Blue Gravel	2	2	2½ to 6	75 to 100
Do	Josephine	2	1	4½ to 5	75
WASCO.					
Ochoco	Wickaiser & Co	2	....	1¼ and 1½	....

SOUTH CAROLINA.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
CHESTERFIELD.					
....	Brewer	2	1	1½ and 3	35

UTAH.

County and district.	Mine.	No. of nozzles.	No. fed by one pipe.	Size.	Mean length of stream.
SALT LAKE.					
West Mountain	Argonaut	1	1	3	80

DUTY OF THE MINER'S INCH.—In loose gravel the excavating power of the hydraulic stream is frequently greater than the transporting power of the same water in the sluices. It would be useless to pipe down more gravel than can be sluiced, so that the transporting power in such cases becomes the measure of duty. Computations made by different engineers, and based upon actual experiment, show a range of between 1 and 10 cubic yards of material moved per 24-hour inch of water (2,250 cubic feet), with an average of about 3 yards per inch. The amount transported depends not only upon the character of the material, heavy and cement gravel requiring much more water than light, loose wash, but also upon the grade of the sluices. An increase in the grade with a given volume of water results in greater carrying capacity, though the exact ratio of increase is not reduced as yet to law. The conditions vary widely in different localities.

WATER-WHEELS.—In some hydraulic mines the power for operating the derricks by which the large bowlders are handled is furnished by water-wheels, usually of the hurdy-gurdy type, in which the direct impact of water under considerable head is directed through nozzles against the periphery of small, rapidly-revolving wheels. The power developed usually ranges between 5 and 20 horse-power for each wheel. These wheels and small overshot wheels are also used in connection with drift mines for pumping and for driving air-compressors and for motive power in the cement mills. Chinese irrigating wheels are sometimes employed to raise water for sluicing in creek washings.

SLUICES FROM BANK TO CHIMNEY.—These are usually cuts in the bed-rock of irregular width, the bottoms of which have a grade of from 6 inches to 1 foot in 12 feet.

SLUICES IN TUNNELS.—The natural rock floor of a tunnel may serve as a sluice, but more commonly the tunnels are fitted with large, substantially-built wooden sluices, having rock riffles of basalt, wooden block riffles, or old railroad iron and scantling faced with iron, as described below.

SLUICES BELOW TUNNELS.—These are constructed after the manner described under the head of flumes, and are really ground flumes designed to carry gravel, etc., in addition to the water, but are more strongly built than the water fluming. A few typical sluices are briefly described in the accompanying table:

TABLE LXX.—DIMENSIONS, ETC., OF SLUICES IN PLACER MINES.

Name.	Location.	In tunnels or cuts.				Outside of tunnels.			
		Width.	Grade.	Length.	Style of riffles.	Width.	Grade.	Length.	Style of riffles.
		Feet.		Feet.		Feet.		Feet.	
Black Hawk	Five miles northwest of Quincy, Plumas county.					1⅝	5 in. in 12 ft	½ mile.	Blocks.
Del Norte	On Klamath river, near Happy Camp.	2	8 in. in 12 ft	300	Blocks	2⅝	....do	1,200	Do.
Gold Run	One mile southwest of Gold Run, Placer county.	6	6 in. in 12 ft	2,500	Old car rails				
Hager & Haas	In Junction city, Trinity county.					4	3½ to 7 in. in 12 ft.	1,440	Blocks.
Harvey Bros	Weaver district, Trinity county.					3	3 in. in 12 ft	4,800	Do.
Holman & Mahon	....do					3½	2 in. in 12 ft	3,600	Do.
John Young	In town of Oro Fino, Siskiyou county.	4 to 5	⅞ to 1½ in. in 12 ft	2,000	Blocks				
Oroville	On Feather river, near town of Oroville.					4	2½ in. in 12 ft	2,400	Blocks.
Rule Bros	Weaver district, Trinity county.					3	....do	3,000	Do.
Spring Valley	Cherokee Flat, Butte county	6	8 in. in 16 ft	1,800	Basalt	4 to 6	4 to 8 in. in 16 ft.	6½ miles.	Basalt and wooden blocks.
Van Emmons	Town of Michigan Bluffs, Placer county.	2⅝	13 in. in 12 ft	3,600	Wooden blocks	2⅝	10 in. in 12 ft	300	Rock.
Weed's Point	Two miles north of Camptonville, Yuba county.	4½	6½ in. in 12 ft	600	Rock and wooden blocks.	3½ to 4	4 in. in 12 ft	4,200	Blocks.
Wiltshire	Trinity county.					4	6 in. in 12 ft	1,200	Do.

GRADE.—The average grade of sluices is 6 inches per box of 12 feet, though if the gravel is very heavy, containing bowlders, a steeper grade is required, and as much as 18 inches in 12 feet is sometimes demanded. Light sandy gravel can be carried on flatter grades than the standard, and in all cases it is advisable to have the sluices set at no steeper grade than is absolutely necessary for the transportation of material.

LINING OF SLUICES.—The sides of the sluices are protected by an interior facing of 2-inch plank, which extends above the riffles as high as the portion exposed to wear.

GRIZZLIES.—These are gratings of parallel iron rails which allow the sand and fine gravel to fall into the undercurrents, while the larger masses are carried on in the main line of sluices or are rolled off to one side out of the way.

DROPS.—Where it is possible, drops of two or more feet are made in the sluice string for the purpose of breaking up pipe-clay and disintegrating cement concretions. Even if the gravel is apparently quite loose and free, such drops can be usefully introduced if there is sufficient fall, and with tough, clayey gravel they are still more valuable.

UNDERCURRENTS.—Wide and very flat sections of sluice, placed by the side of the main line of sluices and fed by the fine material which falls through the gratings, are called undercurrents. Here, the flow of water being comparatively shallow and sluggish, an opportunity is given for the rusty gold and float amalgam to settle. The tailings of the undercurrent are returned again to the main sluice at a point where the grades coincide.

CONSIDERATIONS INVOLVED.—The exigencies are such that in very many mines the engineer is unable to adopt the style of sluices, etc., which would give the best results, and is constrained to resort to the most practicable makeshift. The appliances for saving gold have been developed to a high degree of perfection and are well understood by hydraulic miners, and with the right facilities very efficient means are taken. Given plenty of fall, an abundance of water, and a line of sluices extending along the side of a cañon, the system adopted would be somewhat as follows: A number of drops would be introduced to disintegrate the clayey gravel. By a series of grizzlies the larger sized material (bowlders, pebbles, etc.) would be shot off down the cañon, the apertures between the bars being successively diminished until only the finest gravel and sand would be left in the sluices. It has been recommended that this sizing should be carried to a point where the final siftings should only exceed by two or three diameters the coarsest gold particles found by experience to occur in the mine. This light material could be carried on a quite flat grade with a shallow volume of water, thus making the sluice practically a continuous undercurrent below the point where the last of the refuse, coarse material had been eliminated, or a series of still flatter undercurrents, returning their tailings to the main sluice, could be added. Auxiliary streams of clean water would be used to offset the loss over the grizzlies. The style of pavement and the length of the string would then be a matter of economic judgment.

There is no question but that the rush of water necessary to move heavy barren material through the sluices carries off with it much fine rusty gold and float amalgam. This is corrected in part by the liberal use of undercurrents; but the very efficiency of these undercurrents proves the advantage of light grades and shallow water, which are only compatible with a close sizing of material. If there are twenty-five undercurrents connected with the sluice string (and this number has been reached in some mines), the lowest one invariably is found to save gold and amalgam, though each one successively catches less and less, thus showing that a further development of the system would result in still greater saving. In practice, however, the fall, the amount of water available, and the topography of the country below the mine are seldom such as to allow unlimited choice of means; and, as regards the first cost of the gold-saving plant, the engineer is constantly limited by the consideration of immediate profits. Thus with reasonably permanent plant an undercurrent is seldom added, even if practicable, if it is not thought that it will pay for itself in the course of a couple of seasons. Theoretical perfection must give way to the expediency of the moment in this as in other mining operations.

RIFFLES.—The earliest form of riffle used in sluices was a plain transverse cleat. To resist the heavy rush of water, gravel, and bowlders from large hydraulic workings it is necessary that the pavement and lining of the sluices should be very substantial. The most common form of paving in use consists of blocks of wood, for which heart sugar-pine answers excellently, placed with the grain vertical and securely wedged. These blocks are from 6 to 12 inches thick, more frequently 8 inches, and are either squared, with rounded corners, or more rarely of natural section. The interstices in which the amalgam collects are from a fraction of an inch to 4 inches in width. By reversing the blocks after one side is worn an additional life is secured. In average mines the block riffles last one season, and by turning are made serviceable during two seasons; but if the amount of material carried is comparatively small, the duration is indefinitely extended, as much as five years being reported in exceptional cases.

Rock riffles have been advantageously substituted for wooden blocks in many localities. The rock commonly used is basalt, but quartz and other materials have also been employed. The flooring is set somewhat after the fashion of cobbles, slightly inclined from the vertical, and the pieces are selected with some aim at uniformity. These rock riffles are very durable, and are more economical than wooden blocks, but the labor of handling them in cleaning up is much greater. Usually they are placed in parts of the sluice which it is seldom necessary to clean up. They require more water and heavier grade than do the wooden blocks. At the Spring Valley mine, where the wooden blocks last but three months, the rock pavement remains serviceable just twice as long, though the duration in each case is shorter than is usual, the rock in smaller mines often lasting many years.

Longitudinal slats of scantling, set on edge, arranged somewhat like a grating, make effective riffles, and are very conveniently handled. For this reason they are frequently placed at the heads of sluices, so that these portions may be readily cleaned up. They do not last nearly so long as the block or rock systems; hence, if the wear is excessive, owing to the transportation of bowlders and large pebbles, a facing of iron strips is added. Old rails can be utilized in the same way.

A large number of variations in the style of riffles, some of them patented, have been introduced. It is a very common thing for several systems to be used in the same string of boxes, thus: slats at the head, with alternating sections of block and rock pavement below. The choice of material and of form is governed by economical considerations, by the character and the quantity of the gravel sluiced and by the fineness of the gold.

WORKING IN BENCHES.—When the bank is very high, and there is danger to the nozzles and the pipemen from caving, it is sometimes the practice to work off the gravel in two or more benches, thus dividing the height. At the Polar Star mine, Placer county, California, the average depth of gravel was 300 feet and the maximum 350 feet. It was found advisable to work this deposit in two benches. Previous to the census year the upper bench, the 150 feet bank, had been piped off and the nozzles were then directed upon the lower bench, which had a bank of 100 feet where being worked. The necessity for working in benches does not, however, very often arise. Very high banks, sometimes as much as 250 feet, are worked in a single bench, though accidents to the apparatus and to the men are apt to occur when very deep deposits are attacked in this way, and if for safety the nozzles are set back from the bank at too great a distance the streams lose force.

DISTRIBUTION OF GOLD AND AMALGAM IN THE SLUICES.—In a string of plain sluice-boxes the bulk of the gold is invariably found at and near the head of the line; and if it is the practice to add the quicksilver in the first boxes, the greater part of the amalgam also is recovered from the same locality. Below, the accumulation of gold and amalgam diminishes in almost geometrical ratio, but if there are undercurrents a noteworthy percentage of the total yield is caught by them, and the proportionate amounts saved by each of a series of undercurrents is in inverse ratio to their order of succession. At the mines where ground-sluicing forms the main reliance the gold is similarly deposited near the heads of the cuts. The testimony on this point is unanimous and agrees quite closely in detail. The statements received from the following mines will illustrate the manner in which experience has shown the distribution of gold to occur. Other returns, given with less particularity, show a similar mode of occurrence.

ARIZONA.

Jackson: Mostly in first 2 boxes.

CALIFORNIA.

A. B. C.: Mostly within 50 feet of head.
Bay City: 90 per cent. in first 10 boxes.
Black Hawk: In first 20 boxes.
Bunker Hill: 80 per cent. in first 10 boxes.
Carroll: Nearly all in upper boxes.
China Creek: 66 per cent. in first 10 boxes.
Coyote Gulch: 90 per cent. in first 15 boxes.
Del Norte: 90 per cent. in first 15 boxes.
Dry Creek: 90 per cent in first 10 or 15 boxes.
Duncan Cameron: Nearly all in upper boxes.
Duryea: Mostly in first 150 feet.
Evans & Bartlett: 75 per cent. in first 4 boxes.
Happy Camp: 90 per cent. in first 10 boxes.
Hardscrabble: Nearly all in upper boxes.
Harvey Bros.: 90 per cent. in head boxes.
Hidden Treasure: Mostly within 200 feet from head.
Hiyou: 80 per cent. in upper boxes.
Hungarian Hill: Mostly in first 20 boxes.
Hupp & Murray: 80 per cent. in first 700 feet.
John Young: 80 per cent. in first 15 boxes.
Johnston: 75 per cent. in first 10 boxes.
La Grange: 90 per cent. in upper boxes.
Lewiston: 90 per cent. within 50 feet of head.
Lincoln, Hart & Henry: Nearly all in upper boxes.
Magalia: Mostly in first boxes.
Mammoth: Mostly in first 175 feet.
Mammoth: 25 per cent. in first 100 feet, 25 per cent. in undercurrents.
McKenna: 50 per cent. in first 50 feet, 10 per cent. in undercurrents.
Morris Ravine: Mostly in first 20 boxes.
Muc-a-muc: 75 per cent. in first 10 boxes.
North Fork: In first 3 boxes.
Oroville: Mostly in first 10 boxes.
Pellet & Truitt: 90 per cent. in bed-rock sluices.
Penobscot: 90 per cent. near head of sluice.
Plumas M. and W.: Mostly in first 20 boxes.
Rule Bros.: 80 per cent. in first 180 feet.
Siwash: Nearly all in upper boxes.
Trinity: 90 per cent. in first 120 feet.
Wingate: 80 per cent. in first 10 boxes.

COLORADO.

Blue River: Mostly in first 200 feet.
Hahn's Peak: Mostly in first 3 boxes.
Rob Roy: Mostly in first 100 feet.
Sisler: Mostly in first 75 feet.

GEORGIA.

Battle Branch: Five-eighths in first 20 feet.
Cleveland & Buggs' Branch: Mostly in first 50 feet.
Coosa: 95 per cent. in first 10 feet.
Forest Spring: Over 50 per cent. in first 36 feet.
Glade: 90 per cent. on bed-rock.
Griscom: In upper 50 feet of boxes.

IDAHO.

Crepisculla: Mostly in first 6 boxes.
Hon. Ben. Wilson: Mostly in first 6 boxes.
Noble, Lower & Mann: Mostly in first 2 boxes.
R. W. Spencer: Mostly in first 6 boxes.
Thorn Creek: Mostly in first two boxes.

MONTANA.

Butler & Anderson: Mostly in first 3 or 4 boxes.
California: Seven-eighths in first 4 boxes.
Charles Pryse: Mostly in first boxes.
Diamond F. and H. Co.: Mostly in first quarter of sluice.
Morgan Bar: 75 per cent. in first 3 boxes.
Pioneer: Mostly in first 3 boxes.
Shoup & Blume: Mostly in first 3 boxes.
Squaw Gulch: Mostly in first 10 boxes.
Tubbs & Ramsey: 75 per cent. in first 3 or 4 boxes.
White Bar: Mostly in first 3 boxes.

NORTH CAROLINA.

Cochrane: Mostly in first 2 or 3 boxes.

OREGON.

Ah Moon: Mostly in first 2 boxes.
Anderson & McCall: 90 per cent. in first 2 boxes.
Baisly: 90 per cent. in race.
Baisly & Daily: 90 per cent. in race, balance in first 5 boxes.
Borne & Lucas: Mostly in first 2 boxes.
Cannon & Co.: 90 per cent. in race.
Catchings: Mostly in 2 upper lengths.
Colt & Co.: Nine-tenths in the race.
Dyer & Son: In first 2 boxes.
Gin Lin: Mostly in first 4 boxes.
J. N. Osborne & Co.: Two-thirds in race and first 3 boxes.
Klopp & Johnson: Mostly in first 2 boxes.
Grand Applegate: 90 per cent. in first 2 boxes.
Lew Cooper & Co.: Seven-eighths in the race, balance in first 3 boxes.
Littlefield & Duckworth: Seven-eighths in the race, balance in first 5 boxes.
Marshall's: Five-eighths in first 2 boxes.
Marysville: Nine-tenths in the race.
Neversweat: 95 per cent. in the race, balance in first 5 boxes.
Porter: Three-fourths in race and first 3 boxes.
Powers & Co.: 90 per cent. in the race.
Rogers & Copeland: Three-fourths in the race, balance in first 3 boxes.
Salmon: Mostly in first 2 boxes.
Salmon Creek: 90 per cent. in the race, balance in first 100 feet.
Sproul: 90 per cent. in the race, balance in first 3 boxes.
Squaw Lake: 90 per cent. in first two boxes.
Steiger's French Gulch: Mostly in first and second boxes.
Sterling: Mostly in first 10 boxes.
Stevenson's: Mostly in first box.
Trail Creek: Mostly in first 3 boxes.
W. Bosswell: Mostly in upper boxes.
W. Ruble: Three-fourths in ground sluices.
Wickaiser & Co.: In first 3 boxes.

This concentration of the gold within a comparatively narrow distance allows a frequent partial clean-up of the more productive boxes to be made, while the greater portion of the line can be left untouched for a longer run. For this reason a double set of upper boxes, arranged as are the arms of a Y and converging toward the main line, may be recommended where it would not be economically expedient to adopt a complete double-string of sluices, so that the washing of gravel need not be interrupted while one set of head-boxes is being cleaned up. But the fact that most of the gold is found near the upper part of the sluices is no reason why the string of boxes should be shorter than the limit fixed by the demands of expediency, for sluice plant is never so perfect that some saving of gold may not be made at its extremity.

LOSS OF GOLD AND QUICKSILVER.—The admirable economy of the hydraulic process, which admits of handling material containing an average of a few cents only per cubic yard, leads also to some uncertainty as to the proportion of gold which is saved, and this very important question becomes rather a matter of opinion than of absolute knowledge. Means of testing the tailings are simply a continuance or extension of methods adopted in the gold-saving appliances, for the minute and irregular dissemination of the fine gold particles is such as to defy the fire-assay or any similar means. If, therefore, a careful reworking of the tailings is undertaken and the results obtained are insignificant, it merely proves that no large amount of gold which is susceptible to the amalgamating and gravity appliances in use has escaped in the first treatment—not that there does not exist a considerable quantity which, from excessive fineness or peculiar chemical attributes, would be lost were the ordinary means of gold-saving indefinitely extended.

In the majority of well-appointed hydraulic mines it is claimed, and apparently with good reason (though not with any degree of precision), that about 90 per cent. of the gold present in the gravel is saved, and some intelligent miners consider that the loss is even less. On the other hand, in a few cases, generally where the sluices are not sufficiently extended or because of very clayey material, a loss of 33 per cent. is admitted. These are wide ranges of expression, it is true, but still it cannot well be doubted that the working of an average hydraulic mine gives closer results than does the ordinary mill process.

With well-designed plant even gold may be lost because of at least three known conditions: It may be so microscopically comminuted, and in such thin flakes, as not to sink in the thick muddy water of the sluices; or, after being taken up by the quicksilver, the resulting amalgam may be floured and similarly carried off in the water; or, finally, it may be protected by its quartz matrix and escape in its native pebble. For the last difficulty there is no remedy, since crushing gravel of the usual tenor worked in hydraulic mines is evidently out of the question.

In the mines where careful retorting is practiced and the bulk of the quicksilver lost escapes from the sluices the consumption of this metal is very considerable. The range of loss is reported to extend to from 5 to 37½ per cent. of the quantity used, and in the majority of cases from 10 to 15 per cent. is known to escape. The loss of quicksilver involves the loss of gold, but in what ratio is not known. The amalgam from undercurrents has been found to be poorer in gold than that from the main sluices. As the consumption of quicksilver is a known element, a careful and somewhat extended investigation into the tenor of amalgam collected from different portions of the sluices and escaping in the tailings might lead to useful results, and at least would indicate approximately the ratio in which gold that is susceptible to amalgamation is lost as compared with the waste of quicksilver. It is worth while to recall, in this connection, the well-known fact that float amalgam has been caught at distances of 20 miles from the point where the sluices from which it had escaped tailed into the stream.

RETORTING OF AMALGAM.—After removing the excess of quicksilver by straining and washing the amalgam is retorted, commonly in cast-iron bulb-retorts, and the distilled quicksilver is collected under water. At a few of the larger mines the retorted amalgam is melted into bars, weighed, and stamped, but usually it is sold in the crude state. At many of the smaller mines, and particularly in new districts where there are no facilities for retorting, the amalgam, after straining as closely as possible by hand through chamois or cloth, is placed in a pan or on a shovel and the remainder of the quicksilver is volatilized in the open air over a common fire.

LENGTH OF SHIFT.—Most of the large hydraulic mines during the height of the season are worked full time, or with two shifts of ten hours each, thus running twenty hours per day. When, because of scarcity of water or for other reasons, the mines are worked during the day only, the shift is from ten to twelve hours. Although the work in hydraulic mines is often laborious, it is of a healthful nature, and is probably not a greater tax upon the men than is the shorter shift common in underground mining.

LENGTH OF SEASON.—This depends on the duration of the period during which water can be supplied, and is limited by either ice or drought. For the more important hydraulic mines the average length of season throughout the country may be stated at about 200 days, though during the latter part of the run most of the mines are worked on half time or less and with diminishing water supply. Of the unreported mines the season is known to be much shorter than the period mentioned.

ECONOMY IN HYDRAULIC MINING.—This method of mining depends for its success on handling vast quantities of matter of so low a grade as to yield but a few cents per cubic yard. In many mines the product is not above 10 cents per yard, and in some favorably-situated workings a considerably lower rate of production results in profit.

Professor Whitney's (*a*) estimate was that gravel yielding $4\frac{3}{4}$ cents per cubic yard could be profitably worked under the best conditions. Since this opinion was published a still lower tenor has been shown to be profitable. Between 1870 and 1874 the North Bloomfield Company (*b*) washed three and a quarter million cubic yards of top gravel, yielding 2.9 cents per cubic yard, at a bare profit of only $2,232 84, showing, however, that a very slight improvement in the quality of the gravel would have rendered a considerable profit. The conditions necessary for cheap working are not only an abundant water supply, sufficient dump, and high banks of loose fine gravel which can be easily piped, but in addition to these there is required the closest attention to details and the strictest economy on the part of the management.

COST OF HYDRAULIC MINING.—The method of measuring the cost, yield, and profit of hydraulic mining is a question concerning which opinions differ. The estimate of product based on the quantity of material moved is the most common, but the conditions vary so greatly in different places that for purposes of comparison this mode has but little value, while the measurement of the irregular bodies worked is also a matter of some uncertainty. Indeed, objections may be raised against each of the other ways proposed, such as stating the yield per miner's inch of water used, per square foot of bed-rock stripped, or the cost per ounce of gold extracted. Custom has so established the method of calculating product and cost by the cubic yard of gravel washed that this is likely to remain the standard, though for technical purposes the product per miner's inch of water used forms a simple means of comparison, and is preferred by many engineers as being more generally applicable. From a purely business point of view the expenses and the profits are perhaps best shown by reference to the product at its market value. Thus, for example, to produce a dollar in gold the costs would be stated as so many cents for labor, for water, for powder, for quicksilver, etc., each item forming a percentage on the product without further computation. This latter mode also permits of comparison with the results obtained in other branches of mining and in industrial pursuits in general.

A cubic yard of gravel may be taken at from $1\frac{1}{2}$ to $1\frac{3}{4}$ tons. When it is considered that this quantity of material can be handled under the best circumstances at a cost of less than 3 cents by the hydraulic process, some idea of the wonderful economy and efficiency of this means of mining may be gained. If a ton of gravel is treated at a cost of 2 cents, the expense is between one-fiftieth and one one-hundredth of the minimum outlay involved in mining and milling the most favorably situated and most easily reduced free-milling gold ores. The average cost of hydraulic mining bears about the same relationship to the average cost of mining and reduction of auriferous vein deposits as does the minimum. A comparison with the expense of mining and reducing rebellious silver ores shows a still wider divergence. Thus, if the two extremes are stated at 2 cents per ton for working gravel under the very best possible conditions and $100 per ton for mining, hauling, and reducing the silver ore under exceptional disadvantages, the range in cost of handling similar weights of material is expressed by the ratio 1 : 5,000. In addition to the obvious advantages possessed by the hydraulic process, such as saving in labor, etc., and the capability of handling vast quantities of material with great rapidity, a feature which especially characterizes it is the fact that it is continuous and very nearly automatic throughout, while in vein mining the process is divided into at least two distinct operations, mining and reduction, with possibly many successive handlings in which manual labor is more or less involved.

The minimum cost of hydraulic mining, taken from the accounts of a few of the largest, most favorably situated, and most economically and skillfully worked mines, is apt to be misleading if applied as a basis for calculation in projecting new enterprises. While a very few exceptional mines are worked at a cost of between 2 and 3 cents per cubic yard, it is probable that the average cost for all the hydraulic mines of the country, large and small, is not less than 10 cents per yard, while among the census returns are cases ranging all the way from this point up to between 40 and 50 cents per yard.

The itemized costs of mining during the census year at a few specimen hydraulic mines in the northern part of California are cited in Table LXXI, and in Table LXXII the results of operations at a group of mines in Stanislaus county, and at the North Bloomfield mine of Nevada county, are shown. The figures of the latter table are for an irregular period, about four years previous to the present investigation, and are from data compiled by Mr. Augustus J. Bowie, jr.

a *Auriferous Gravels*, p. 371.

b Hydraulic Mining in California, *Transactions Am. Inst. of Mining Engineers*, vol. vi, p. 35.

TABLE LXXI.—COST OF HYDRAULIC MINING AT VARIOUS MINES IN DEL NORTE AND SISKIYOU COUNTIES, CALIFORNIA.

Cost of—	Bunker Hill.	China Creek.	Happy Camp.	Muc-a-muc.	Wingate.	Bay City.	Coyote Gulch.	Thompson's Creek.
Labor	$4,950 00	$2,167 36	$8,588 00	$1,039 00	$4,288 50	$835 00	$1,950 00	$1,095 00
Repairs to ditch	....	....	1,000 00	56 00	....	....	....	....
Powder and fuse	2,250 00	315 00	500 00	135 00	800 00	....	....	....
Blocks, etc	1,000 00	412 80	1,587 00	110 00	500 00	100 00	24 00	40 00
Boxes	60 00	120 00	....	....	60 00	100 00	30 00	....
Quicksilver	150 00	45 00	25 00	12 00	35 00	....	14 00	28 00
Tools	50 00	100 00	100 00	....	50 00	....	50 00	....
Sundries	200 00	20 00	....	148 00	200 00	....	....	100 00
Total	8,660 00	3,180 16	11,800 00	1,500 00	5,933 50	1,035 00	2,068 00	1,263 00
Number of cubic yards of gravel moved	132,300	32,234	314,600	22,554	263,000	24,750	31,740	19,600
Cost of moving 1 cubic yard	$0.0654	$0.0987	$0.0375	$0.0665	$0.0225	$0.042	$0.065	$0.0645

TABLE LXXII.—COST OF HYDRAULIC MINING AT VARIOUS MINES IN STANISLAUS AND NEVADA COUNTIES, CALIFORNIA.

Cost of—	Chesnau.	French Hill.	Johnson.	Light.	North Bloomfield.	Sicard.
Labor	$0.036	$0.042	$0.02	$0.022	$0.0225 (Labor to Melting and refining)	$0.025
Blocks and lumber	0.0042	0.0042	0.0029	0.008		0.0061
Material	0.0062	0.0057	0.0076	0.0015		0.0088
Melting and refining	0.0005	0.0004	0.0004	0.0003		0.0007
Water	0.008	0.0104	0.006	0.006	0.0075	0.004
Total cost per cubic yard	0.055	0.063	0.037	0.038	0.03	0.039
Yield per cubic yard	0.16	0.13	0.04	0.066	0.0533	0.13
Yield per inch of water	0.23	0.14	0.08	0.12	0.23	0.37
Number of cubic yards of gravel washed	284,932	676,968	196,632	683,244	4,104,700	155,347
Total yield	$47,781 73	$90,186 19	$9,148 27	$45,444 65	$207,007 50	$20,197 07
Total cost	15,923 71	42,655 83	7,465 99	25,962 82	147,012 58	6,205 40

PROFITS IN HYDRAULIC MINING.—When a mine is fully developed, the returns are very regular and uniform and can be counted on with quite as much certainty as, for instance, in manufacturing pursuits. Indeed, it is usually possible to estimate beforehand with considerable precision whether the returns from a given undertaking are likely to pay for the expense of opening the mine. The chief elements of uncertainty are the amount of rainfall and the duration of the working season, which in all localities are liable to vary from year to year. These remarks, of course, apply mainly to claims having deep beds of gravel and worked upon a somewhat large scale, and in such mines, while there is not the constant excitement dependent upon the possibilities of sudden strikes and bonanzas, there is, on the other hand, little fear of the mine "petering" so long as there is a good gravel bank in sight and the means of working it are at hand. Hence it is that few hydraulic mines are worked at a loss, except during the prosecution of dead-work necessary to development, or, perhaps, in unexpectedly short seasons. The hydraulic miner can easily ascertain whether it is worth while to continue operations, and when he finds himself running behind he is apt to close down at once. The amount of work done and of money invested in this class of enterprises is therefore very closely adjusted to the possibilities of profit. While, however, there are a large number of mines operated on a bare margin of profit, it is believed that, leaving out of consideration the value of the permanent investment, the running expenses average hardly more than 50 per cent. of the gross yield.

PRESENT STATUS OF THE INDUSTRY.—From the inception of hydraulic mining the tendency has been constantly toward improvement in method and increase in the scale of operations, necessitating the employment of large capital, and, consequently, a consolidation of interests. At present the more important enterprises are prosecuted by strong corporations, which are able to perform an immense amount of preliminary dead work before receiving any returns; but, on the other hand, many small mines are still yielding handsome profits on smaller investments to individual owners. Progress has been made chiefly in an extension in the field of operations, larger tracts being developed and heavier rigs brought to bear. Greater amounts of water, at higher heads, and nozzles of larger aperture; long tunnels, extended strings of sluices, and the use of double lines of sluices; increase in the number of undercurrents, drops, grizzlies, etc.—these are the principal directions in which advance is continually manifesting itself. Each year brings new knowledge, and though the hydraulic method has again and again been declared to be as near perfection in point of practical economy as could be hoped for, still there is reason to believe that, while the general principles are now well established, the future has in store many further improvements.

In California a serious set-back has occurred in the conflict between the hydraulic mining interest and the farmers whose lands, on the line of drainage below the mines, have been injured by the deposit of tailings from the mines. Damage has also been done the navigable rivers by the same cause. During the census year some of the important mines were closed down for a considerable time by injunctions restraining them from working, and much litigation was in prospect. The miners have, however, pending the final solution of the difficulty, of their own accord taken steps to impound their tailings by dams; and whether the system proposed by Lieutenant-Colonel Mendell is carried out by state aid or by that of the general government, or not at all, the agitation of the *débris* question will undoubtedly result in checking the damage, though if the miners are compelled, unaided, to restrain their tailings the necessary improvements will add to the cost of mining. One effect of the "slickens" controversy will undoubtedly be a resort to drift mining for certain placer deposits.

DRIFT MINING.

This method of working placer deposits is practiced in localities where the gravel is overlaid by lava, or where the paying portion is concentrated in a thin stratum on the bed-rock under a deep wash of barren or very low grade gravel which could not be profitably mined by the hydraulic process. It also takes the place of hydraulic mining in places where, from scarcity of water or insufficiency of dump room, it would be impracticable to move the whole depth of the deposit by piping.

The system of mining is analogous to that followed in vein mines. The deposit is opened by tunnel, shaft, or incline to the bed-rock, developed by cross-cutting, and the pay-streak stoped out. The latter usually consists of about 3 feet of gravel lying immediately upon the bed-rock, with the upper portion of the bed-rock itself to a depth of from a few inches to sometimes 3 feet. The gravel is shoveled into hand-cars and wheeled out to the mouth of the tunnel, or is loaded in buckets upon "buggies" and carried to the bottom of the shaft, where it is hoisted to the surface. The gold is extracted by simply washing in sluices, though sometimes the gravel is first crushed in a cement stamp-mill. As the gold on the bed-rock is sometimes very coarse, sluicing without quicksilver is in such cases practicable. In the underground workings careful timbering is required; and in breasting out the gravel pillars are left protecting the main galleries, or square sets of timber are introduced, which are filled with waste. Blasting is practiced to some extent, but in many of the mines the gravel is soft picking ground. Pumping is often required, the pumps being driven by water or steam power.

Drift mining is conducted extensively in Sierra and Placer counties; also in Siskiyou and El Dorado counties, California. The agitation of the *débris* question has redirected attention to this branch of mining, and its importance is increasing. At present it is thought that about one-third of the deep-placer product of the state is from drift mines. It is also practiced to a limited extent in various portions of the territories. Some of the California mines have yielded largely, as may be seen from the following specimen cases:

TABLE LXXIII.—PRODUCT OF SPECIMEN DRIFT MINES IN CALIFORNIA.

Mine.	Locality.	Length of claim.	Yield per linear foot.	Product.
		Feet.		
Hidden Treasure	Placer county	10,560	$204 00	*a* $274,283 00
Bald Mountain	Sierra county	7,500	404 00	*b* 1,728,616 00
Hawkeye	...do	800	437 50	*c* 350,000 00
Empire	...do	1,560	482 05	*c* 752,000 00
Monumental	...do	1,040	312 00	*c* 325,000 00
Pittsburgh	...do	860	506 00	*c* 420,000 00
Union	...do	2,400	625 00	*c* 1,500,000 00

a To May 1, 1880. *b* 1872 to August 1, 1880. *c* 1870 to 1880.

COST OF DRIFT MINING.—The conditions which determine the expense of mining on this plan vary widely. Favorably situated deposits, requiring neither hoisting nor pumping appliances, can be worked at extremely low costs; on the other hand, if the water is troublesome, the ground loose, and the pay irregularly disposed, the expenses are much enhanced. Thus, while gravel yielding a trifle over $1 per yard can be made to pay a profit under favorable conditions, in other localities an average tenor of $3, $4, $5, or $6 per yard will barely cover expenses. At the Lyon mine, El Dorado county, California, where the cement is crushed by stamps, gravel yielding an average of $3 per ton is profitable; and at the Paragon mine, in Placer county, where crushing is also practiced, gravel of the same grade yields a handsome profit above the cost of mining and milling. An average of $2 per ton covers expenses at the Hidden Treasure mine, Michigan bluffs. An analysis of the cost of mining in a series of mines in McAdams and Indian Creek districts is appended. These mines are shallow workings, from 28 to 74 feet in depth, the shafts penetrating a light wash and tailings. The "pay" is quite regular, lying on and in the bed-rock, and is stoped out on the long-wall system, hoisted in buckets to the surface by horse-whims, and washed in sluices near the shaft mouths.

TABLE LXXIV.—COST OF DRIFT MINING IN McADAMS AND INDIAN CREEK DISTRICTS, SISKIYOU COUNTY, CALIFORNIA.

Cost per cubic yard mined.	Cameron mine.	Carrol mine.	Hardscrabble mine.	Lincoln, Hart & Henry, and Oak Grove mines.	Siwash mine.	Williams mine.
Total cost of drift mining per cubic yard	$1.207	$1.629	$1.50	$1.634	$0.915	$0.89
Labor	0.952	1.148	1.00	1.148	0.66	0.552
Timber	0.15	0.816	0.31	0.816	0.15	0.164
Powder	......	......	......	0.005	......	......
Lights	0.02	0.004	0.05	0.064	0.02	0.012
Falls	......	......	......	......	......	0.036
Horse-feed	0.02	0.027	0.02	0.027	0.02	0.016
Incidentals and wear and tear	0.065	0.074	0.12	0.074	0.065	0.11

GRAVEL MILLS.—Cement gravel, if rich enough, and sometimes also gravel which is quite loose, is crushed in stamp-mills of the same character as those working on free-gold ores from veins but fitted with very coarse screens.

The gravel from the Lyon mine, El Dorado county, California, is crushed by a 20-stamp mill driven by water power. The stamps weigh 450 pounds each, and drop 90 times per minute, with an 8-inch fall. Thirty miner's inches of water under a head of 130 feet furnish the motive power. Of the total amount of gold saved 80 per cent. is caught in the battery. Outside of the mortar the pulp flows over a silver-plated copper apron, and thence through 800 feet of sluices. But little gold is recovered from the sluices, however. The material is crushed without previous sizing.

The mill of the Paragon Company, in Placer county, California, has 10 stamps of 850 pounds each, with steel shoes and dies, dropping 90 times per minute, with a fall of 10 inches. The mill is driven by steam. The capacity is 40 tons per 24 hours. Here the coarser gravel and bowlders are not crushed, but only the finer and softer gravel. The screens are sheet-iron, with $\frac{3}{16}$-inch round holes. From 60 to 70 per cent. of all the gold saved is caught by battery amalgamation, from 20 to 25 per cent. on aprons, and the remainder by a concentrator and in 150 feet of sluices. The record of a continuous run from September 19, 1879, to April 14, 1880, as quoted by Mr. W. A. Skidmore, gave the following results:

Car-loads of gravel crushed	4,241
Total yield	$44,835 53
Average yield per car-load	$10 57
Average yield per ton	$7 05
Average cost per car-load, mining and milling	$3 94

ACCIDENTS IN PLACER MINING.

While a very large number of minor accidents, usually caused by the caving in of banks, occur in placer mining, these for the most part are confined to mere bruises, and do not permanently disable the miners. In comparison with the number of men employed in this branch of mining serious accidents are infrequent. The returns for the census year include only thirty-seven casualties considered worth reporting; of these, thirteen resulted in death, and twenty-four were not fatal. The number of men killed and injured by caving was nearly four-fifths of the total accidents reported, while the next most frequent cause appears to have been the premature explosion of powder in bank-blasting or in blowing up bowlders, stumps, etc. The returns are necessarily imperfect, owing to the fact that a large number of the smaller claims were not reported upon in detail. The following table illustrates, however, with sufficient clearness the relative frequency of the different classes of accidents, and the average frequency with which the latter occur in mines of the largest extent and employing the greatest number of hands:

TABLE LXXV.—ACCIDENTS IN PLACER MINING DURING THE CENSUS YEAR.

State or territory.	CAUSE AND NUMBER.									
		Fatal accidents.			Accidents not fatal.					
	Total accidents.	Total fatal accidents.	Caving of bank.	Premature explosions.	Total accidents not fatal.	Caving of bank.	Premature explosions.	Crushed by log.	Carelessness in handling tools.	Unclassified.
The United States	37	13	11	2	24	17	2	1	2	2
Arizona	1	......	......	......	1	1	......	......	......	......
California	28	9	8	1	19	12	2	1	2	2
Colorado	1	1	1	......	......	......	......	......	......	......
Dakota	1	1	1	......	......	......	......	......	......	......
Idaho	1	......	......	......	1	1	......	......	......	......
Oregon	5	2	1	1	3	3	......	......	......	......

MINING DITCHES.

The system of artificial water channels, made necessary by the requirements of hydraulic mining, and serving also to supply placer mines not worked by the hydraulic process, as well as quartz-mills and other works, has become of vast extent and importance. There are now over 10,000 miles of ditch lines in the United States, which, with their flumes, pipes, reservoirs, etc., represent an investment of $27,000,000, exclusive of the purchase of water rights. In the construction of these lines many novel problems have arisen demanding the exercise of a high degree of engineering skill. Some idea of the magnitude of the water interest may be gained from the following exhibit:

Total length of ditch lines	(miles)	10,783
Total length of ditches proper	do	10,183
Total length of flumes	do	450
Total length of pipes	do	150
Greatest length of lines under one ownership	do	290
Average length of ditch lines reported, including feeders, etc	do	26
Average length of all California lines	do	12¼
Maximum capacity of ditch lines	(gallons per 24 hours)	7,560,000,000
Total cost of plant, including reservoirs, etc., and excluding cost of water rights	(dollars)	27,056,942 11
Average cost per mile, including reservoirs, etc., of lines reported	do	3,800 60
Average cost per mile, including reservoirs, etc., of all lines	do	2,509 22
Highest cost of plant reported under one ownership	do	2,100,000 00
Nominal capital stock of 13 corporations, exclusive of mining companies owning ditches	do	38,805,000 00
Working capital of 27 lines	do	1,451,300 00
Total annual expense of maintenance	do	827,280 41
Annual cost of repairs	do	200,288 66
Annual cost of attendance, exclusive of repairs	do	626,991 75
Average length of season of lines reported	(days)	211½

An analysis of the returns shows that of 152 lines for which the ownership is specified 88.82 per cent. are owned in the state or territory where they are situated, while 11.18 per cent. are owned in other states or territories. Of the latter more than one-half are controlled by New York capitalists. The ditches are largely owned in connection with the mines which they supply, though a few very important lines are operated by water companies not engaged in mining. Thus, of 171 hydraulic mines from which particulars as to ownership of water were received, 136 own the water which they use and 35 buy it from the owners of ditches. Table LXXVI shows the manner in which the ownership of the ditch lines is divided:

TABLE LXXVI.—LOCALITY OF OWNERSHIP OF MINING DITCHES.

State or territory in which ditch lines are located.	Total number of lines with ownership specified.	Owned in state or territory where located.	Owned in other states or territories than those in which the lines are located.								
			Total.	California.	District of Columbia.	Illinois.	Indiana.	Massachusetts.	New Mexico.	New York.	Pennsylvania.
Total	152	135	17	1	1	1	2	1	1	9	1
Alabama	1	1									
Arizona	3	1	2						1	1	
California	43	37	6				2			3	1
Colorado	8	6	2			1		1			
Dakota	6	4	2							2	
Georgia	8	4	4		1					3	
Idaho	16	16									
Montana	11	11									
Oregon	56	55	1	1							

CAPITAL STOCK OF WATER COMPANIES.—Thirteen corporations, exclusive of mining companies owning ditches, report an aggregate nominal capital of $38,805,000. Nominal capital, it should be observed, bears very little relation either to the cost or to the value of plant.

WORKING CAPITAL.—The replies to an inquiry as to the actual working capital of water owners (exclusive of that considered elsewhere under the head of hydraulic mines) were very scanty and useless for statistical purposes. In California two ditch lines reported $504,000 working capital, in Georgia one line reported $200,000, and in Oregon 24 lines reported $747,300. The aggregate of these returns from 27 lines is only $1,451,300—a sum insignificant in comparison with the true total. At the same time it should be noted that in a large number of cases "working capital" is represented by the gross receipts from the sale of water, or by profit in mining where the water is used by the owners.

EXTENT OF PLANT.—The following list gives particulars as to the total length of a large number of important water-lines, the length of fluming and pipes (exclusive of feed-pipes on hydraulic mines), and the reservoirs, as reported by the census experts. It includes a few lines which supply water for quartz-mills and not for hydraulic mining, and several which carry water both for mining and for other uses. These details are summarized by states and territories in Table LXXVIII. The totals reached are merely the aggregates of the direct schedule returns. While the latter cover most of the important ditch lines, a few large ones and many of the smaller ones not reported upon in detail are omitted. An estimate of the actual total extent of ditch plant is elsewhere appended.

TABLE LXXVII.—EXTENT OF PLANT OF MINING DITCHES REPORTED UPON IN DETAIL.

County and district.	Ditch.	Total length of line, including flumes, etc.	Reservoirs. Number.	Reservoirs. Capacity.	Length of flumes.	Length of pipes.
ALABAMA.						
CLAY.		*Miles.*			*Feet.*	*Feet.*
	Idaho	1			600	
ARIZONA.						
APACHE.						
Greenlee Gold Mountain	Boston	1½			825	
MARICOPA.						
	Vulture Pipe Line	16				84,480
YAVAPAI.						
	Jackson	1¾	1		812	1,200
CALIFORNIA.						
BUTTE.						
Cherokee	Spring Valley	100	2	300,000,000 cubic feet	12,000	23,040
Morris Ravine	Morris Ravine	40	1	8,000,000 gallons	21,120	10,560
Oroville	Feather River and Ophir	25	4	500 inches each for 24 hours	13,200	None.
CALAVERAS.						
Mokelumne Hill	Cook & Clarke	41			7,920	21,120
	Mokelumne and Campo Seco	100	6		10,560	
	Union	40	1			None.
DEL NORTE.						
	Bunker Hill	5½	1	800 inches per diem for 2½ months	13,200	
	China Creek	3¾	1	1,687,500 gallons	1,620	None.
	Del Norte	10			2,640	
	Happy Camp	23½	1	400,000 gallons	21,120	
	Muc-a-muc	4½			5,280	None.
	Wingate	10			7,920	None.
EL DORADO.						
Georgetown	California	250	12	600,000,000 cubic feet	13,200	
	El Dorado	110	2	1,070,000,000 cubic feet	5,280	15,840
	Park Canal	200	1		63,360	4,600
NEVADA.						
Nevada City	South Yuba	123	4	Total, 473,000 inches	18,480	
PLACER.						
Gold Run	Gold Run	80	5	Total, 20,000 inches	23,760	12,000
Iowa Hill	Iowa Hill	25	2		5,280	None.
PLUMAS.						
Indian Valley	Round Valley	8	1		2,500	None.
Seneca	Dutch Hills	33½	2	Tule lake, and one reservoir of 3,027,000 gallons.	36,960	42,240
	Black Hawk	4½	2	112,000 gallons each	None.	None.
	Hungarian Hill	10	1		None.	
	Plumas	40	2	Lakes	588	None.
SHASTA.						
Igo	Dry Creek	28½			10,560	
SISKIYOU.						
Indian Creek	Bay City	10			1,200	None.
Do	Coyote Creek	5½	1	900,000 gallons	410	None.
McAdams Creek	Hiyou Gulch	2	1	67,500 gallons	600	None.
Oro Fino	Altoona	18			400	None.
Do	Barker	6			1,000	None.
Do	Wright & Fletcher	7½			1,000	None.
Do	Young's	10			None.	None.
Quartz Valley	Beaver Dam	1½			None.	None.
Do	Shackelford Creek	14			None.	None.
Sciad Valley	Fort Goff	2¼			480	None.
Do	Thompson Creek	1			None.	
Yreka	Pellett & Truitt	1	2	Total, 550,000 gallons	None.	

TABLE LXXVII.—EXTENT OF PLANT OF MINING DITCHES REPORTED UPON IN DETAIL—Continued.

CALIFORNIA—Continued.

County and district.	Ditch.	Total length of line, including flumes, etc.	Reservoirs.		Length of flumes.	Length of pipes.
			Number.	Capacity.		
TRINITY.		*Miles.*			*Feet.*	*Feet.*
Buckeye	Buckeye	39½	4		5,280	3,000
Hayfork	(Four ditches)	12				1,700
Do	Fry Brothers		1	500 inches		
Do	Hubbard & Edwards	4	1			
Do	Hurst & Ellason	1				
Do	New River	9			36,960	
Do	Point Bar	4				
Do	Tourot	4				
Indian Creek	Johnston	5			200	
Junction City	Lewiston	7				1,500
Lewiston	Chamberlain	5				
Do	Chinese Company	7½				
Do	Cunningham	2½				
Minersville	Ridgeville	11½	8		200	None.
Taylor's Flat	Trinity	4			10,560	
Trinity Center	Coil	3				1,500
	Bowerman	13				
	Chapman & Fisher	4	3			
	Good Friday	1½	1	400 inches		
	Jacobs No. 1	2	8		250	
	Jacobs No. 2	1	4			
	Oregon Gulch	1	1			
	Patterson	1				
	Sheridan	1				
	Trinity G. M. Co	4	2	Total, 2,000 inches for 10 hours	480	
TUOLUMNE.						
Columbia	Tuolumne	125	5	Total, 1,500 inches per diem for 4 months.	31,680	15,000

COLORADO.

County and district.	Ditch.	Total length of line, including flumes, etc.	Number.	Capacity.	Length of flumes.	Length of pipes.
LAKE.						
California	Star	8	1	120,000 gallons	None.	None.
Do	Stevens & Leiter	13½	1		800	600
PARK.						
Alma township	Alma Placer	8	1	4,000,000 gallons	None.	None.
ROUTT.						
Hahn's Peak	Elk River	20			7,408	
SUMMIT.						
	Boston G. and S. M. Co	8			36	None.
	Gold Run	12			120	None.
	Sisler	2¾			None.	None.
	Union French	1½			None.	None.

DAKOTA.

County and district.	Ditch.	Total length of line, including flumes, etc.	Number.	Capacity.	Length of flumes.	Length of pipes.
CUSTER.						
Battle Creek	Battle Creek	10¾	4	Total, 40,000,000 gallons	43,560	
LAWRENCE.						
Cape Horn	McKay & Ross	5/8			2,800	None.
Confederate	Stockade	3	1	300,000 gallons	3,000	
Whitewood	Black Hills C. and W. Co	29				2,200
PENNINGTON.						
Cañon	Last Chance	3/8				
Rockerville	Black Hills Placer M. Co	18			95,040	None.

GEORGIA.

County and district.	Ditch.	Total length of line, including flumes, etc.	Number.	Capacity.	Length of flumes.	Length of pipes.
DAWSON.						
Fourth, Fifth, and Thirteenth	Anicolola and Etowah	26	2	345,576 gallons	1,200	None.
HALL.						
Twelfth	Glade	6¼			2,050	None.
LUMPKIN.						
Twelfth	Dahlonega	40	2	Total, 1,000,000 gallons	2,640	5,000
Do	Hand	38	1			14,000
Do	Singleton	13	2	6,000 cubic feet	1,200	None.
UNION.						
Tenth	Coosa Creek	3			None.	None.
WHITE.						
Third	Nacoochee	9			5,280	None.
Fourth	Town Creek	5			120	1,000

TABLE LXXVII.—EXTENT OF PLANT OF MINING DITCHES REPORTED UPON IN DETAIL—Continued.

IDAHO.

County and district.	Ditch.	Total length of line, including flumes, etc.	Reservoirs. Number.	Reservoirs. Capacity.	Length of flumes.	Length of pipes.
		Miles.			*Feet.*	*Feet.*
ALTURAS.						
Elk Creek	Lisson	5	1	300 inches for 10 hours	None.	None.
BOISÉ.						
Boston	Spencer	6	2	Total, 840,000 gallons	200	None.
Moore's Creek	Alderson	16	1	875,000 gallons	3,060	None.
Do	Dunn	4			2,000	None.
Do	Christy	10			1,320	
Do	Crepisculla (feeders)	13¼	2	Total, 840,000 gallons	192	None.
Do	Crepisculla (main)	16	3	Total, 1,260,000 gallons	3,500	None.
Do	Cuddy	8			800	None.
Do	East Moore's Creek	18			2,640	None.
Do	Mountain	3			225	None.
Do	Hanson	12			480	
Do	Upper Alderson	7			300	None.
Do	Plowman	10½		Direct from creek	200	876
Do	Thorn Creek	12	1	7,000 gallons	300	None.
Do	Lambing	8			1,200	None.
Pioneer	Stevenson & Noble	11½			200	None.
Do	Wilson	120	1	8,400,000 gallons	11,880	None.

MONTANA.

County and district.	Ditch.	Total length of line, including flumes, etc.	Reservoirs. Number.	Reservoirs. Capacity.	Length of flumes.	Length of pipes.
BEAVER HEAD.						
Bannack	Bannack D and M. Co	40½	1	500 inches	1,800	
Do	White Bar	6			10,560	
DEER LODGE.						
Henderson Gulch	Smart's Creek	13	1		1,320	
Independence	Hail Columbia	15	2		None.	
Nelson	Pioneer and Keystone	9	1		None.	
Squaw Gulch	Rock Creek	12	1		10,560	
Summit Valley	John Noyes	18			3,960	None.
LEWIS AND CLARKE.						
Last Chance	Wm. A. Cheesman	20	1	5,000,000 gallons	13,200	None.
MEAGHER.						
German	Diamond Flume and Hydraulic Co	7½			700	1,700
Thompson Gulch	Birch Creek	3	1		528	
Do	Camas Creek	2½	1			

OREGON.

County and district.	Ditch.	Total length of line, including flumes, etc.	Reservoirs. Number.	Reservoirs. Capacity.	Length of flumes.	Length of pipes.
BAKER.						
Blue Cañon	Littlefield & Duckworth	4	2	Total, 800 inches for 10 hours	400	None.
Do	Marysville	40	2	One, 200 inches for 24 hours One, 1,000 inches for 10 hours	500	None.
Chicken Creek	J. N. Osborne & Co	8	4	Total, 550 inches for 10 hours		
Clarksville	Placer Gold Mining Co	40	2	Total, 6,383,100 gallons	3,140	None.
Humboldt	Colt	1	4	Total, 540,000 gallons	None.	None.
Pocahontas	Baisly	2	1	100 inches for 10 hours	300	None.
Do	Jones & Carpenter	3	1	80 inches for 2 hours	None.	None.
Do	Lew Cooper & Co	2½	2	Total, 150 inches for 10 hours	None.	None.
Do	Nelson	11			None.	None.
Rye Valley	Powers	20	3	Total, 700 inches for 10 hours	None.	
Shasta	Eldorado	142	6	Total, 3,105,000 gallons	6,000	
Sumter	Young & Rimbol	3½			700	None.
Willow Creek	W. Boswell	⅝	1	281,000 gallons		
COOS.						
	Pioneer	7			2,000	None.
DOUGLAS.						
Big Bend Cow Creek	J. G. Fuller	2	1	250,000 gallons	600	
Do	D. A. Leavens	2¼			100	
Do	Merriam & Anderson	1½	3	Total, 743,000 gallons	30	None.
Do	D. F. Salmon	7	1	225,000 gallons	600	
Cañonville	Catching Bros	1¼			300	None.
Do	McWilliams & Ash	2			None.	None.
Green Mountain	Charles Dwelley	2¼				
Do	Dyer & Sons	1½				
GRANT.						
Cañon City	Humboldt	7½			7,920	
Do	Wolfinger's	8			13,200	
Elk Creek	Deep Creek	11	2	Total, 500 inches for 10 hours	None.	None.
Granite	Borne & Lucas	4½				
Do	J. B. Gardner's	7	1	30,296,000 gallons	None.	None.
Do	Klopp & Johnson	14½			240	1,[illegible]00
Marysville	Hillis	18	1	800 inches for 12 hours	23,760	
Do	Miner's	20			13,200	
Do	Prairie Diggings	2			None.	None.
Do	Thompson's	8	2	Total, 180 inches for 12 hours	1,980	None.
Rock Creek	Lake	8	1	150 inches for 3 months	None.	None.
Do	Rock Creek	7			None.	None.

TABLE LXXVII.—EXTENT OF PLANT OF MINING DITCHES REPORTED UPON IN DETAIL—Continued.

OREGON—Continued.

County and district.	Ditch.	Total length of line, including flumes, etc.	RESERVOIRS.		Length of flumes.	Length of pipes.
			Number.	Capacity.		
JACKSON.		*Miles.*			*Feet.*	*Feet.*
Applegate	Grand Applegate	5			1,200	None.
Do.	Squaw Lake	12½	2		2,640	None.
Ashland	Anderson & McCall	9			None.	None.
Coyote Creek	Marshall's	1¾				
Do.	William Rush	1½				
Farris Gulch	Farris Gulch	37½	1	33,750,000 gallons	825	600
Forty-nine	Ashland	9½			5,280	
Do.	Forty-nine	17			None.	
Sam's Valley	Hays & Magruder	3½			60	
Sterling	Saltmarsh & Co.	1	5	Total, 500 inches for 3½ hours	None.	
Do.	Sterling	23				
Uniontown	Chapel & Co.	4¼	1	800 inches for 10 hours	None.	None.
Do.	Gin Lin	7			None.	None.
Wolf Creek	Gross Bros	3	1	117,612,000 gallons		
JOSEPHINE.						
Grass Creek	Goff, Triplett & Chapin	6½			None.	
Do.	Steam Beer	3				
Murphy	Carson & Johnson	2¼	2	55,500 gallons		
Waldo	Desselles	17			472	
Do.	Waldo	8			1,200	None.
Yank	Blue Gravel	7½	1	4,500,000 gallons	1,500	
	Josephine	10			300	
WASCO.						
Ochoco	Wickaiser & Co	6	1	200 inches for 2 weeks, 10 hours a day	None.	

TABLE LXXVIII.—RECAPITULATION BY STATES AND TERRITORIES OF EXTENT OF PLANT OF MINING DITCHES REPORTED UPON IN DETAIL.

State or territory.	No. of ditch lines.	Total length, including flumes, etc.	No. of reservoirs.	Length of flumes.	Length of pipes.
		Miles.		*Feet.*	*Feet.*
Total	175	3,049½	173	715,921	266,816
Alabama	1	1		600	
Arizona	3	19	1	637	85,680
California	65	1,707	83	387,248	152,700
Colorado	8	58¾	3	8,424	600
Dakota	6	61¾	5	145,300	2,200
Georgia	8	140¼	7	12,190	20,660
Idaho	17	286	11	29,487	876
Montana	11	160½	9	42,628	1,760
Oregon	56	615¼	54	89,047	2,400

TABLE LXXIX.—ADDITIONAL PARTICULARS AS TO MINING DITCHES IN CALIFORNIA NOT INCLUDED IN THE CENSUS RETURNS.

Name.	Length.	Capacity.	Grade, per mile.	Cost.	DIMENSIONS.		
					Top.	Bottom.	Depth.
	Miles.	*Inches.*	*Feet.*	*Dollars.*	*Feet.*	*Feet.*	*Feet.*
Total	408½	21,500	6 to 25	3,609,912	5 to 9	4 to 6	2 to 4
North Bloomfield, including reservoirs	157	3,200	12 to 16	708,841	8¾	5	3½
Milton, including reservoirs	80	3,000	12 to 25	391,579	6	4	3½
Eureka lake and Yuba	103	5,800		723,342			
Smartsville ditches		5,000	9	1,000,000	8	5	4
Hendricks	46½		6 to 12	136,150	5		2
La Grange	20	2,700	7 to 8	500,000	9	6	4
Blue Tent	32	1,800	10	150,000	8	6	4

Table LXXX gives the total length of the ditch lines of California by counties according to the official returns of the state surveyor-general, the figures for 1870, from the same source, being annexed for the purpose of comparison. The increase in the aggregate length and the decrease in the number of lines in the decade indicate a tendency toward consolidation of interests and also toward operating on a much larger scale than heretofore. In 1870 the average length per ditch was about 8⅙ miles; in 1880 it had increased to 12½ miles, the increase in the average being largely attributable to the construction of a few lines, each of which is greatly in excess of the present average. In this connection it may be remarked that the average length of the California ditch lines reported upon by the census agents is slightly over 26 miles, showing, as previously explained, that the deficiencies in the census returns were mainly of the minor properties.

TABLE LXXX.—NUMBER AND LENGTH OF MINING DITCHES IN CALIFORNIA IN 1880 AS COMPARED WITH 1870.

County.	1880. Number of ditch lines.	1880. Length.	1870. Number of ditch lines.	1870. Length.	1870. Amount of water used per day.	County.	1880. Number of ditch lines.	1880. Length.	1870. Number of ditch lines.	1870. Length.	1870. Amount of water used per day.
		Miles.		*Miles.*	*Inches.*			*Miles.*		*Miles.*	*Inches.*
Total	484	6,036	504	4,014	228,248	Nevada	217	824	70	946	42,400
						Placer	22	358	10	302	14,000
Amador	7	500	32	405	5,450	Plumas	34	700	....	....	....
Butte	....	300	32	100	41,000	Sacramento	2	200	2	45	4,000
Calaveras	26	525	10	515	5,800	San Bernardino	....	....	2	5	500
Del Norte	22	87	30	112	8,912	Shasta	28	650	....	....	....
El Dorado	5	500	58	966	9,450	Sierra	55	366	49	208	21,000
Inyo	1	6	1	3	40	Siskiyou	6	250	24	290	5,010
Kern	....	....	2	5	1,728	Stanislaus	1	15	3	12	1,000
Klamath	....	....	80	90	16,000	Tehama	....	....	1	7	160
Lassen	3	7	....	....	....	Trinity	25	400	116	340	45,773
Los Angeles	4	21	3	25	800	Tulare	1	....	....	....	....
Mariposa	....	107	10	66	Unknown.	Tuolumne	14	100	....	....	....
Mono	5	40	2	13	720	Yuba	6	100	18	69	4,500

In the absence of similar authoritative data for other portions of the country the grand total can only be approximately estimated. It may fairly be conceded that the schedules of the experts, which aimed at securing useful details of the technology of the subject rather than at mere aggregates, and which included an examination of only 1,707 miles of the more important lines in California, would show an equal ratio of deficiency in other portions of the country. If this assumption be reasonably near the truth, the total length of the ditch lines of the United States may be estimated at no less than 10,783 miles.

Of the ditches reported in the schedules the proportionate amount of fluming and pipes (exclusive of feed-pipes on hydraulic mines) is as follows:

TABLE LXXXI.—PROPORTIONATE EXTENT OF FLUMES AND PIPES IN CONNECTION WITH MINING DITCHES.

	Miles.	Percentage.
Total length of ditch lines reported in schedules	3,049.50	100.00
Total length of flumes reported in schedules	135.59	4.44
Total length of pipes reported in schedules	50.53	1.66
Total length of ditches proper reported in schedules	2,863.38	93.90

The proportion of flumes and pipes belonging to the water lines not scheduled is probably a little smaller than with the lines of more extensive equipment. It is thought safe, however, to estimate the total length of flumes at 450 miles and pipes at 150 miles, both of which are included in the general estimate of 10,783 miles, the remainder (10,183 miles) being assumed to represent the extent of the ditches proper.

California contains by far the most extensive system of artificial water channels in the United States, including six-tenths of the total length of ditch lines in the whole country. The relative importance of the California ditch lines is, however, inadequately represented by the mere standard of length, their other dimensions, capacity, more costly construction, and economic bearing placing them still higher in rank.

No general estimate can be made as to the entire amount of work which has been done in the way of ditch construction since the beginning of hydraulic mining. Thousands of miles of now idle and useless ditches were built in camps long since deserted; and in localities where placer mining is still profitably prosecuted there are also many idle ditches which have been supplanted by newer and larger ones at higher grades. As an instance in point, the case of Boisé basin, Idaho, may be cited. In this one district alone there are estimated to be no less than 800 miles of old and abandoned ditches, which cost about $850,000, and aggregated more than double the length of the lines now in operation. Many such cases exist in California. Even a very rough approximation to the extent of these old, disused lines throughout the country is hardly practicable; but it can only be broadly stated as being very large.

COST OF PLANT.—Table LXXXII gives particulars as to the cost per yard of ditches, flumes, and pipes, and the cost of some of the reservoirs, of a number of water lines, as reported in the census schedules. There are some unexplained discrepancies in these figures; but the returns are published as received, without further comment than to call attention to the fact that while the totals seldom correspond to the sums of cost reached by comparing the average prices with the total extent of the four incomplete classes of plant named (ditches, flumes, pipes, and reservoirs), as elsewhere stated, they are more reliable than would be the sums of the items. In fact, in many instances the totals alone have been returned without an attempt to segregate the items, the latter being obtainable with greater difficulty as well as with greater uncertainty. A few of the amounts represent the prices paid by present owners, who were unable to state the original cost of the works.

TABLE LXXXII.—COST OF PLANT OF MINING DITCHES, ETC., REPORTED UPON IN DETAIL.

County and district.	Line.	Ditch per yard.	Flume per yard.	Pipe per yard.	Reservoirs.	Total cost.
ALABAMA.						
CLAY.						
	Idaho	$0 30	$0 20			$586 00
ARIZONA.						
MARICOPA.						
	Vulture Pipe Line					60,000 00
CALIFORNIA.						
BUTTE.						
Cherokee	Spring Valley	1 25	4 00	$25 00	$120,000 00	417,780 00
Morris Ravine	Morris Ravine	1 98	3 06	8 25		171,153 76
Oroville	Feather River and Ophir					280,000 00
CALAVERAS.						
Mokelumne Hill	Cook & Clarke	45	7 00	5 00		50,000 00
	Mokelumne and Campo Seco	0 01 to 3 65	1 40 to 1 82	1 80 to 12 00		50,000 00
	Union				10,000 00	250,000 00
DEL NORTE.						
	Bunker Hill	3 44	2 00			27,000 00
	China Creek				500 00	a 1,500 00
	Del Norte	2 25	2 25			100,000 00
	Happy Camp (south fork Indian river)	1 87	1 96			
	Happy Camp (main fork Indian river)	2 68	1 75		10,000 00	74,000 00
	Happy Camp (Grider's line)	27	2 03			
	Muc-a-muc	82	1 70			5,000 00
EL DORADO.						
Georgetown	California	0 50 to 5 00	0 50 to 3 00	1 40 to 9 00	100 to 4,500 00	600,000 00
	El Dorado	5 50	4 50	3 50		600,000 00
	Park Canal	1 83	2 37	3 50	60,000 00	2,100,000 00
NEVADA.						
Nevada City	South Yuba				375,000 00	1,100,000 00
PLACER.						
Gold Run	Gold Run				20,000 00	450,000 00
Iowa Hill	Iowa Hill	1 83	5 00		8,000 00	200,000 00
PLUMAS.						
Indian Valley	Round Valley	94	3 00		8,000 00	33,000 00
Seneca	Dutch Hill					325,000 00
	Black Hawk	20			1,000 00	2,524 00
	Hungarian Hill	72			4,000 00	16,600 00
	Plumas	72	1 50			50,000 00
SHASTA.						
Igo	Dry Creek					120,000 00
	Sawmill Flat					5,000 00
SISKIYOU.						
Indian Creek	Coyote Creek		75		300 00	5,000 00
McAdams Creek	Hiyou Gulch		50	34	100 00	3,000 00
Oro Fino	Altoona	05½	1 75			a 3,950 00
Do	Barker	12	1 25			a 1,650 00
Do	Young's (Howard ditch)	27				6,000 00
Do	Young's (Kidder ditch)	20				
Quartz Valley	Beaver Dam	14				a 400 00
Do	Shackelford Creek	13	2 00			a 3,600 00
Sciad Valley	Fort Goff					1,381 50
Do	Thompson Creek	29				500 00
Yreka	Pellett & Truitt	05			400 00	500 00

a Cost to present owners; original cost not stated.

TABLE LXXXII.—COST OF PLANT OF MINING DITCHES, ETC., REPORTED UPON IN DETAIL—Continued.

CALIFORNIA—Continued.

County and district.	Line.	Ditch per yard.	Flume per yard.	Pipe per yard.	Reservoirs.	Total cost.
TRINITY.						
Buckeye	Buckeye				$2,500 00	$150,000 00
Hayfork	Fry Bros				500 00	15,000 00
Do	Hubbard & Edwards				1,500 00	8,500 00
Do	Hurst & Eliason					3,500 00
Do	New River					70,000 00
Do	Point Bar					20,000 00
Do	Charles Tourot					18,000 00
Indian Creek	Johnston					20,000 00
Junction City	Lewiston					16,000 00
Lewiston	Chamberlain					4,000 00
Do	Chinese Company					7,000 00
Do	Cunningham					3,500 00
Minersville	Ridgeville				1,500 00	36,000 00
Taylor's Flat	Trinity					40,000 00
Trinity Center	Coil					12,000 00
	Bowerman					7,000 00
	Chapman & Fisher				6,000 00	11,000 00
	Cañon Creek					3,500 00
	Good Friday					3,400 00
	Jacobs No. 1					5,000 00
	Jacobs No. 2					2,500 00
	Oregon Gulch					2,000 00
	Patterson					1,500 00
	Sheridan					1,000 00
	Trinity G. M. Co				8,000 00	20,000 00
TUOLUMNE.						
Columbia	Tuolumne	$4 50	$14 00	$1 00	150,500 00	800,000 00

COLORADO.

County and district.	Line.	Ditch per yard.	Flume per yard.	Pipe per yard.	Reservoirs.	Total cost.
PARK.						
Alma township	Alma Placer	57			2,000 00	5,000 00
ROUTT.						
Hahn's Peak	Elk River	71	1 85			75,000 00
SUMMIT.						
	Boston G. and S. M. Co	57	7 50			*a* 4,000 00
	Sisler	62				*a* 3,000 00
	Union French					*b* 1,500 00

a Estimated. *b* Cost to present owners; original cost not stated.

DAKOTA.

County and district.	Line.	Ditch per yard.	Flume per yard.	Pipe per yard.	Reservoirs.	Total cost.
CUSTER.						
Battle Creek	Battle Creek Gravel M. Co	80	3 37½		12,000 00	62,000 00
LAWRENCE.						
Cape Horn	McKay & Ross		3 00			4,000 00
Confederate	Stockade	50	50		300 00	3,000 00
Whitewood	Black Hills C. and W. Co	93		1 60		300,000 00
PENNINGTON.						
Cañon	Last Chance	83				200 00
Rockerville	Black Hills Placer Co					210,000 00

GEORGIA.

County and district.	Line.	Ditch per yard.	Flume per yard.	Pipe per yard.	Reservoirs.	Total cost.
DAWSON.						
Fourth, Fifth, and Thirteenth	Amicalola and Etowah	06½	2 48		233 00	
HALL.						
Twelfth	Glade	15	5 00			6,595 00
LUMPKIN.						
Twelfth	Dahlonega	25	2 00	3 50		20,000 00
Do	Hand	10	6 00	9 00	900 00	500,000 00
Do	Singleton	17	60			
UNION.						
Tenth	Coosa Creek	09				500 00
WHITE.						
Fourth	Town Creek	40	85	2 70	100 00	5,000 00

TABLE LXXXII.—COST OF PLANT OF MINING DITCHES, ETC., REPORTED UPON IN DETAIL—Continued.

IDAHO.

County and district.	Line.	Ditch per yard.	Flume per yard.	Pipe per yard.	Reservoirs.	Total cost.
ALTURAS.						
Elk Creek	Lisson	$0 36			$600 00	$5,190 60
BOISÉ.						
Boston	Spencer	40	$5 00		200 00	4,727 60
Moore's Creek	Alderson				1,200 00	25,000 00
Do	Christy					20,000 00
Do	Crepisculla (feeders)	45	2 00		1,200 00	11,880 00
Do	Crepisculla (main)	65	2 50		2,000 00	22,437 50
Do	Cuddy					15,000 00
Do	Dunn					9,000 00
Do	East Moore's Creek					30,000 00
Do	Hanson					22,000 00
Do	Lambing	40	6 00			3,000 00
Do	Mountain					4,500 00
Do	Plowman	77	12 00	$4 05		30,000 00
Do	Thorn Creek	36	1 45			20,000 00
Do	Upper Alderson	34	2 00			a 3,000 00
Pioneer	Stevenson & Noble	98	4 00			20,000 00
Do	Wilson				2,000 00	125,000 00

a Estimated.

MONTANA.

County and district.	Line.	Ditch per yard.	Flume per yard.	Pipe per yard.	Reservoirs.	Total cost.
BEAVER HEAD.						
Bannock	Bannock	55	12 50	1 15	1,000 00	
DEER LODGE.						
Henderson Gulch	Smart's Creek	60	1 10		800 00	5,000 00
Independence	Hail Columbia	90			1,000 00	30,000 00
Nelson	Pioneer and Keystone	1 50			800 00	10,000 00
Squaw Gulch	Rock Creek		10 00		1,000 00	20,000 00
Summit Valley	John Noyes	1 00	2 00			48,000 00
LEWIS AND CLARKE.						
Last Chance	Wm. A. Cheesman	1 00	5 00		10,000 00	80,000 00
MEAGHER.						
German	Diamond Flume & Hydraulic Co	6 50	4 50			90,000 00
Thompson Gulch	Birch Creek	51			700 00	1,500 00
Do	Camas	40			300 00	3,000 00

OREGON.

County and district.	Line.	Ditch per yard.	Flume per yard.	Pipe per yard.	Reservoirs.	Total cost.
BAKER.						
Blue Cañon	Littlefield & Duckworth	40	37		1,500 00	4,550 00
Do	Marysville					7,500 00
Chicken Creek	J. N. Osborne & Co	50	1 00		1,300 00	8,300 00
Clarksville	Placer Gold	70	3 00		5,000 00	45,000 00
Humboldt	Colt	15			200 00	450 00
Pocahontas	Baisly	27½	2 00		400 00	4,000 00
Do	Jones & Carpenter	50			100 00	2,740 00
Do	Lew, Cooper & Co	25			600 00	1,700 00
Do	Nelson	20				3,872 00
Rye Valley	Powers				5,000 00	20,488 00
Shasta	Eldorado	2 00	6 00		2,200 00	455,200 00
Sumter	Young & Rimbol	90	1 00			4,985 00
Willow Creek	W. Boswell	20			128 00	275 00
COOS.						
	Pioneer					a 15,000 00
DOUGLAS.						
Big Bend Cow Creek	J. G. Fuller	80			200 00	2,600 00
Do	D. A. Levens	27	1 00			1,100 00
Do	Merriam & Anderson	0 25 to 0 45			420 00	1,435 00
Do	D. F Salmon	50	50		150 00	6,000 00
Cañonville	Catching Bros	10½	10½			240 00
Do	McWilliams & Ash	46				1,646 00
Green Mountain	Charles Dwelley	25				720 00
GRANT.						
Cañon City	Humboldt	73	1 81			12,455 50
Do	Woltinger	63	68			12,000 00
Elk Creek	Deep Creek					16,272 00
Granite	Borne & Lucas	88				7,000 00
Do	J. B. Gardner	80			8,000 00	20,000 00
Do	Klopp & Johnson	0 22 to 0 36		1 00		10,960 00
Marysville	Hillis	82	1 82		4,000 00	40,000 00
Do	Miner's					15,000 00
Do	Prairie Diggings					1,000 00
Do	Thompson	75	1 90		8,000 00	19,320 00
Rock Creek	Lake	55			1,000 00	7,744 00

a Estimated.

TABLE LXXXII.—COST OF PLANT OF MINING DITCHES, ETC., REPORTED UPON IN DETAIL—Continued.

OREGON—Continued.

County and district.	Line.	Ditch per yard.	Flume per yard.	Pipe per yard	Reservoirs.	Total cost.
JACKSON.						
Applegate	Squaw Lake	$0 99	$4 50		$1,000 00	$26,000 00
Ashland	Anderson & McCall	25				7,000 00
Coyote Creek	Marshall	20	3 00			600 00
Do	Wm. Rush	25				700 00
Farris Gulch	Farrish Gulch (upper)	28	2 00	$1 66	1,000 00	30,868 00
Do	Farrish Gulch (lower)	00	2 00	1 66		
Forty-nine	Ashland	16	2 00			6,000 00
Do	Forty-nine (Anderson)	10				
Do	Forty-nine (Coleman)	51				51,000 00
Do	Forty-nine (Wagner)	34				
Sam's Valley	Hays & Magruder	24	3 00			1,500 00
Sterling	Saltmarsh & Co	22½				2,090 00
Do	Sterling	25	75			11,236 25
Uniontown	Chapel & Co	60			600 00	5,100 00
Do	Gin Lin	97				11,900 00
Wolf Creek	Gross Bros				100 00	300 00
JOSEPHINE.						
Grass Creek	Goff, Triplett & Chapin	30				3,500 00
Do	Steam Beer	38				2,050 00
Murphy	Carson & Johnson	45½			300 00	2,350 00
Waldo	Desselles & Co. No. 1	2 80	3 75			90,000 00
Do	Desselles & Co. No. 2	4 00	2 50			
Do	Waldo	65	2 00			10,000 00
WASCO.						
Ochoco	Wickaiser & Co	30			150 00	3,951 60

TABLE LXXXIII.—RECAPITULATION BY STATES AND TERRITORIES OF THE COST OF MINING DITCHES, ETC., REPORTED UPON IN DETAIL.

State or territory.	Number of ditch lines reporting total cost.	Corresponding number of miles.	Average cost per mile, including flumes, pipes, reservoirs, etc.	Cost.
Total	154	2,836½	$3,800 60	$10,780,414 31
Alabama	1	1	586 00	586 00
Arizona	1	16	*a* 3,750 00	60,000 00
California	60	1,667½	4,698 97	7,835,539 26
Colorado	5	30¼	2,925 62	88,500 00
Dakota	6	61¾	*b* 9,379 76	570,200 00
Georgia	5	92¼	*c* 5,767 97	532,095 00
Idaho	16	286	1,296 28	370,735 70
Montana	9	105	2,738 10	287,500 00
Oregon	51	576¾	1,779 38	1,026,258 35

a Pipe line. *b* Including an expensive flume line. *c* Including a large proportion of pipe.

From Table LXXXIII it appears that 154 ditch lines, with a total length of 2,836½ miles, cost $10,780,414 31, or an average of $3,800 60 per mile for all plant, including flumes, pipes, reservoirs, buildings, etc. The 213 miles of ditch lines reported in the schedules, without particulars as to cost, are assumed to have cost quite as much per mile as the 2,836½ miles for which the expense is specified, or $809,527 80, bringing the total cost of 3,049½ miles scheduled to $11,589,942 11. The average cost per mile of the lines not included in the experts' schedules cannot, however, be nearly so great as that of the ones which, because of special engineering difficulties, extent, or capacity were chosen for minute investigation; for although some important works unfortunately escaped the canvass of the census agents, the bulk of the lines omitted were of less costly construction than those included in the returns. Assuming an average cost of $2,000 per mile for these lines, the whole expense of building 10,783 miles (the estimated total length of ditch lines in operation) would be:

Cost of 2,836½ miles, at $3,800 60 per mile, as per schedules	$10,780,414 31
Estimated cost of 213 miles for which the schedules do not state cost, at $3,800 60 per mile	809,527 80
Estimated cost of 7,733½ miles, at $2,000 per mile	15,467,000 00
Total cost of 10,783 miles	27,056,942 11

This is exclusive of the purchase cost of water-rights, for which the aggregate amount paid is not ascertainable.

SOURCE OF WATER.—The answers received from 149 lines as to the source from which ditches receive their supply are classified in the accompanying table according to the wording of the replies. It is evident that the primal source of springs, lakes, rivers, or creeks must be either snow or rain, through whichever medium the ditches are fed; but a very noteworthy feature is the fact that only in one instance is direct rainfall alone given as the means of supply. A very large proportion of ditches head at reservoirs in creek beds or at lakes, or take their water directly from the natural channel, and in such cases the response naturally refers to the original rather than to the immediate source of the water.

TABLE LXXXIV.—SOURCE OF WATER.

State or territory.	Total number of reports.	Perennial springs.	Melted snows.	Chiefly snow.	Snow and springs.	Snow and rain.	Springs and rain.	Rain.	Lake (source unspecified).	Creek (source unspecified).
Total	149	24	23	25	54	2	18	1	1	1
Alabama	1	1	......	......	......	......	......	......	......	......
Arizona	3	1	1	......	1	......	......	......	......	......
California	39	1	10	......	22	1	4	......	......	1
Colorado	8	3	1	......	4	......	......	......	......	......
Dakota	6	2	......	......	4	......	......	......	......	......
Georgia	8	8	......	......	......	......	......	......	......	......
Idaho	17	......	2	15	......	......	......	......	......	......
Montana	11	......	......	2	9	......	......	......	......	......
Oregon	56	8	9	8	14	1	14	1	1	......

Excluding 26 answers which do not specify whether the water came originally from rainfall or from melting snows, the following groupings may be made:

From melted snow	23	From rain and springs	18
Chiefly from snow	25	From direct rainfall alone	1
From snow and springs	54		
	102		19

Or,

	Number of answers.	Per cent.
From snow	102	82.93
From rain	19	15.45
From snow and rain	2	1.62
Total	123	100.00

While in parts of California and Oregon the gravel deposits are at comparatively low altitudes, the mean elevation of the placers of the United States, so far as reported in the census returns, is 3,447 feet above sea-level. As they are for the most part located in the foot-hills or on the flanks of high mountain ranges and in adjacent valleys, the mines receive water from original sources, which are at altitudes generally above the winter snow-line, even where the mines themselves, their ditch lines, and the tributary streams may be considerably below it. This explains the large preponderance of cases in which water is chiefly derived from the melting of snows. Of 199 hydraulic mines from which returns were received as to the immediate source of supply 173 derive their water from rivers and creeks, 2 from lakes, and 24 from various sources, such as directly from melting snow, perennial springs, etc.

Water is sometimes used a second time where the conditions will admit. Thus, of 164 answers from hydraulic mines on this head, 36 report the use, in more or less quantity, of water which had been previously employed in mining.

LENGTH OF THE WATER SEASON.—This is a very indefinite period, but in the experts' reports is taken to be the whole duration of time during which water is available, in however small amount, for mining purposes. By means of large reservoirs water may be stored in sufficient quantity to bridge over the interval between the times of rainfall, though even thus the supply gradually dwindles; and in many cases where such storage is impracticable the supply fails entirely in the dry months. When water is scanty it is often customary to economize by using it during a part of the twenty-four hours only, storing enough during the night in small reservoirs placed near the mines to suffice for a run of say ten hours or less during the day-time.

The beginning of the season in some places is with the first heavy rains, which in California seldom fall before the middle of October, and at high altitudes with the melting snows at the end of winter and in the spring. The close is determined either by drought (which may be artificially provided against) or by freezing if at high altitudes. The rainy season in California is over before the first of May. The placer districts in the territories of Idaho and Montana, which depend for water chiefly upon the melting of the snow, have consequently a season beginning later than those at comparatively low altitudes on the western side of the Sierra. This variation in altitude and in climatic conditions explains the wide divergencies in the time when the season opens, as shown in the following table, while the irregular lengths of season and the time of close depend partly upon these conditions and partly on the facilities for storing the water:

TABLE LXXXV.—MINING DITCHES—LENGTH OF WATER SEASON.

County and district.	Line.	Months during which water is supplied.	Length of water season.
ALABAMA.			
CLAY.			*Days.*
	Idaho	Whole year	365
ARIZONA.			
APACHE.			
Greenlee Gold Mountain	Boston	Whole year	365
MARICOPA.			
	Vulture Pipe Line	do	365
YAVAPAI.			
	Jackson	January, February, and March; in census year to May 15.	135
CALIFORNIA.			
BUTTE.			
Cherokee	Spring Valley	Whole year	365
Morris Ravine	Morris Ravine	do	365
Oroville	Feather River and Ophir	do	365
CALAVERAS.			
Mokelumne Hill	Cook & Clarke	do	365
	Mokelumne and Campo Seco	Whole year; in latter part of summer and beginning of fall only one-third supply.	365
	Union	Whole year	365
DEL NORTE.			
	Bunker Hill	do	365
	China Creek	January to June 1	151
	Del Norte	Whole year	365
	Happy Camp	do	365
	Mue-a-muc	January to July 1	181
	Wingate	January to July 15	196
EL DORADO.			
Georgetown	California	Whole year	365
	El Dorado	Whole year, with short supply in extremely cold winters and very dry summers.	365
	Park Canal	Whole year	365
NEVADA.			
Nevada City	South Yuba	do	365
PLACER.			
Gold Run	Gold Run	November 15 to August 1	258
Iowa Hill	Iowa Hill	November to June	212
PLUMAS.			
Indian Valley	Round Valley	Whole year	365
Seneca	Dutch Hill	April 1 to December 1	244
Shasta	Quartz Gulch		150
	Black Hawk	March 1 to July 1	122
	Hungarian Hill	March to July 15	137
	Plumas	April 1 to August 15	137
SHASTA.			
French Gulch	Four Ditches	Five months	150
Igo	Dry Creek	Seven or eight months	225
SISKIYOU.			
Indian Creek	Bay City	March 1 to June 1	92
Do	Coyote Creek	February 1 to May 15	104
McAdams Creek	Hiyou Gulch	February 1 to June 1	120
Oro Fino	Altoona	March to July 1	122
Do	Barker	Whole year	365
Do	Wright & Fletcher	February 1 to July 1	150
Do	Young's	do	150
Quartz Valley	Beaver Dam	Whole year	365
Do	Shackelford Creek	March 1 to July 1	122
Sciad Valley	Fort Goff	November to July	242
Do	Thompson Creek	Whole year	316
Yreka	Pellett & Truitt	December to July	252

TABLE LXXXV.—MINING DITCHES—LENGTH OF WATER SEASON—Continued.

CALIFORNIA—Continued.

County and district.	Line.	Months during which water is supplied.	Length of water season.
TRINITY.			*Days.*
Hayfork	Hubbard & Edwards	Four months	120
Do	Hurst & Eliason	Three months	90
Do	Point Bar	......do	90
Do	Tourot	Four months and 25 days	145
Indian Creek	Johnston	January to July	181
Junction City	Lewiston	December to September	274
Taylor's Flat	Trinity	Nine to ten months	285
Trinity Center	Chapman & Fisher	January to August 1	212
	Trinity G. M. Co	November to August 1	273
TUOLUMNE.			
Columbia	Tuolumne	Ten months	300

COLORADO.

County and district.	Line.	Months during which water is supplied.	Length of water season.
LAKE.			
California	Star	June, July, and August	92
Do	Stevens & Leiter	May, June, July, August, and September	153
PARK.			
Alma township	Alma Placer	May 1 to October 1	153
ROUTT.			
Hahn's Peak	Elk River	May 1 to September 15	138
SUMMIT.			
	Boston G. and S. M. Co	May to October	153
	Gold Run	May to November	184
	Sisler	May to October	153
	Union French	May to November 15	199

DAKOTA.

County and district.	Line.	Months during which water is supplied.	Length of water season.
CUSTER.			
Battle Creek	Battle Creek Gravel M. Co	April 1 to November 1	214
LAWRENCE.			
Cape Horn	McKay & Ross	March to November	245
Confederate	Stockade	......do	245
Whitewood	Black Hills C. and W. Co	Whole year	365
PENNINGTON.			
Cañon	Last Chance	April 1 to December 1	244
Rockerville	Black Hills Placer Co	March to December 1	275

GEORGIA.

County and district.	Line.	Months during which water is supplied.	Length of water season.
DAWSON.			
Fourth, Fifth, and Thirteenth	Amicalola and Etowah	Whole year	365
HALL.			
Twelfth	Glade	......do	365
LUMPKIN.			
Twelfth	Dahlonega	......do	365
Do	Hand	......do	365
Do	Singleton	......do	365
UNION.			
Tenth	Coosa Creek	......do	365
WHITE.			
Third	Nacoochee	......do	365
Fourth	Town Creek	......do	365

IDAHO.

County and district.	Line.	Months during which water is supplied.	Length of water season.
ALTURAS.			
Elk Creek	Lisson	April 26 to November 1	189
BOISÉ.			
Boston	Spencer	March 20 to July 1	103
Moore's Creek	Alderson	April 1 to November 1	214
Do	Christy	......do	214
Do	Crepisculla (feeders)	March 20 to August 1	134
Do	Crepisculla (main)	......do	134
Do	Cuddy	April 1 to November 1	214
Do	Dunn	April 1 to July 15	106
Do	East Moore's Creek	April 15 to November 15	215
Do	Hanson	April 15 to August 1	108
Do	Lambing	March 15 to July 15	123

TABLE LXXXV.—MINING DITCHES—LENGTH OF WATER SEASON—Continued.

IDAHO—Continued.

County and district.	Line.	Months during which water is supplied.	Length of water season.
BOISÉ—continued.			*Days.*
Moore's Creek	Mountain	April 30 to August 1	93
Do	Plowman	March 15 to July 15	123
Do	Thorn Creek	April 24 to July 31	99
Do	Upper Alderson	April 1 to November 1	214
Pioneer	Stevenson & Noble	May 1 to September 3	126
Do	Wilson	April 15 to November 1	200

MONTANA.

County and district.	Line.	Months during which water is supplied.	Length of water season.
BEAVER HEAD.			
Bannock	Bannock	May to October	153
Do	White Bar	June to October	122
DEER LODGE.			
Independence	Hail Columbia	April to October	183
Nelson	Pioneer and Keystone	May 1 to November 1	184
Summit Valley	John Noyes	May to August	92
LEWIS AND CLARKE.			
Last Chance	Wm. A. Cheesman	April to November	92
MEAGHER.			
Thompson Gulch	Camas	June to October	122

OREGON.

County and district.	Line.	Months during which water is supplied.	Length of water season.
BAKER.			
Blue Cañon	Littlefield & Duckworth	April 1 to November 1	214
Do	Marysville	do	214
Chicken Creek	J. N. Osborne & Co	April to August	122
Clarksville	Placer Gold	March 1 to December 1; short supply after July 1	275
Humboldt	Colt	March to May	61
Pocahontas	Baisly	April to November	214
Do	Jones & Carpenter	April 1 to November 1	214
Do	Lew Cooper & Co	April 1 to September 1	153
Do	Nelson	do	153
Rye Valley	Powers	April 1 to November 1	214
Shasta	Eldorado	May 1 to November 20	204
Sumter	Young & Rimbol	April 1 to September 1	153
Willow Creek	W. Boswell	February to May	89
COOS.			
	Pioneer	October to May	212
DOUGLAS.			
Big Bend Cow Creek	J. G. Fuller	December to June	182
Do	D. A. Levens	do	182
Do	Merriam & Anderson	December to April 1	121
Do	D. F. Salmon	December to May	151
Cañonville	Catching Bros	do	151
Do	McWilliams & Ash	December to April	121
Green Mountain	Charles Dwelley	December to May	151
Do	Dyer & Son	do	151
GRANT.			
Cañon City	Humboldt	April 1 to December 1	244
Granite	Borne & Lucas	April 1 to September 1	168
Do	J. B. Gardner	April 1 to August 15	137
Do	Klopp & Johnson	April 1 to September 15	168
Marysville	Prairie Diggings	April to June	61
Do	Thompson	February to December	303
JACKSON.			
Applegate	Squaw Lake	Whole year	365
Coyote Creek	Marshall	December 1 to March 1	90
Do	Wm. Rush	December 1 to July	212
Farris Gulch	Farris Gulch	February to August 15	196
Forty-nine	Ashland	do	196
Do	Forty-nine	February to June	120
Sam's Valley	Hays & Magruder	December to May	151
Wolf Creek	Gross Bros	December to June	182
JOSEPHINE.			
Grass Creek	Goff, Triplett & Chapin	do	182
Do	Steam Beer	December to May	151
Murphy	Carson & Johnson	December to June	182
Waldo	Desselles & Co	February to August	181
Do	Waldo	December 1 to July 1	212
Yank	Blue Gravel	November to August	273
	Josephine	December to June	182
WASCO.			
Ochoco	Wickaiser & Co	November to June	212

The data given in the foregoing list are summarized by states and territories in Table LXXXVI, from which it appears that reports from 142 water lines give a general average of 211½ days, with a range between an average of 135½ days in Montana and a continuous supply in Georgia. Regarding these results, two essential qualifications should be noted: First, that the averages are computed solely from the limited schedule data; and second, that as the investigation included mainly the more important lines, the probabilities are that considerably higher averages are obtained than would be the case were all the lesser lines taken into account.

TABLE LXXXVI.—MINING DITCHES—AVERAGE LENGTH OF WATER SEASON.

State or territory.	Number of ditch lines reporting length of season.	Average number of days.
Total	142	211½
Alabama	1	365
Arizona	3	288⅛
California	48	242¾
Colorado	8	153⅛
Dakota	6	264⅔
Georgia	8	365
Idaho	17	153⅓
Montana	7	135½
Oregon	44	178⅓

CAPACITY OF MINING DITCHES.—The amount of water delivered by 173 lines upon which reports were made is 184,088,958 gallons per hour, corresponding to 262,984 miner's inches, and it is presumed that the figures reported in the majority of cases are of the maximum capacity, not the actual average delivery of the several lines. The average delivery per ditch of these lines in the height of the season is 1,064,098 gallons per hour, or 1,520 miner's inches. For the whole number of ditch lines in operation in the United States, including ditches not reported upon, the maximum capacity is estimated at not less than 450,000 inches, or 315,000,000 gallons per hour and 7,560,000,000 gallons per 24 hours. This is about eighty times the capacity of the Croton aqueduct, which supplies New York city with water. The amount of water actually delivered is, however, very variable, and the average during the season is far below the maximum capacity of the ditches.

Table LXXXVII gives the amount of water used in mining in the Sacramento and San Joaquin basin, California, in 1880 and discharged into the river beds, expressed in terms of 24-hour miner's inches. The figures are from the county assessor's returns, supplemented by data furnished by the state engineer department and by information collected by Lieutenant Payson, United States engineer corps, as published in the report of Lieutenant-Colonel Mendell on *Mining Débris in California Rivers* (page 16). Taking the miner's inch at 2,250 cubic feet per 24 hours, the total quantity used in this region represents a sheet of water 37¾ miles long, 3 miles wide, and 10 feet deep.

TABLE LXXXVII.—QUANTITY OF WATER USED IN MINING IN THE SACRAMENTO AND SAN JOAQUIN BASIN IN 1880.

Name of stream.	Twenty-four hour miner's inches.
Total	14, 034, 965
Table Mountain, or Dry creek	833, 250
Butte creek	24, 000
Feather river	1, 259, 363
Yuba river	6, 458, 171
Bear river	1, 117, 082
Dry creek No. 2	44, 229
American river	1, 914, 500
Cosumnes river	504, 000
Dry creek	162, 000
Mule creek	38, 000
Sutter creek	457, 750
Jackson creek	171, 150
Mokelumne river	224, 500
Calaveras river	975, 750
Stanislaus river	38, 720
Tuolumne river	812, 500

LEAKAGE AND EVAPORATION.—Replies from owners of 62 ditch lines as to the amount of water lost in transit through the ditches show that the average amount believed to be lost by leakage is 7.40 per cent., and by evaporation 9.06 per cent., of the quantity actually delivered. The statements selected in making this computation were those in which the losses by both leakage and evaporation were specifically stated, and many of the answers gave the total supposed loss, but did not discriminate as to the cause. While these results have not the weight of careful experiment, they represent the current opinion of well-informed persons. With well-built and established lines the loss by leakage is usually very small, though new lines, cut in light soil, are apt to leak badly for a time until their walls have thoroughly settled and the bad spots have been strengthened. Evaporation depends upon the length of the line; that is, the time during which the water is exposed in transit; upon the location of the ditch, whether on the north or the south slopes of the hills, and whether shaded or partially shaded by timber; upon the climate and season, the latitude and the altitude, and upon the porosity of the ditch banks. The earth at the sides of the ditches acts as a sponge, absorbing water and by capillary attraction bringing it under the influence of the sun's rays, thus increasing the exposed water area. It is therefore not remarkable that the loss by evaporation should as a general average exceed that by leakage, though in particular cases the circumstances are reversed. The variation according to season is naturally very marked, not only because of the difference in intensity of the solar heat, but also because of the difference in humidity of earth and air in the rainy and the dry portions of the year. The average total loss by both leakage and evaporation is 16.46 per cent., calculated upon the amount of water delivered. Table LXXXVIII gives the delivery and the loss of a number of specimen ditches.

TABLE LXXXVIII.—QUANTITY OF WATER DELIVERED BY SPECIMEN MINING DITCHES AND LOSS BY LEAKAGE AND EVAPORATION.

ARIZONA.

County and district.	Line.	Quantity of water delivered per hour.	Quantity lost by leakage.	Quantity lost by evaporation.	Total quantity lost.
APACHE.		*Gallons.*	*Per cent.*	*Per cent.*	*Per cent.*
Greenlee Gold Mountain	Boston	300,000	6.66	16.67	23.33

CALIFORNIA.

County and district.	Line.	Quantity of water delivered per hour.	Quantity lost by leakage.	Quantity lost by evaporation.	Total quantity lost.
BUTTE.					
Oroville	Feather River and Ophir	1,750,000	4	8	12
CALAVERAS.					
Mokelumne Hill	Cook & Clarke	1,260,000	20	15	35
	Mokelumne and Campo Seco	700,000	2	10	12
	Union	1,750,000	3	10 to 25	13 to 28
DEL NORTE.					
	Del Norte	1,296,000	16.66	16.67	33.33
	Happy Camp	8,283,200	8	12	20
EL DORADO.					
Georgetown	California	8,400,000	5 to 10	20 to 30	25 to 40
	El Dorado	2,800,000	15 to 20	20	35 to 40
	Park Canal	1,540,000	5	15 to 20	20 to 25
PLACER.					
Gold Run	Gold Run	1,505,000	10	8	18
SISKIYOU.					
Indian Creek	Bay City	594,000	10	10	20
Do	Coyote Creek	1,186,920	10	20	30
Oro Fino	Altoona	630,000		10	10
Do.	Barker	490,000	10	10	20
Do	Wright & Fletcher	3,150,000	Very slight.	10	
Do	Young's	3,110,400	Very slight.	10	
Quartz Valley	Beaver Dam	560,000	Very slight.	5	
Do	Shackelford Creek	1,400,000		10	
Seiad Valley	Thompson Creek	1,069,200	5	5	10
TRINITY.					
	Trinity G. M. Co	1,400,000	1.5	1.5	3
TUOLUMNE.					
Columbia	Tuolumne	2,100,000	5	15	20

TABLE LXXXVIII.—QUANTITY OF WATER DELIVERED BY SPECIMEN MINING DITCHES, ETC.—Continued.

COLORADO.

County and district.	Line.	Quantity of water delivered per hour.	Quantity lost by leakage.	Quantity lost by evaporation.	Total quantity lost.
LAKE.		*Gallons.*	*Per cent.*	*Per cent.*	*Per cent.*
California	Star	840,000	1.4		
Do	Stevens & Leiter	2,800,000	10		
PARK.					
Alma township	Alma Placer	275,000	12	9	21
ROUTT.					
Hahn's Peak	Elk River	1,400,000	5	8	13
SUMMIT.					
	Boston G. and S. M. Co	700,000	10		
	Gold Run	700,000	3	8	11
	Sisler	190,000	10	8	18
	Union French	210,000	6	8	14

DAKOTA.

County and district.	Line.	Quantity of water delivered per hour.	Quantity lost by leakage.	Quantity lost by evaporation.	Total quantity lost.
CUSTER.					
Battle Creek	Battle Creek Gravel M. Co	472,500	3	1	4
LAWRENCE.					
Cape Horn	McKay & Ross	210,000	5		
Confederate	Stockade	280,000	10	1	11
Whitewood	Black Hills C. and W. Co	126,700	5.5		
PENNINGTON.					
Cañon	Last Chance	25,600	1	0.25	1.25
Rockerville	Black Hills Placer Co	1,400,000	5	1	6

GEORGIA.

County and district.	Line.	Quantity of water delivered per hour.	Quantity lost by leakage.	Quantity lost by evaporation.	Total quantity lost.
HALL.					
Twelfth	Glade	560,000	10		
LUMPKIN.					
Twelfth	Dahlonega	198,447	12.50	25	37.50
Do	Hand	1,023,694			
Do	Singleton	198,447	10	10	20
WHITE.					
Fourth	Town Creek	350,214			25

IDAHO.

County and district.	Line.	Quantity of water delivered per hour.	Quantity lost by leakage.	Quantity lost by evaporation.	Total quantity lost.
BOISÉ.					
Boston	Spencer	280,000			10
Moore's Creek	Alderson	700,000	5		
Do	Christy	560,000			6.25
Do	Crepisculla (feeders)	630,000			6
Do	Crepisculla (main)	560,000	2.50	2.50	5
Do	Caddy	280,000	5	7 to 8	12 to 13
Do	Dunn	280,000			6.25
Do	East Moore's Creek	700,000			6
Do	Hanson	700,000			3
Do	Lambing	700,000	6	3	9
Do	Mountain	210,000			35
Do	Plowman	400,000	5.75	2.87	8.62
Do	Thorn Creek	700,000			10
Do	Upper Alderson	210,000	3.33	5	8.33
Pioneer	Stevenson & Noble	2,800,000		4	
Do	Wilson	3,150,000			15

MONTANA.

County and district.	Line.	Quantity of water delivered per hour.	Quantity lost by leakage.	Quantity lost by evaporation.	Total quantity lost.
BEAVER HEAD.					
Bannock	Bannock	9,100,000	10	6	16
Do	White Bar	280,000	5	1	6
DEER LODGE.					
Henderson Gulch	Smart's Creek	560,000		10	
Independence	Hail Columbia	175,000		16.67	
Squaw Gulch	Rock Creek	1,050,000	10		
Summit Valley	John Noyes	400,000			10
LEWIS AND CLARKE.					
Last Chance	Wm. A. Cheesman	1,050,000	10	5	15
MEAGHER.					
German	Diamond Flume and Hydraulic Co	1,750,000	10		
Thompson's Gulch	Birch Creek	175,000	8	8	16

TABLE LXXXVIII.—QUANTITY OF WATER DELIVERED BY SPECIMEN MINING DITCHES, ETC.—Continued.

OREGON.

County and district.	Line.	Quantity of water delivered per hour.	Quantity lost by leakage.	Quantity lost by evaporation.	Total quantity lost.
		Gallons.	*Per cent.*	*Per cent.*	*Per cent.*
BAKER.					
Blue Cañon	Littlefield & Duckworth	280,000	1.25	1.25	2.50
Do	Marysville	700,000	20	5	25
Chicken Creek	J. N. Osborne & Co	210,000	10	50	60
Clarksville	Placer Gold	1,120,000	15.63	12.50	28.13
Humboldt	Colt	210,000	2	....	....
Pocahontas	Baisly	420,000	3.33	1.67	5
Do	Jones & Carpenter	420,000	2.50	0.83	3.33
Do	Low Cooper & Co	175,000	10	8	18
Do	Nelson	490,000	5.75	1.42	7.17
Rye Valley	Powers	770,000	4.55	6.82	11.37
Shasta	Eldorado	826,000	20	13	33
Sumter	Young & Rimbol	700,000	3	1	4
Willow Creek	W. Boswell	140,000	1.50	....	....
DOUGLAS.					
Big Bend Cow Creek	J. G. Fuller	1,050,000	10	....	....
Do	D. A. Leavens	834,400	20	....	....
Do	D. F. Salmon	1,176,000	33⅓	....	....
Cañonville	Catchings Bros	371,000	20	....	....
Green Mountain	Charles Dwelley	9,000,000	10	....	....
GRANT.					
Cañon City	Humboldt	700,000	5	5	10
Granite	Borne & Lucas	420,000	8.33	....	....
Do	J. B. Gardner	980,000	2.14	0.71	2.85
Do	Klopp & Johnson	1,050,000	8.33	....	....
Marysville	Hillis	560,000	3.12	5	8.12
Do	Miner's	210,000	8.33	16.67	25
Do	Prairie Diggings	350,000	4	2	6
Do	Thompson	525,000	3.33	5.33	8.66
Rock Creek	Lake	175,000	4	10	14
JACKSON.					
Applegate	Squaw Lake	700,000	5	15	20
Sam's Valley	Hays & Magruder	324,000	....	10	....
Sterling	Sterling	1,260,000	11.11	22.22	33.33
Uniontown	Gin Lin	1,400,000	3	2	5
JOSEPHINE.					
Waldo	Desselles & Co	2,494,800	6.25	6.25	12.50
Do	Waldo	1,458,000	5	5	10
Yank	Blue Gravel	1,620,000	15	10	25
WASCO.					
Ochoco	Wickaiser & Co	140,000	12.50	7.50	20

GRADE OF DITCHES.—The grade of the larger ditches ranges from 9 to 20 feet per mile, with exceptional higher grades. If the ditches are built in light soil, the grades are necessarily low; but where the ground is firm and tenacious the present tendency is to increase the grade, thus giving a more rapid current, and consequently greater capacity in proportion to the cross-section of the ditch. It is evident that, the less the time occupied in transit, the less is the proportionate amount of leakage and evaporation; and, besides this, it is found that narrow, deep, and comparatively steep ditches are less liable to damage by storms and are more readily repaired. Grades of 16 to 20 feet are now recommended by some engineers for lines cut in good ground.

The gradient is expressed either in inches and fractions of inches per rod or in feet per mile, the latter mode of expression being adopted in this discussion. For convenient reference the following conversion table, giving the equivalents in the two systems, is annexed:

TABLE LXXXIX.—GRADE EQUIVALENTS.

Inches per rod	⅛	¼	⅜	½	⅝	¾	⅞	1
Feet per mile	3⅓	6⅔	10	13⅓	16⅔	20	23⅓	26⅔
Inches per rod	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2
Feet per mile	30	33⅓	36⅔	40	43⅓	46⅔	50	53⅓

VELOCITY OF CURRENT.—The velocity of water in the ditches is from 1½ miles per hour in the lines of least grade up to 5 miles per hour in the steepest ditches. The average current is slightly over 3 miles per hour.

DIMENSIONS.—The cross-section of ditches is trapezoidal, the width at the top being considerably greater than that at the bottom, though the newer ditches are cut with less slope to the banks than was formerly the rule, as well as deeper in proportion to the width. Table XC gives the grade and the dimensions of specimen ditches.

TABLE XC.—GRADE AND DIMENSIONS OF MINING DITCHES.

ALABAMA.

County and district.	Ditch.	Grade.	Width at top.	Width at bottom.	Depth.
CLAY.		*Feet per mile.*	*Feet.*	*Feet.*	*Feet.*
....	Idaho	13⅓	2	1½	1½

ARIZONA.

County and district.	Ditch.	Grade.	Width at top.	Width at bottom.	Depth.
APACHE.					
Greenlee Gold Mountain	Boston	13	5	2½	2½

CALIFORNIA.

County and district.	Ditch.	Grade.	Width at top.	Width at bottom.	Depth.
BUTTE.					
Cherokee	Spring Valley	12	9	6	3½
Morris Ravine	Morris Ravine	9	....	5	3
Oroville	Feather River and Ophir	11	9	6	3
CALAVERAS.					
Mokelumne Hill	Cook & Clarke	12	3	2½	1⅝
....	Mokelumne and Campo Seco	12	9	5	2
....	Union	20 to 25	....	....	....
DEL NORTE.					
....	Bunker Hill	13⅓	5	4	2
....	China Creek No. 1	13⅓	4	2½	1⅔
....	China Creek No. 2	18⅓	3½	2	1⅔
....	China Creek No. 3	18⅓	2½	1⅔	1½
....	China Creek No. 4	18⅓	6	4	2
....	China Creek No. 5	18⅓	6	4	2
....	Del Norte	....	6 to 9	5 to 8	....
....	Happy Camp No. 1	13⅓	6	5	2
....	Happy Camp No. 2	13⅓	6	5	2½
....	Happy Camp No. 3	13⅓	5	4	1½
....	Muc-a-muc	10⅔	4½	2½	1⅔
....	Wingate No. 1	13⅓	3	2	1⅓
....	Wingate No. 2	13⅓	3	2½	1⅔
....	Wingate No. 3	13⅓	5	4	2
EL DORADO.					
Georgetown	California	6 to 16	3½ to 8	2 to 5	1½ to 3
....	El Dorado	4	10	6	4
....	Park Canal	....	8	5	2½
NEVADA.					
Nevada City	South Yuba	8 to 13	6	....	4 to 5
PLACER.					
Gold Run	Gold Run	26	6	4	2½
Iowa Hill	Iowa Hill	10	10	7	4½
PLUMAS.					
Indian Valley	Round Valley	10	4	2	3
Seneca	Dutch Hill	40	6	3	3
....	Black Hawk	Irregular.	2	1⅔	1⅔
....	Hungarian Hill	12	6	2½	2½
....	Plumas	13⅓	7	5	3½
SHASTA.					
Igo	Dry Creek	6	....	....	....
SISKIYOU.					
Indian Creek	Bay City No. 1	13⅓	2	1½	1½
Do	Bay City No. 2	13⅓	3	2	1½
Do	Coyote Creek No. 1	13⅓	2	1½	1½
Do	Coyote Creek No. 2	13⅓	3	2	1⅔
Do	Coyote Creek No. 3	13⅓	4½	3	2
McAdams Creek	Hiyou Gulch No. 1	12⅓	3	2	2
Do	Hiyou Gulch No. 2	13⅓	1½	1	1
Oro Fino	Altoona	16⅔	6	4	3½
Do	Barker	6⅔	5	3	3
Do	Wright & Fletcher	13⅓	10	8	3
Do	Young's No. 1	13⅓	6	3½	2½
Do	Young's No. 2	13⅓	10	7	2
Quartz Valley	Beaver Dam	6⅔	5	3½	3
Do	Shackelford Creek	6⅔	7	5	4
Scott Valley	Fort Goff No. 1	26⅔	4	3	2
Do	Fort Goff No. 2	26⅔	6	4	2
Do	Thompson Creek	13⅓	5	4	2
Yreka	Pellett & Truitt No. 1	6⅔	5	3	2
Do	Pellett & Truitt No. 2	6⅔	3	2	1
Do	Pellett & Truitt No. 3	6⅔	3	2	1
TRINITY.					
Buckeye	Buckeye	10	5	3	3
Hayfork	New River	9	....	....	....
Indian Creek	Johnston	10	5½	4½	3
Junction City	Lewiston	....	5	3	3
Minersville	Ridgeville	26⅔ to 40	....	....	....
Taylor's Flat	Trinity	10	7	5	3½

TABLE XC.—GRADE AND DIMENSIONS OF MINING DITCHES—Continued.

OREGON—Continued.

County and district.	Ditch.	Grade.	Width at top.	Width at bottom.	Depth.
JOSEPHINE.		*Feet per mile.*	*Feet.*	*Feet.*	*Feet.*
Grass Creek	Goff, Triplett & Chapin No. 1	20⅔	3	2	1½
Do	Goff, Triplett & Chapin No. 2	26⅔	1½	....	1½
Do	Steam Beer	16⅔	3½	2	2
Murphy	Carson & Johnson	13⅓	3½	3	1
Waldo	Desselles No. 1	13⅓	6	4	3
Do	Desselles No. 2	13⅓	3½	3	2
Do	Waldo (main)	6⅔	7	5	3
Do	Waldo (pipe ditch)	6⅔	3½	2½	2
Do	Waldo (waste-water ditch)	6⅔	7	5	2¼
Yank	Blue Gravel	20	5	3	3
....	Josephine No. 1	13⅓	5	4	3
....	Josephine No. 2	13⅓	4½	3	2
WASCO.					
Ochoco	Wickaiser & Co	13⅓	2	1½	1½

LINING OF DITCHES.—Under ordinary circumstances it is not customary or necessary to add a lining or facing of any kind, the fine silt held in suspension by the water of the ditch forming in time without artificial puddling (though this is sometimes resorted to) a clayey covering on the inner surfaces sufficiently impermeable for practical purposes. It is from this cause that, within reasonable limits and with proper repairs, the carrying capacity increases considerably with the age of the ditch, the loss from leakage gradually diminishing. This result is also furthered by the settling of the earth of the outer embankment, which, as it becomes more compact, is less liable to leakage and at the same time presents a better surface for the flow of water.

In following the contours of the hill-sides, to maintain a constant grade without resorting to the expedient of flumes, sharp turns are often unavoidable, as in crossing the head of ravines or in rounding a sharply projecting flank of the hill. It is at such points that eddies are formed and the greatest exposure occurs. If the embankment is here in danger of being washed out, it may be protected by cribbing with timber and logs or by facing with stone or boards at the salients. After a new ditch has been in operation a short time these weak spots manifest themselves and are fortified as occasion demands, the whole line being under very careful scrutiny until its permanence is established. At re-entering angles threatened with damage by small water channels crossing the line of the ditch the indications given in advance of construction are usually plain enough to cause suitable precaution to be taken, as by throwing a single box or two of fluming over the exposed point and deepening the natural channel beneath, etc. When it is possible, these side waters are, of course, turned directly into the ditch, to add to its contents and offset the loss from leakage or evaporation, care being taken to bring the confluents in at easy angles and to protect the outer bank from the impinging cross-currents. The experienced ditch builder utilizes these advantages or avoids the dangers as if by instinct.

In order to ascertain roughly the proportionate number of cases in which linings are used, questions to this effect were incorporated in the experts' schedules. From the following list it appears that, out of 139 answers received, only 11 ditch lines were reported to be lined to an extent worth noting, and in but two cases was the lining of any great extent:

TABLE XCI.—LINING OF DITCHES.

State or territory.	Answers received.	Ditches lined to some extent.	Ditches partially lined.	Ditches not lined.
Total	139	3	8	128
Alabama	1	....	....	1
Arizona	1	....	....	1
California	40	2	2	36
Colorado	7	....	1	6
Dakota	4	1	....	3
Georgia	8	....	1	7
Idaho	17	....	1	16
Montana	11	....	2	9
Oregon	50	....	1	49

As a general rule, it is cheaper to put in short lengths of ground flume at the worst points than to attempt to secure them by linings. It is this view of the case which has led the constructors of recent ditches to abandon lining in most instances, except where defects are noticed after the ditches have been running for some time and linings are put in as make-shifts. Typical illustrations of some of the common methods of lining are given in the following cases:

The main ditch of the El Dorado Water and Deep Gravel Mining Company, El Dorado county, California, which is 40 miles long, with 70 miles of tributaries, is lined for a distance of between 2 and 3 miles with granite and slate rock. This is a very important ditch, having a capacity of 10,000 inches of water and actually delivering 4,000 inches, the loss by leakage being from 15 to 20 per cent. of the amount of water taken into the ditch. The grade is very low, only 4 feet to the mile. Notwithstanding the careful construction, repairs and cleaning cost about $800 per month.

The Park canal, in the same county, another important ditch, is lined in places with timber. The grade reported, 3 inches in 16 feet or 82½ feet per mile, is evidently an error, as the velocity of the water is given at only 3 miles per hour. The ditches belonging to this system are well puddled, and it is said that the leakage amounts to only 5 per cent. (2,200 inches, delivered). The cost of repairs, including flume-mending and cleaning of ditches, reaches $2,000 per year.

The Ridgeville ditch, in Minersville district, Trinity county, California, is cribbed with split rails placed close together and held in place by stakes driven in behind them. This ditch has a very steep grade, and for the first mile of the upper portion, where the pitch is 1¼ inches to the rod (40 feet per mile), is walled with rock on the outside; the remainder of the line, 10½ miles, has a grade of 1 inch to the rod (26⅔ feet per mile). The necessity for thorough construction is evident when the force of the current, stated at 6 to 7 miles per hour, and possibly 8 miles in places, is considered. The cost of repairs is nominal.

The Trinity Hydraulic Mining Company's ditch, Taylor's Flat district, in the same county, is lined with 1½-inch lumber, 15 inches wide. The grade is only three-eighths of an inch to the rod (10 feet per mile), but the velocity of the current is reported at 4 miles in 55 minutes, or 4.367 miles per hour. This is a new ditch.

The Stevens & Leiter ditch, of the Oro Mining, Ditch, and Flume Company, California district, Lake county, Colorado, is lined with sod for a distance of 5 miles of its total length of 13½ miles. This ditch delivers 4,000 inches of water, and loses 10 per cent. by leakage. Its grade is low, 5 feet per mile, but the velocity of the water is stated at 3 miles per hour. Repairs are unimportant in amount.

The Black Hills Canal and Water Company's ditches, Whitewood district, Lawrence county, Dakota, supplying water to the mills at Central City, Deadwood, and Lead City, are, with the exception of one ditch (the Pioneer), underground boxed lines, the boxes made of pine lumber and covered over with 3 feet of earth, to prevent freezing in winter and evaporation in summer. The loss by leakage is 10 inches, against 181 inches delivered per hour. During two years run, up to the date of report, no repairs were required. In these ditches the fall is from ½ to 1 inch in 16 feet (13⅓ to 27½ feet per mile).

From Georgia one report of partially lined ditches was received, the Anicalola and Etowah line, in Dawson county. Here the system is to drive in planks at exposed points at the head of ravines.

One of the four ditches of Stevenson & Noble, in Pioneer district, Boisé county, Idaho, is cribbed with timbers and boards on the lower side. This ditch is a large one, has a grade of 1 inch to the rod (26⅔ feet per mile), giving a mean velocity of 4 miles per hour, and loses little by leakage. Repairs average only $400 per season.

The Rock Creek ditch, in Squaw Creek district, Deer Lodge county, Montana, is lined with granite for about a mile at its upper end. This is a large ditch, carrying 1,500 inches of water, with a low grade, 10 feet per mile.

The Diamond Flume and Hydraulic Company's ditch, German district, Meagher county, Montana, is walled in places where required with stone. It carries 2,500 inches of water, losing about 10 per cent. by leakage. The grade is half an inch to the rod (13⅓ feet per mile).

The Squaw Lake ditch, Applegate district, Jackson county, Oregon, is another example of partial lining. For short distances, where there is danger of breaking, it is faced with sawed lumber and slabs. The loss by leakage is 50 inches, against 1,000 inches of water delivered. The current is slow, 2½ miles per hour, with a fall of half an inch per rod. Repairs cost $1,200 during the second season, but the necessity for them diminished as the lining was improved.

FLUMES.—These are used for conveying water across cañons and in places where the grade of the line cannot be maintained by simple earth excavation, to avoid the necessity of cutting the ditch in hard rock, and in spots subject to washouts. They are not so permanent as well-constructed ditches, as they require constant repairs and are liable to damage or destruction by fire. Undoubtedly a substantially-built wall ditch in some instances would in the long run prove more economical than the side-hill fluming commonly adopted, though the first cost of the fluming might be much lighter. On the other hand, it is a question whether the wrought-iron siphon pipe is not preferable in many cases when excessively high trestle-work is required by flumes. But there are many cases where fluming is from topographical reasons unavoidable, and still more where the constructing engineer, after duly weighing the circumstances, finds it more expedient to adopt the simple flume than to attempt a more expensive system. Usually the consideration of first cost is a very weighty one. Large corporations, in building lines intended to be used for many years, can often afford very expensive construction for the sake of permanence. The small mine owner, however, is limited in his plans by the question of initial cost, and hence resorts to fluming wherever that is the simpler and cheaper way out of a difficulty. Flumes cost more per yard than excavation in easy ground where a natural grade exists, but much less than ditches hewn out of solid rock or flanked by high walls. Hence they are ordinarily used wherever their cost is less than that of other means, and this happens in many situations.

There are two leading types of flumes—those which are supported wholly by trestles, and those which follow the hill-side and are braced by struts. These two forms frequently appear in the same line of fluming, the natural bed being followed so far as practicable and then resort being had to trestles to bridge over the awkward spots. When the flume rests wholly or in part upon the earth or rock, it is advisable to set it in very close under the shelter of the bank, for protection against slides, and exposed points are either guarded by wooden aprons placed over the flume or by excavating the gullies beneath the flume. The construction of the flume itself and its framing is similar in either case, the differences in details of the trestle-work varying according to circumstances. For trestled flumes the features of the leading members are as follows:

Sleepers.—These are hewn timbers, preferably of red fir, but usually of whatever wood is at hand, resting upon the earth at right angles to the line of the flume, upon which trestle legs are set. Charring is sometimes resorted to as a protection against decay. They are from 6 by 4 to 10 by 6 inches and upward, and are placed flatwise. The object is not only to give a solid foundation for the trestles, but also to keep the latter from spreading; and for this purpose they should be slightly mortised, to hold the feet of the trestles in place. The length of the sleepers varies with the height of the trestle, the span increasing with the elevation of the flume above the ground. They are set at intervals of 8, 12, 16, and, rarely, 18 feet apart, according to the capacity of the flume and the weight of the superstructure, the former distance being usual with large and well-built flumes. The intervals between the supports are in multiples of 4 feet, which is usually the common distance between the posts of the flume-box, though occasionally the framing of the latter is set as close as 3 or even 2½ feet.

Trestles.—These are commonly two-legged, and for light flumes are made of 6-by-4 inch scantling, and sometimes of unhewn timber. For large flumes the size is increased to 10 by 8 inches and over. Low flumes, under 20 feet in height, of small to medium size, are made with alternate vertical single-leg supports, which support the weight, but have less resistance to the lateral movement of the structure. Very low flumes of from 3 to 6 feet in height may be carried by single legs alone when braced by struts. If sleepers are not used, it is advisable to char the feet of the trestles.

Cross braces of trestles are usually of refuse boards or planks, the same as employed for the sides and bottom of the flume-box, simply nailed to the trestle legs in the form of the letter X and terminating at the angle formed by the junction of the legs with the trestle-cap. Where single posts are used similar cross-braces are added, running from the sleeper to the trestle-cap and nailed to the post at their crossing, or diagonal scantling braces beginning at the post about midway from the ground and meeting the trestle-cap.

Diagonal struts.—These resist any longitudinal movement of the flume in mass, and are necessary with high flumes, especially if the gradient exceeds ½ inch to the rod, as is becoming more and more the practice. They are of 3 by 4 to 4 by 6 inch scantling, set edge up, and running alternately from trestle to trestle in the line of the flume.

Wire stays.—Very high flumes are much exposed to damage by storms and in curves by the momentum of the water carried. In such cases resort is had to wire guys securely anchored at the ground on both sides of the flume and attached at an angle of about 45°.

Trestle-caps, or bearers.—These rest upon the trestle legs at right angles to the line of the flume, and are never omitted. They are of 4 by 6, 6 by 6, or 8 by 8 inch hewn or sawed timbers. The trestle legs are sometimes mortised into the bottom of the cap. In the case of very high flumes, which often greatly exceed 100 feet, the cap becomes a sleeper for the trestle of the next story above, and so on. The lower stories of such flumes are, of course, of wider span than the upper ones.

Stringers.—These are longitudinal timbers, 6 by 4, 8 by 6, or 10 by 8 inches, set on edge, and of such length, usually 16 feet, as to bring the butts over the trestle-caps. They are placed beneath the sills under the posts of the flume-box, or a little outside of them. They give stiffness to the box, and are essential with flumes supported on trestles. Where the flume rests directly upon a rock bed they are sometimes omitted, but this is not considered good practice.

Sills.—These are timbers resting upon the stringers and parallel with the trestle-caps, 4 by 4 or 6 by 4 inches, and extending 18 or 20 inches beyond the posts on each side, where side-braces or knees are used, and 6 to 8 inches if there are no side-braces. The sills have shallow mortises for the reception of the posts, but are seldom mortised for the side-braces.

Posts.—These are from 2 by 4 with the smallest flumes up to 5- by 4-inch uprights with the largest ones. They are mortised into the sills, and usually also into the caps. The posts project about 2 inches above the sides of the flume.

Side-braces, or knees.—These take the lateral thrust of the box, and are 2- by 4-inch pieces, flat side up, extending from near the ends of the sills to the sides of the flume-box at about 45°. They are commonly simply nailed in place, and are not mortised to the sills. Some flumes have side-braces for each post—that is, at intervals of 4 feet; others have side-braces only at alternate posts, or at every third, fourth, or fifth post. Triangular blocks nailed to sills and posts are sometimes substituted, allowing the use of much shorter sills. Objection has been raised to the employment of side-braces at all, and the consequent extension of the sills, on the ground that additional space for the accumulation of snow and ice is thus made. If they are omitted, then the posts should be securely mortised into the caps, and the latter should be of considerable strength.

Caps.—When side-braces are used, the caps are sometimes simply nailed to the tops of the posts, and with very small flumes caps are occasionally omitted altogether. Their width is that of the posts, and the thickness ranges from 1½ to 5 inches, according to the mode of fastening. If mortised, the caps project from 6 to 10 inches beyond the posts. In some situations the absence of caps is a temptation to use the flume as a foot-bridge during the dry season, thus damaging the bottom boards, while, on the other hand, if the caps are to be walked upon it is evident that they should be sufficiently stiff.

The box.—The sides abut upon the posts and the bottom rests upon the sills of the framing, which supports the flumes at intervals of 4 feet. In California planks of heart sugar-pine are commonly used, but other woods are employed as circumstances dictate. The thickness is from 1½ to 2 inches, and with very small flumes sometimes only 1 inch. The length is 16 feet. With flumes of moderate capacity, if it is possible to get boards of sufficient width, say 20 inches and upward, it is an advantage to have the sides of single boards. This is impossible with the largest flumes, where two, and even three, boards are placed one above the other. The planking makes butt joints at the ends, the shrinkage of the wood in this direction being slight. Battens from 3 to 4 inches wide and the thickness of the planking or less, nailed upon the inside of the box, cover the longitudinal seams, except the corner joints, where the sides meet the bottoms. Only the very smallest flumes can be made with single bottom-boards. Knot-holes and large cracks are covered by short battens. When flumes are in constant use the leakage is very slight, and after disuse during the dry season the wood soon swells when the water is turned in and the flume becomes water-tight. Even with imperfectly-seasoned and rough-fitting lumber fluming, unless badly out of repair, carries the water with but little loss.

GRADE OF FLUMES.—The grade is either the same as that of the ditch portion of the same line or is heavier. The tendency of recent practice is to increase it, thus admitting of fluming with considerably less area than the corresponding cross-section of the ditches. From 25 to 30 feet is considered a good grade, and when there is sufficient head at the delivery end of the line some authorities recommend slightly heavier grades. The velocity of the water in flumes is higher than in ditches, especially where the fluming is perfectly straight. Velocities of 4 and 5 miles per hour are not uncommon, and in one case a speed of 7½ miles is credibly reported.

DIMENSIONS.—The size of flumes differs widely according to the amount of water carried and the grade. In the following specimen list the range is from 2 feet by 1 foot up to 8 by 6 feet, with much variation in the shape of the cross-sections. Usually the width is greater than the depth of water, often much more; but some flumes have a cross-section which is square, or nearly so.

TABLE XCII.—GRADE AND DIMENSIONS OF SPECIMEN FLUMES.

County and district.	Line.	Grade.	Width.	Depth.
ALABAMA.				
CLAY.		*Feet per mile.*	*Feet.*	*Feet.*
....	Idaho	13⅓	2	1
ARIZONA.				
APACHE.				
Greenlee Gold Mountain	Boston	13	5	2½
CALIFORNIA.				
BUTTE.				
Cherokee	Spring Valley	12	5	3½
Morris Ravine	Morris Ravine	9	5	2
Oroville	Feather River and Ophir	11	6	3
CALAVERAS.				
Mokelumne Hill	Cook & Clarke	12	3	1⅝
....	Mokelumne and Campo Seco	12	....	....
DEL NORTE.				
....	Bunker Hill	18½	4	2
....	China Creek No. 1	18⅓	2½	1½
....	China Creek No. 2	18⅓	3	1¼
....	China Creek No. 3	18⅓	2	1¼
....	China Creek No. 4	18⅓	4	2
....	China Creek No. 5	18⅓	5	2
....	Del Norte	....	7	1⅝
....	Happy Camp	13⅓ to 40	....	....
....	Muc-a-muc	13⅓	3¾	1⅝
....	Wingate No. 1	13⅓	2½	2
....	Wingate No. 2	13⅓	3	3
....	Wingate No. 3	13⅓	3	3
EL DORADO.				
Georgetown	California	8 to 10	1¼ to 4½	1½ to 4½
....	El Dorado	....	8	6
....	Park Canal	....	6	2½
PLACER.				
Gold Run	Gold Run	12	4	3
Iowa Hill	Iowa Hill	10	7	4½
PLUMAS.				
Indian Valley	Round Valley	10	3½	1½
Seneca	Dutch Hill	40	6	4
....	Plumas	26⅔	4	3

TABLE XCII.—GRADE AND DIMENSIONS OF SPECIMEN FLUMES—Continued.

CALIFORNIA—Continued.

County and district.	Line.	Grade.	Width.	Depth.
SHASTA.		*Feet per mile.*	*Feet.*	*Feet.*
Igo	Dry Creek	6		
SISKIYOU.				
Indian Creek	Bay City No. 1	13⅓	1½	1½
Do	Bay City No. 2	13⅓	2	1½
Do	Coyote Creek No. 1	13⅓	1½	1½
Do	Coyote Creek No. 2	13⅓	1⅓	1½
Do	Coyote Creek No. 3	13⅓	1⅝	1½
McAdams Creek	Hiyou Gulch	13⅓	3	2
Oro Fino	Altoona	16⅔	5	2
Do	Barker	6⅔	4	2
Do	Wright & Fletcher	13⅓	7	2⅔
Quartz Valley	Shackelford Creek	13⅓	6	2
TRINITY.				
Taylor's Flat	Trinity	13⅓		
	Trinity G. M. Co		4	3
TUOLUMNE.				
Columbia	Tuolumne	11 to 32	7½	4½

COLORADO.

County and district.	Line.	Grade.	Width.	Depth.
LAKE.				
California	Stevens & Leiter	5	10	3
ROUTT.				
Hahn's Peak	Elk River	10	4	3
SUMMIT.				
	Boston G. and S. M. Co	7	2½	2
	Gold Run	6⅔	5	1½

DAKOTA.

County and district.	Line.	Grade.	Width.	Depth.
CUSTER.				
Battle Creek	Battle Creek Gravel M. Co	6⅔		
LAWRENCE.				
Confederate	Stockade	8 1/16		
PENNINGTON.				
Rockerville	Black Hills Placer M. Co	6		

GEORGIA.

County and district.	Line.	Grade.	Width.	Depth.
DAWSON.				
Fourth, Fifth, and Thirteenth	Anicolola and Etowah	8	5	4
HALL.				
Twelfth	Glade	8½		
LUMPKIN.				
Twelfth	Dahlonega	4	2	1
Do	Singleton	8	2	1½
WHITE.				
Third	Nacoochee	5	5	3
Fourth	Town Creek	5	3	2

IDAHO.

County and district.	Line.	Grade.	Width.	Depth.
BOISÉ.				
Boston	Spencer	13⅓	2½	3
Moore's Creek	Alderson	13⅓	4	2½
Do	Christy	10	4	2½
Do	Crepisculla (feeders)	10	2	1½
Do	Crepisculla (main)	10	2½	2
Do	Cuddy	13⅓	2	2
Do	Dunn	13⅓	3	2½
Do	East Moore's Creek	10	4	2½
Do	Hanson (upper)	10	3	2½
Do	Hanson (lower)	10	4	2½
Do	Lambing	13⅓	4	3
Do	Mountain	10	3	2½
Do	Plowman	13⅓	3½	2½
Do	Thorn Creek	10 to 13⅓	4	2½
Do	Upper Alderson	13⅓	3	2½
Pioneer	Stevenson & Noble	13⅓ to 16⅔	4	2
Do	Wilson	10 to 13⅓	4	2

TABLE XCII.—GRADE AND DIMENSIONS OF SPECIMEN FLUMES—Continued.

MONTANA.

County and district.	Line.	Grade.	Width.	Depth.
BEAVER HEAD.		*Feet per mile.*	*Feet.*	*Feet.*
Bannock	Bannock D. and M. Co	....	3	1½
Do	White Bar	6¾	3½	1¾
DEER LODGE.				
Henderson Gulch	Smart's Creek	6¾	6	2
Squaw Gulch	Rock Creek	10	7	3½
Summit Valley	John Noyes	13½	....	....
LEWIS AND CLARKE.				
Last Chance	Wm. A. Cheesman		....	....
MEAGHER.				
German	Diamond Flume and Hydraulic Co	13¾	5	3½
Thompson Gulch	Birch Creek		1½	1½

OREGON.

County and district.	Line.	Grade.	Width.	Depth.
BAKER.				
Blue Cañon	Littlefield & Duckworth	13½	2	2
Do	Marysville	13½	4	2½
Chicken Creek	J. N. Osborne & Co	6¾	1¼	1¾
Clarksville	Placer G. M. Co. (Burnt River line)	6¾	6	2½
Do	Placer G. M. Co. (Clark's creek)	20	4	2
Pocahontas	Baisly	20	3	2
Shasta	El Dorado	8 to 12	....	....
Sumter	Young & Rimbol	9½	4	3
COOS.				
....	Pioneer	7½	4	1½
DOUGLAS.				
Big Bend Cow Creek	J. G. Fuller	17¾	1½	1¾
Do	D. A. Leavens	13½	2½	2
Do	D. F. Salmon	10	3	2½
Cañonville	Catching Bros	13½	3	1
GRANT.				
Cañon City	Humboldt	20	3½	2
Granite	Klopp & Johnson	30	1½	1½
Marysville	Hillis	6¾	4	2½
Do	Miner's	5½	2	1¾
Do	Thompson's	45½	3	1½
JACKSON.				
Applegate	Grand Applegate	20	4	4
Do	Squaw Lake	16	4	3
Farris Gulch	Farris Gulch	10	4	2½
Forty-nine	Ashland	53½	3	1½
Sam's Valley	Hays & Magruder	6¾	2	1¾
Sterling	Sterling	....	4½	3
JOSEPHINE.				
Waldo	Desselles No. 1	6¾	4	3
Do	Desselles No. 2	6¾	3	3
Do	Waldo	6¾	5	4
Yank	Blue Gravel	26¾	3	2½
....	Josephine	13½	4	3

BRACKET FLUMES.—As an example of the many expedients for overcoming engineering difficulties in flume construction, the bracket flume of the Miocene Mining Company's ditch, in Butte county, California, may be cited. To avoid the necessity of a trestle-work 186 feet high, in crossing a deep cañon between precipitous basalt cliffs, the line of fluming was carried to the head of the cañon, where the perpendicular wall is 350 feet high. For a distance of 486 feet around this wall the flume is supported upon iron brackets, at a height of 118 feet above the bed of the ravine and more than 200 feet below the crest of the wall. The brackets are 8 feet apart, and are capable of sustaining a weight of 14½ tons each. They are made of T-rails of 30-pound railroad iron bent into the form of an L, 2 feet of which were rounded off and let into ring-bolts clamped and soldered into holes drilled in the rock. The bed of the flume rests upon the horizontal portion of the brackets, and the outer ends of the latter project vertically upward. Suspension rods of ¾-inch round iron run from the ends of the uprights diagonally upward to the wall, where they are securely clamped and soldered into the rock. The flume is 4 feet wide, inside measurement, and 3 feet deep, with a capacity of 3,000 inches of water. The dangerous work of drilling the holes for the brackets and suspension rods was done by men swung by ropes from the top of the cliff.

UNDERGROUND FLUMES.—For supplying quartz-mills with water during the winter, in districts where the cold is so great that freezing would prevent a regular flow, underground flumes or covered ditches are resorted to. Underground flumes are, more properly speaking, simply ditches which are completely boxed with plank and covered over with earth. They are not built with the same nicety of construction as ordinary open-air flumes, the surrounding earth forming a natural bracing and also diminishing leakage. Ditches, the sides and bottoms of which are not lined, are sometimes similarly covered over with lagging, brush, etc., upon which earth is thrown.

This covering not only protects the water from freezing in winter, but also serves to check evaporation in summer. The main objections to the system are the difficulty of inspection and the liability of choking from the top dirt falling into the channel in the case of ditches merely lagged over. The Arrastra, Montana, Hearst, and Deadwood lines of the Black Hills Canal and Water Company, of Lawrence county, Dakota, are examples of the underground flume system. These boxed ditches are covered with 3 feet of dirt, and carry water throughout the year to the mills which they supply. In many other places the same plan has been adopted. Short lengths of underground flumes or box ditches, sometimes strengthened by rock, are also used to convey water under road-beds, etc.

FEED PIPES.—The feed pipes immediately supplying the nozzles of hydraulic mines suggested the adaptability of a similar means for conveying water across deep cañons and over elevations impracticable by fluming. The system has developed into one of great importance and diversity of application, and has resulted in bringing a water supply to placer ground in many cases unavailable by any other means. The material used, sheet iron, is particularly adapted to its purpose by its great tensile strength in comparison with its weight, which is so slight as to render its transportation feasible from the point of manufacture to the locality where used, even though these are widely separated.

A description of the usual methods of construction, quoted from a valuable paper read by Mr. Augustus J. Bowie, jr., before the American Institute of Mining Engineers, and in part applicable to the construction of the feed pipes at the hydraulic mines, is here appended:

The general sizes of the pipes used in the mines are 40, 30, 22, 15, and 11 inches in diameter, of riveted light sheet iron, No. 16, 14, or 12 iron, Birmingham gauge, made in lengths of about 20 feet, and put together in stove-pipe fashion, neither rivets nor wire being used to hold the joints in place. These pipes are light, and can be readily and cheaply moved; this in hydraulic mining is of great importance, as it is often requisite to change the position of the lines of pipes. Pipe put together in this rough manner will remain tight when subjected to even as great a pressure as 200 pounds to the square inch. Where the pressure requires it, lead joints are used. [Formed by filling the space between an iron sleeve and the pipe with melted lead. A flange is bolted to one length of the pipe on the inside for the other pipe to fit over, and preventing the lead from entering the pipe.] Though roughly constructed and of very light iron, this kind of pipe (connected more like stove-pipe than water-pipe) is found in practice to be most serviceable, and, from its form, floating particles of matter readily render it water-tight. Such a pipe, 12 inches in diameter, made of No. 18 iron, is riveted in the longitudinal seams every inch to inch and a quarter; while in the round seams the rivets, which are only one-eighth of an inch in diameter, may be as much as 3 inches apart, showing daylight between the iron; but after the water has run through the pipes a short time nearly all leaks stop. If necessary, however, two or three bags of sawdust put in the inlets, and a few shovelfuls of earth, will usually make everything tight.

This class of pipe is now being replaced by one of better make, in which the round seams are made with rivets three-fourths of an inch apart, and the longitudinal seams are double riveted, with rivets one inch apart in the row, and about one-half inch apart from one row to the other. If riveted with care, such pipes, after being dipped in an asphaltum bath, are excellent, and will last for many years. For this asphaltum bath the following preparation can be used:

		Per cent.
	Crude asphaltum	28
	Coal tar (free from oily substances)	72
Or,		
	Refined asphaltum	16⅔
	Coal tar (free from oily substances)	83⅓

When the mass has been boiled to a proper consistency, and by test the coating is found to be brittle, it at once indicates that the mixture has been boiled too hot, or that there was too much oil in the tar or asphaltum.

The thickness of the iron is usually proportionate to the head of water and the diameter of the pipe. Pipes made of the different sizes iron here mentioned will stand the following strain per sectional inch:

Number of iron.	Made to stand strain per sectional inch, pounds avoirdupois.
12	7,000 to 9,000
12 to 9	9,000 to 12,000
9 to 3/16-inch	12,000 to 14,000
1/4-inch to 3/8-inch	17,000 to 18,000

The head of the water in pounds avoirdupois, multiplied by the diameter of the pipe in inches and divided by the above co-efficients, gives twice the thickness of the iron to be used. Allowance must be made for the security required, that is, if the breakage of the pipe will cause much damage it is advisable to lower the margin for greater safety. The diameters of the rivets usually used are:

Number of iron	18	16	14, 12, 11	10, 8, 7	1/4-inch.	5/16-inch.	3/8-inch.
Corresponding diameter of rivets	3/32-inch.	5/32-inch.	3/16-inch.	3/8-inch.	1/2-inch.	5/8-inch.	3/4-inch.

They are usually spaced to make the pipe tight, that is, closer than is necessary for the strength of the seam; but this, in turn, is governed by the pressure on the pipes.

The following table shows the details of construction for a 22-inch pipe:

Thickness of iron.	Diameter of rivets.	Length of rivets.	Pitch of circle seams.	Number of rivets in each circle seam.	Pitch of the rivets in the longitudinal seam or double row.	Width between centers of rivets in the double row.
No. 12	3/16-inch	5/8-inch	1-inch	69	1 3/8-inch	5/8-inch.
No. 11	5/16-inch	5/8-inch	1-inch	69	1 3/8-inch	5/8-inch.
No. 9	3/8-inch	13/16-inch	1 3/16-inch	59	1 7/16-inch full	5/8-inch.
3/16-inch	1/2-inch	1 1/4-inch	1 7/16-inch	39	1 11/16-inch full	1 1/16-inch.
1/4-inch	1/2-inch	1 1/2-inch	1 7/16-inch	39	1 13/16-inch full	1 1/16-inch.

When the pipe is made and put in position, air-valves are provided to allow the escape of air from the pipe while filling, and especially to prevent any collapse should a break occur. These valves are of many forms, the most usual being a piece of leather loaded and forming a valve opening to the inside of the pipe, and when shut covering a plain hole of from 1 inch to 4 inches on the top side of the valve. When required, a better class of valve is used, which sinks and opens when the water leaves it, and floats and shuts when the water rises up to it. An important point is the admission of the water to the pipe in such a way as to prevent air from being sucked into and traveling along the pipe, which will happen, and in large quantities, unless the water is regulated. The best plan is to put a gate in the pipe a little below the level where the water enters it, and regulate the flow by the gate, and by this means a steady pressure without violent oscillation can be obtained. Usually, however, the water enters through a funnel-shaped pipe, which allows the air to escape as it enters, and with a little care can be made to answer every purpose. In some instances an air- or stand-pipe is put in at a distance from the inlet. This catches the air as it travels along the top of the pipe and allows it to escape.

The following abstracts from the experts' reports give details as to the construction and duty of the pipes in different localities and under varying circumstances, showing the range in size and in pressure sustained in the typical cases:

ARIZONA.

YAVAPAI COUNTY.

JACKSON.—Diameter for 200 yards, 1 foot; for 175 yards, 7 inches; balance, 7 inches. Longitudinal joints are lapped and riveted; circular joints are lapped 2 inches and are held together by wiring four ears on each joint. These ears are riveted to the pipe.

CALIFORNIA.

BUTTE COUNTY.

CHEROKEE DISTRICT: *Spring Valley.*—Diameter, 30 and 34 inches. The iron used was ordinary English plate of fair quality. The greatest pressure it sustains is 887 feet, and the thickness of the iron at that point is 3/8 of an inch. The pressure and maximum strains on the several sizes of iron used are given in the following table:

TABLE XCIII.—DETAILS OF THE SPRING VALLEY PIPES.

SIZE OF IRON.		GREATEST PRESSURE.		Maximum tensile strain per square inch, in pounds.
No. of gauge (Birmingham gauge.)	Thickness in decimals of an inch.	Feet.	Pounds.	
14	0.083	170	74	13,374
12	0.109	288	125	17,202
11	0.012	293	127	15,875
10	0.134	355	154	17,240
3/16	0.187	435	188	15,080
1/4	0.250	594	257	15,420
5/16	0.312	842	365	17,540
3/8	0.375	887	384	15,360

Longitudinal joints double-riveted; circular joints double-riveted and caulked. Longitudinal seams double-riveted; circular seams single-riveted. Air-valves are placed at several points.

MORRIS RAVINE DISTRICT: *Morris Ravine.*—Diameter of pipes, 22 inches; Nos. 12, 14, and 16 iron, used at depths of 250–310, 150–250, and 150 feet, respectively. Air valves placed where the pipe changes its angle. Joints single-riveted, and tarred before joining.

CALAVERAS COUNTY.

MOKELUMNE HILL DISTRICT: *Cook & Clarke.*—Diameter, 12 inches; thickness under greatest head, No. 14 Birmingham gauge. All joints riveted. One air-valve near head.

Mokelumne and Campo Seco.—Diameter, 12 to 14 inches; Nos. 16 and 14 Birmingham gauge. Sections (18 or 20 feet) stove-piped and riveted. Depth, 70 feet.

EL DORADO COUNTY.

GEORGETOWN DISTRICT: *California.*—Diameter, 7¼ to 22 inches; Nos. 12, 16, 18, and 20 iron. Longitudinal slip-joints stove-piped and riveted, circular joints riveted. No air-valves. Depth of cañons crossed, 40 to 200 feet.

El Dorado.—Diameter, 16 to 30 inches; Nos. 18 to 12 Birmingham gauge. Made in 20-foot sections. Slip-joints and riveted. Air-valves every hundred feet.

Park Canal.—Diameter, 15 to 22 inches; Nos. 18 to 14 Birmingham gauge. Longitudinal joints stove-piped and wired or double riveted, circular joints riveted. Air-valves at highest points. Depth, 128 feet.

PLACER COUNTY.

GOLD RUN DISTRICT: *Gold Run.*—Diameter, 16 inches; No. 14 Birmingham gauge throughout. Joints stove-piped and riveted. Air-valves 150 feet apart throughout length of pipes.

PLUMAS COUNTY.

SENECA DISTRICT: *Dutch Hill.*—Diameter, 22 inches. The iron varies between single riveted No. 14 to doubled riveted No. 12—the latter used at point of greatest pressure, 518 feet, 5 miles from the head of the pipe. Longitudinal joints single or double riveted, according to pressure; circular joints are driven together and fastened by means of hooks. Air-valves are placed at the highest points along the line.

TUOLUMNE COUNTY.

COLUMBIA DISTRICT: *Tuolumne.*—Diameter, 6 to 16 inches, averaging 11 inches. Average thickness, No. 16 Birmingham gauge, 0.065 inch shell, weighing 2.627 pounds per square foot. Joints riveted. Air-valves at head.

COLORADO.

LAKE COUNTY.

CALIFORNIA DISTRICT: *Stevens & Leiter.*—Diameter, 13, 15, 18, 21, and 30 inches; all No. 14 iron. No air-valves.

DAKOTA.

LAWRENCE COUNTY.

WHITEWOOD DISTRICT: *Black Hills Canal and Water Company.*—Diameter, 8 inches; No. 14 iron. Lap-joints held by four lugs drawn together by wire. Depth of cañon crossed, 250 feet.

GEORGIA.

LUMPKIN COUNTY.

TWELFTH DISTRICT: *Dahlonega.*—Diameter, 12 inches; No. 16 iron. Spiral pipes, single riveted. Circular sleeve-joints, ends fluted and joined by wired lugs. No air-valves.

Hand.—Diameter, 36 inches. Thickness at greatest pressure, ⅜ inch; at other points, $\frac{3}{16}$. Grade between head and discharge, 8 feet to the mile. Longitudinal lapped-joints double riveted in one section, 42 feet in length, single riveted in the other sections. Circular flange-joints made of cast iron turned in lathe, made tight with lead, and bolted with ¾-inch bolts at intervals of 6 inches in the circumference. Joints riveted to the pipes. No air-valves, but the pipes are provided with man-holes.

WHITE COUNTY.

FOURTH DISTRICT: *Town Creek.*—Diameter of upper third, 20 inches; middle third, 18 inches; lower third, 16 inches; $\frac{3}{16}$-iron. Spiral pipe, single riveted. Circular sleeve-joints, one end corrugated, united by lugs and wire. Joints covered with rubber-cloth and three thicknesses of tarred canvas, with three iron clamps over each joint. Air-valves used.

IDAHO.

BOISÉ COUNTY.

MOORE'S CREEK DISTRICT: *Plowman.*—Diameter, 11 inches; No. 18 iron; pressure, 84 feet. Longitudinal slip-joints; circular joints made with an elbow in one piece. No air-valves.

MONTANA.

MEAGHER COUNTY.

GERMAN DISTRICT: *Diamond.*—Diameter, 22 inches; thickness, ¼-inch throughout; pressure, 440 feet; joints riveted. No air-valves.

OREGON.

GRANT COUNTY.

GRANITE DISTRICT: *Klopp & Johnson.*—Diameter, 18 inches; thickness, $\frac{1}{16}$ throughout. Longitudinal joints riveted; circular slip-joints. No air-valves. Greatest depth, 84 feet.

JACKSON COUNTY.

FARRIS GULCH DISTRICT: *Farris Gulch.*—Diameter, 22 inches; thickness, $\frac{1}{16}$ throughout; pressure, 60 feet. Longitudinal slip-joints; circular joints made with curved elbow, riveted. Three air-valves near head.

In addition to the pipes carrying water for the use of hydraulic mines, examples of bold engineering are shown by the lines of several water companies supplying cities on the Pacific coast. Among these the line of the Virginia City and Gold Hill Water Company is the most noteworthy. It includes an inverted wrought-iron siphon, 11½ inches in diameter, which sustains a pressure of 1,720 feet or 750 pounds per square inch at its greatest depression. At this point No. 0 iron is used, hot-riveted with ⅝-inch rivets, double row on the longitudinal seam and single riveted on the round seam. It is said to have been tested to a pressure of 1,400 pounds per square inch. A second siphon, made of lap-welded pipe, ¼-inch iron, 10 inches inner diameter, has been added.

The pipe of the Spring Valley Water Company, which supplies San Francisco, is 18 inches in diameter and 5,800 feet long, and has a tensile strain of from 5,000 to 6,000 pounds per sectional inch. It is subjected to the pulsations of a single-acting plunger pump making at times 36 strokes per minute.

The Vulture Pipe Line, Maricopa county, Arizona, is included in the official schedules, though it is not used for hydraulic mining, but for supplying the Vulture 80-stamp mill. It is 16 miles long, and the diameter for the first 5½ miles is 9 inches; balance, 7¼ inches. It is of No. 19 iron, in bands of 2½ feet, made into sections 24 feet long. The longitudinal joints are slip-joints riveted together; the circular joints are made by slipping 4 inches of the end of one section into the next without riveting, and are wrapped around with rags. There are no air-valves. For 5 miles the pipe falls 5 feet to the mile, and water is then raised 320 feet in a distance of 6,200 feet by steam pumps driven by a 50 horse-power compound engine; thence to point of delivery the grade is 11 feet per mile. The greatest pressure is stated at about 40 pounds per square inch.

RESERVOIRS.—For the purpose of storing water for use during the dry season many of the mining and water companies have constructed expensive dams, forming large reservoirs. These dams are built of logs, stone, or earth and brush, or a combination of these materials, and are commonly faced with water-tight planking. Culverts, gates, and strainers are provided for drawing off the water. In California there are many such fine examples of engineering skill, costing upward of $100,000 each, from 60 to 130 feet high, with catchment basins of from 5 to 30 square miles. Some idea of the magnitude of these dams and reservoirs may be gained from the following list (a) of the respective capacities of reservoirs on the Feather, Yuba, Bear, and American rivers, in California:

TABLE XCIV.—RESERVOIRS ON THE FEATHER, YUBA, BEAR, AND AMERICAN RIVERS IN CALIFORNIA.

Name.	Capacity in cubic feet.
Total storage	7,600,000,000
North Bloomfield	1,050,000,000
Milton	630,000,000
Eureka lake	1,130,000,000
South Yuba	1,800,000,000
Omega and Blue Point	300,000,000
Spring Valley	300,000,000
California	600,000,000
El Dorado	1,070,000,000
Other small reservoirs on the Feather, Yuba, and American rivers.	700,000,000

ACCIDENTS TO DITCH LINES.—Few lines escape without more or less small breakages or washouts during a season's run. At times, when the ditches are not in use, they are also liable to damage from storms, slides, and other causes; but it seldom happens with well-constructed lines that any serious injury is received sufficiently great to be termed an accident. Inquiries made as to the accidents which occurred during the year, their character, cause, and effect, developed the fact of their infrequency. The subjoined analysis of the answers received on this head shows that out of 175 lines examined, representing 3,049½ miles, only 24 reported accidents of any kind, however trivial, while 116 reported no accidents, and 35, in which there were also probably none, returned no account of any.

TABLE XCV.—ACCIDENTS TO DITCH LINES.

State or territory.	Number of ditch lines reported.	Number reporting accidents.	Number reporting no accidents.	Blanks, probably no accidents.
Total	175	24	116	35
Alabama	1	1		
Arizona	3		2	1
California	65	9	31	25
Colorado	8	1	6	1
Dakota	6		5	1
Georgia	8		7	1
Idaho	17		17	
Montana	11	2	9	
Oregon	56	11	39	6

a From Lieutenant-Colonel Mendell's report, page 13, quoted on the authority of Mr. Hamilton Smith, jr.

Among the accidents reported the following cases serve to illustrate the more common causes of damage:

In Alabama the Idaho ditch, in Clay county, suffered from small caves and washouts, caused by the boring of cray-fish. The usual remedy for this annoyance consists in putting in fluming instead of reconstructing the ditch.

In California the Feather River and Ophir line, at Oroville, Butte county, reports injury from several slides on the hill-side, requiring a considerable force for repairs and entailing a delay of fourteen days. The Mokelumne and Campo Seco line, in Calaveras county, met with breaks caused by heavy storms and also by the burrowing of gophers. The superintendent states that gophers are the worst enemies of ditch-owners in this locality. In Del Norte county a slide in the ground carried away part of the Del Norte ditch, which had to be replaced by fluming; and a reservoir belonging to the Hungarian Hill Mining Company, in Plumas county, was swept away during the month of May, entailing a loss of $4,000 and much inconvenience. Heavy storms of rain and snow caused slides and breaks in the ditches of the Fort Goff line at Sciad Valley, Siskiyou county. The Buckeye ditch, in Trinity county, was also badly damaged by a slide during the winter, while the Lewiston ditch at Junction City, the Trinity at Taylor's Flat, and Chapman & Fisher's line, all in the same county, suffered more or less from slides.

The only accident reported from Colorado was the breaking of a short section of a flume in California gulch, Lake county, owing to the rottenness of the wood.

In Idaho the casualties were of too small importance to be classed as accidents.

The Bannock ditch, in Beaver Head county, Montana, had two considerable breaks, one caused by flood and the other by gradual undermining, necessitating repairs to the extent of $1,000. In the same county the White Bar flumes were broken by rock falling upon them from the cliffs.

In Oregon quite a number of minor accidents occurred. The line of J. N. Osborne & Co., in Chicken Creek district, Baker county, broke five times during the year, 60 feet of flume being carried away on each occasion; but the repairs were promptly made, and only a delay of ten days ensued. A slide injured the Nelson ditch, Pocahontas district, in the same county, but the damage was repaired by ten men in five days. In Shasta district, also in Baker county, five rods of the El Dorado ditch were washed away, and in Sumter district the Young & Rimbol line met with two slight accidents—one from a snow slide, caused by the rapid melting of the heavy snow, and one from the ditch overflowing. In Coos county the Pioneer ditch was damaged by the caving and breakage of the embankment and the flume fell in places. Part of the Thompson flume, in Marysville district, Grant county, was blown down during the winter, but it was repaired before the opening of the season. In Jackson county the Squaw Lake ditch, Applegate district, was filled by a heavy snow-storm in the beginning of January, which caused a suspension of mining for seventeen days and necessitated constant repairs to the ditch during that month and throughout February. The Sterling ditch, in Sterling district, was broken in three places, and was repaired by putting in flume boxes at the weakened spots without much delay. At Wolf Creek a slide of land and snow carried away a section of Gross Brothers' main ditch, and for two months the line was in an insecure condition. The Blue Gravel ditch, in Josephine county, reports a few small breaks, without serious effects.

The foregoing "chapter of accidents" covers the more frequent vicissitudes to which artificial water channels are subject. That the injuries are not of greater moment is owing to the constant inspection and prompt attention given to strengthening weak and threatened points. Some disasters, such as those caused by very heavy storms and unusual freshets, are inevitable even with the most painstaking supervision; but the surest guarantee of security is a strict observance of the time-honored maxim, especially applicable to ditch-tenders, that "a stitch in time saves nine". The first insidious attacks of flowing water are easily combated if detected at an early stage; it is only when they are allowed to pass unnoticed and unchecked that they become irresistible, as a spadeful of dirt at the right moment will often obviate the necessity for days of repairs.

Repairs.—The ordinary trifling damages are considered by owners as matters of course, and their repair is looked upon in the light of a regular and necessary item of expense, included under the general head of work preliminary to resuming operations at the beginning of each season. While such small breakages, as a rule, are individually slight, they amount in the aggregate to a large annual tax upon the water interests; and even with single lines their frequent recurrence entails large expense, while the general overhauling, cleaning, puddling, and strengthening of the longer ditches calls for a heavier outlay than does the average "accident", and sometimes reaches a high percentage on the original cost of construction. The repairs during the year on the Mokelumne and Campo Seco line, in Calaveras county, California, for instance, amounted to $6,000, as against a first cost of $50,000, or 12 per cent.; on the Round Valley, in Plumas county, they reached 6 per cent.; on the Plumas, in the same county, $10,000 on an investment of $50,000, or 20 per cent., including, however, a thorough regrading of the ditch; the Rock Creek line, in Deer Lodge county, Montana, $2,500 in repairs, against $20,000 first cost, or 12½ per cent.; and many others ranged from 3 to 15 per cent. Among lines calling for large expenses of this kind may be mentioned the Spring Valley, $5,000 per year; the Morris Ravine, $4,500; the Happy Camp, $1,000; the California, $2,500; the El Dorado, $9,600; the Park Canal, $2,000; the South Yuba, $15,000; the Gold Run, $2,000; the Iowa Hill, $3,000; and the Tuolumne, $8,000—all in California; the Elk River, in Colorado, $2,400; the East Moore's Creek, $1,000, and Plowman, $1,400, in Idaho; the Bannock, $1,000, in Montana; and the El Dorado, in Oregon, $6,240; the Osborne, Placer Gold, Borne & Lucas, Squaw Lake, Farris Gulch, and Sterling lines entailing an annual expense for repairs of $1,000 each or over.

The smaller, cheaper, and less permanent lines require lighter annual expenditure per mile for repairs than the plant of the greater engineering enterprises, but these repairs amount to a higher percentage upon first cost. The yearly improvements (other than repairs included under the head of general labor) upon 2,836½ miles of ditch amounted to $114,365 50, or $40 32 per mile. This corresponds to a yearly tax of 1.06 per cent. upon an original investment of $10,780,414 31. A similar rate of expense is assumed to have been incurred by 213 additional miles scheduled, bringing the total for 3,049½ miles up to $122,953 66. In the absence of data for estimating what proportion of the repairs incidental in operating 7,733½ miles of ditch included in the total plant are to be assumed as additional to the cost of regular attendance, or even what proportion were in active use, the arbitrary ratio of $10 per mile is assumed as being within the probabilities. As the lines not included in the schedules of the experts were, as a rule, of the less important class, it is not probable that their cost of maintenance would be so high as that of the scheduled lines. To recapitulate:

Annual cost of repairs on 2,836½ miles of ditch (as given by schedule returns)	$114,365 50
Estimated annual cost of repairs on 213 miles scheduled, but without specified cost	8,588 16
Estimated annual cost of repairs on 7,733½ miles not scheduled	77,335 00
Total	200,288 66

WAGES OF EMPLOYÉS.—The price paid for labor varies greatly in different localities. In Georgia, for instance, as low as 50 cents per day is reported, while in Dakota, Idaho, and Montana, where the cost of living is necessarily very high, the pay often reaches $4. California, which contains the largest artificial water system, shows a medium status in respect to wages, the rates paid being sufficient to maintain the employés comfortably and yet not severely taxing the ownership. Wages at $3 per day in the latter state admit of better living than would $4 in the territories. Chinese laborers receive much less than do the whites, usually from $1 30 to $2 per day; though in some cases as much as $3 per day is earned by skilled Chinese in Idaho. As a rule, their pay averages from one-half to two-thirds that of white men engaged in the same character of work. It is customary in some districts for the employés to mess together, receiving board in part payment. The following statements give the range of salaries and wages (without board) in different parts of the country:

ARIZONA.—Ditch tenders, $60 per month to $3 per day.

CALIFORNIA.—Superintendents, $100 to $250 per month; collectors, $75 per month; bookkeepers, $50 per month; ditch builders, $3 per day; ditch tenders, $1 50 to $3 per day; Chinese laborers, $1 30 per day.

COLORADO.—Ditch tenders, $2 50 to $3 per day.

DAKOTA.—Ditch tenders, $2 50 to $4 per day.

GEORGIA.—Ditch tenders, 50 cents to $1 50 per day.

IDAHO.—Ditch builders and tenders, $4 per day; Chinese ditch cleaners and laborers, $2 25 to $3 per day.

MONTANA.—Ditch tenders, $60 per month to $4 per day.

OREGON.—Ditch tenders, $40 per month to $3 per day.

The length of shift for ditch employés is from ten to twelve hours per day, more commonly the longer time, depending upon the number of hours run in the hydraulic mines supplied by the ditches. The average price per day for all employés, Chinese included, is $2 75, without board.

An examination of the reports from scattered districts shows an average of one person employed for every 10 miles of ditch; but this does not include the irregular attendance upon ditches by men engaged for the greater part of their time in hydraulic mining, and who are consequently classed with the regular mine force. The wages paid to the force employed for a short period at the beginning of the supply season in making repairs and overhauling the lines preparatory to active operations are also considered in the foregoing statement of cost of repairs. In the same way the men at work in constructing new lines are also excluded from the regular force of the ditches, as their wages appear under the heading of cost of plant. The wages of employés usually continue only during the water season, though a few of the more important lines, which do not furnish water during the whole year, keep a small force constantly occupied. The amount paid for attendance during the season of 1880 is estimated at $626,991 75, being the wages of 1,078 employés of all classes for 211½ days at an average pay of $2 75 per day.

DURATION OF DITCH LINES.—From reports on 142 ditch lines it is found that the average date of the original construction of the lines now in operation, so far as reported upon, was 1867, which may be taken as the time of greatest activity in ditch building. Many of these ditches, however, have been enlarged or improved since that time to such an extent as to amount to a virtual reconstruction. A few ditches in California and Oregon still in useful service date back to 1850. Of existing ditches in Montana the oldest were built in 1861, and in Idaho the oldest date from 1863; but the average life or period of useful duration from the time of first construction up to the close of the census year is thirteen years. For California, owing to the earlier inception of hydraulic mining, the average is still higher, or eighteen years.

SALE OF WATER.—Of the ditch lines reported upon, 72 per cent. supply water only to mining ground held under the same ownership as the water rights, and do not sell water, either the whole or in part. Some of the more important lines are owned by water companies which do not themselves use the water for mining or other purposes, but derive their revenue solely from the sale of water to hydraulic mines, quartz-mills, etc., or for irrigation and domestic use. A larger number of water owners, however, sell only such quantity as is a surplus above what is required for supplying their own mines, this surplus being either a constant amount beyond their own requirements, or the balance of water running in the ditches toward the close of the season, at times when the supply is too low to be available for working their own claims. The amount required varies greatly with the "rig" of different mines, it being possible to work some claims with much less water than is demanded by others, and also to continue ground-sluicing after the supply is too light for hydraulicking. Very frequently, too, a head of water, having become insufficient for operating the higher hydraulic mines, is still useful on lower ground, where the fall partly offsets the deficiency in quantity. The proportionate extent to which the ditch lines (including water rights) and the mining property are held under the same ownership is illustrated in the following analysis. Possibly with fuller returns this proportion (72 per cent) of unity of ownership would be still higher, as the reports are mainly of the larger ditch lines—that is, those which are more apt to be sellers:

TABLE XCVI.—SALE OF WATER.

State or territory.	Number of ditch lines reported.	Number of lines which sell water in part or wholly.	Number of lines which supply only owners' mines.
Total	143	40	103
Alabama	1		1
Arizona	2		2
California	40	14	26
Colorado	6		6
Dakota	6	1	5
Georgia	8	3	5
Idaho	17	10	7
Montana	11	3	8
Oregon	52	9	43

In California the rates charged for water vary greatly, the lowest price reported being 3 cents per inch for twenty-four hours, in Butte county. In the same county, however, another line charges 5 cents per inch for ten hours. Other rates are 5, 7, 10, and 12 cents per inch for twenty-four hours, the highest price reported for that length of time for water used in hydraulic mining being 25 cents per inch. One company in Calaveras county charges 10 cents per 24-hour inch for first water, but less for water which is used over again. One mine in Del Norte county sells its surplus of water to small claims at $50 each per season, and after closing down its own works sells the whole of the water running during the balance of the season. A large water company in El Dorado county has the following scale of prices: To hydraulic mines, 6½ to 10 cents per 10-hour inch, according to quantity purchased; to quartz-mills, 20 cents per 24-hour inch; for irrigation, 25 cents per 24-hour inch. Another large company in Tuolumne county, which supplies water also for two flour-mills, one foundery, and other power, as well as for irrigation, etc., reports the following price-list for water used in hydraulic mining:

One stream of 12 inches	per day..	$3 00
One stream of 15 inches	do....	3 50
One stream of 18 inches	do....	4 00
One stream of 21 inches	do....	4 50
One stream of 24 inches	do....	5 00
For larger amounts up to 48 inches	per inch..	20
From 60 to 100 inches	do....	18

A company in Shasta county which receives 5 cents per 10-hour inch asks 10 cents for 24-hour inch. These last rates may be taken as the average throughout the state for localities well supplied with water and during favorable seasons.

The quartz-mills in Whitewood district (Black hills), Dakota, pay for water-power at the low rate of $2 a week per stamp.

In Georgia the rates reported are 12 and 12½ cents per inch.

The prices paid in Boisé basin, Idaho, are 10, 12½, 13, 15, and, in one case (a small head of 100 inches), 30 cents per 24-hour inch. Rates in this locality vary according to the quantity sold, and also according to the elevation of the delivery point above the claims supplied. Thus, of two parallel ditch lines, one, the lower, sells water at 10 cents per inch, while water from the higher line commands 15 cents. One firm owning a large area of placer ground which is controlled by their own water rights makes a practice of leasing claims to Chinese miners free of charge for the profit in selling water to them. It may here be remarked that in some districts it is not unusual for the Chinese to be taxed a considerably higher water rate than is charged to white miners.

The rates reported in Montana are 10 cents per 10-hour inch, 16 cents per 20-hour inch, and 15 cents per 24-hour inch.

In western Oregon the conditions are similar to those in California, the price of water quoted in the schedules being, if anything, slightly lower than in the latter state. Rates reported in Baker county, in the eastern part of the state, are 8, 10, 12½, and 15 cents per 10-hour inch, and in one case as low as 7½ cents per 24-hour inch. The lowest price stated for this county is one lease of 275 inches (full time) for $30 per week, or only 1½ cents per inch daily—possibly an error. One ditch-owner here has adopted a sliding scale of prices regulated by the relative mining profits of his customers, charging more for water supplied to the best producing claims than to those which do not pay so well. The report does not state whether this discrimination is for the purpose of encouraging the mining industry, or whether, as in other matters, the price is determined by what the buyer can afford to pay. In Grant county a somewhat similar discrimination is noted, 50 cents per inch of twelve hours being charged for water used in washing drift dirt, as against 6 cents per inch for the same time for hydraulic mining, though in this case the element of relative quantity is perhaps the deciding consideration.

It may be laid down as a general rule that the price of water depends not so much upon its scarcity or abundance, or upon the expense of conveying it, as upon the status of the mining interest in any given locality. Thus, when a new placer camp is first opened and the miners are making large profits by working only the richer spots, they are willing and able to pay the owners of water rights rates which, in the subsequent seasons, when the best ground has been exhausted, would be prohibitory. In working large masses of gravel, containing only a few cents per cubic yard, the closest economy is necessary to a profitable result; and if the miner finds that with a certain water tax his net outcome is not satisfactory, then the water-owner, perforce, has to reduce his charge or let his ditches lie idle. This fact establishes a natural equilibrium.

Competition does not affect prices to the extent which might be supposed. In a large number of cases, for a given gravel deposit there is practically only one available source of supply, owing to the manner in which water rights are secured. Where there is competition, the higher head of water, other things being equal, commands the better terms.

THE MINER'S INCH.—The miner's inch is a simple and convenient measure of water, an early outgrowth of hydraulic mining, and is the recognized unit upon which prices are fixed and estimates of efficiency based. It is, however, an entirely arbitrary standard, varying considerably in different districts according to the local definition prevailing, and is occasionally of irregular value even in the same district. This variation is practically not a matter of very great consequence, as the range in price is far wider than that of measure; but, for the purpose of comparison, it would undoubtedly be an advantage if a uniform standard and an identical mode of applying the measurement were adopted throughout the country.

The conditions which affect the value of the inch are the head (measured in some cases from the top and sometimes from the center of the orifice); the form of the aperture, its height, and in a less degree the distance between its lowest point and the bottom of the measuring box; the thickness of the plank or partition through which the water flows; and the nature of the approaches, and the character of the fall on the delivery side of the aperture. As these conditions are varied in different localities, the amount of water delivered varies correspondingly. The following deductions (*a*) from experiments on the discharge of fluids from reservoirs are here applicable:

1. That the quantities of a fluid discharged in equal times by the same apertures from the same head are nearly as the areas of the apertures.

2. That the quantities of a fluid discharged in equal times by the same apertures, under different heads, are nearly as the square roots of the corresponding heights of the fluid above the surface of the apertures.

3. That the quantities of a fluid discharged during the same time by different apertures, under different heights of the fluid, are to one another in the compound ratio of the areas of the apertures and of the square roots of the heights of the fluid above the center of the aperture.

4. That, on account of the friction, small-lipped or thin orifices discharge porportionally more fluid than those which are larger and of similar figure under the same height of fluid.

The most common definition of the miner's inch is "the amount of water discharged through an opening 1 inch square under a pressure of 6 inches above the opening". This is qualified in some districts by limitation as to the thickness of the partition, which is usually a 2-inch plank. The standard of pressure is irregular, being sometimes more and sometimes considerably less than 6 inches, but the ordinary range is from 4 to 6 inches. The abstract definition and the mode of applying the measurement do not, however, always coincide. In practice, for the sake of convenience in measuring large quantities, a higher aperture than that of 1 inch is often used, in order to dispense with very wide gauge-boxes. Thus, an opening 2 inches high delivers 2 "miner's inches" per inch in width of the box; that is, if the aperture extends across 20 inches, it will deliver 40 miner' inches. The opening is sometimes made still higher; if 3 inches, then each inch in width delivers 3 miner's inches, and if an aperture of this height is 20 inches wide it will deliver 60 miner's inches. Table XCVII shows the varieties in definition and in application as given by schedule answers from 146 hydraulic mines in different localities.

a Engineers' and Mechanics' Pocket-Book, Charles H. Haswell, 1879, p. 359.

TABLE XCVII.—VARIOUS DEFINITIONS OF THE MINER'S INCH, AS REPORTED IN SCHEDULES.

Definition locally accepted.	Total number of replies, according to nature of definition.	Arizona.	California.	Colorado.	Dakota.	Georgia.	Idaho.	Montana.	North Carolina.	Oregon.	South Carolina.	Utah.
Total number of replies, by states and territories	146	2	45	10	11	9	3	13	1	50	1	1
Stream of water passing through—												
"A square inch orifice under 6-inch head" (thickness of partition and point from which pressure is measured, whether top, center, or bottom of orifice, not stated).	97	1	20	10	11	5	1	11	......	38	......	......
"A square inch orifice under 6-inch head above top" (thickness of partition not stated)	1	......	......	......	......	......	......	......	......	......	......	1
"A square inch orifice under 6-inch head, measured from center; 2-inch plank"	3	......	3	......	......	......	......	......	......	......	......	......
"A square inch orifice under 6-inch head" (point from which pressure is measured not stated); "2-inch plank".	7	......	7	......	......	......	......	......	......	......	......	......
"A square inch orifice under a head varying from 4 to 6 inches"	2	......	2	......	......	......	......	......	......	......	......	......
"A 1-inch orifice under 4-inch head"	7	......	3	......	......	4	......	......	......	......	......	......
"An orifice 2 inches high under 5-inch head" (delivering 2 miner's inches per inch in width of orifice).	1	......	1	......	......	......	......	......	......	......	......	......
"An orifice 2 inches square under 6-inch head from center" (= 4 miner's inches).	1	......	......	......	......	......	......	......	......	1	......	......
"An orifice 3 inches high under 3-inch head" (delivering 3 miner's inches per inch in width).	9	......	......	......	......	......	......	......	......	9	......	......
"An orifice 3 inches high under 6-inch head" (delivering 3 miner's inches per inch in width).	1	......	......	......	......	......	......	......	......	1	......	......
"An orifice 4 inches high under 4-inch head" (delivering 4 miner's inches per inch in width).	2	......	1	......	......	......	......	......	......	1	......	......
"An orifice 4 inches high under 6-inch head, above top of aperture" (delivering 4 miner's inches per inch in width).	1	......	......	......	......	......	1	......	......	......	......	......
"An orifice 6 inches high under 3-inch head above top, shingle partition" (delivering 6 miner's inches per inch in width).	1	......	......	......	......	......	1	......	......	......	......	......
A delivery of—												
"10 gallons per minute"	2	......	......	......	......	......	......	1	1	......	......	......
"675 gallons per hour"	1	1	......	......	......	......	......	......	......	......	......	......
"1.5 cubic feet per minute"	1	......	......	......	......	......	......	1	......	......	......	......
"10 gallons per minute; or, water flowing through an orifice 1 inch square in a thin vertical partition, under 5-inch head."	1	......	......	......	......	......	......	......	......	......	1	......
Running inch: in cross-section of ditch or flume, without pressure	8	......	8	......	......	......	......	......	......	......	......	......

The average delivery of the common miner's inch, as determined by Mr. J. D. Hague, is 1.5625 cubic feet per minute, 93.75 cubic feet per hour, and 2,250 cubic feet per twenty-four hours.

Very careful experiments were made in 1874 by Mr. Hamilton Smith, jr.,(a) at Columbia Hill, California, latitude 39° north, elevation 2,900 feet above sea-level. The module used was a rectangular slit 50 inches wide and 2 inches high, pressure 7 inches above the center of the opening. The discharge was over a 3-inch plank, the last inch chamfered. The size of the opening was taken with a measure (micrometer attached) which had been compared with and adjusted to a standard United States yard. Time was read to one-fifth of a second. The level of the water (drawn from a large reservoir) was determined with Boyden's hooks, micrometer adjustment. The following results were obtained:

	Cubic feet.
One miner's inch will discharge in one second	0.02624
One miner's inch will discharge in one minute	1.5744
One miner's inch will discharge in one hour	94.4640
One miner's inch will discharge in twenty-four hours	2,267.1360

Ratio of actual to theoretical discharge, 61.6 per cent. These figures are stated to be within the limit of 1–500 possible error.

In 1878 a further series of experiments to determine the effective value of the above described inch (which is that used at the North Bloomfield, Milton, and La Grange mines), made at La Grange by Mr. Aug. J. Bowie, jr., gave the following results:

	Cubic feet.
One miner's inch discharged in one second	0.02499
One miner's inch discharged in one minute	1.4994
One miner's inch discharged in one hour	89.9640
One miner's inch discharged in twenty-four hours	2,159.1360

Ratio of effective to theoretical discharge, 59.05 per cent.

At Smartsville, Yuba county, California, the water is measured by a 4-inch orifice with a 7-inch board top, or a pressure of 9 inches above the center of the aperture, each inch in width giving 4 miner's inches. The bottom of the aperture is flush with the bottom of the box, and the board top is 1 inch thick. Mr. Thurston's determination of the value of this unusually large miner's inch is 1.76 cubic feet per minute, 105.6 cubic feet per hour, and 2,534.4 cubic feet per twenty-four hours for each square inch of the opening.

For the purposes of this investigation the average delivery of the miner's inch is assumed to be 700 gallons per hour, which corresponds to 0.1944+ gallon per second, 11.666+ gallons per minute, and 16,800 gallons per twenty-four hours.

a *Transactions of the American Institute of Mining Engineers*, vol. vi, p. 59.

. GAUGE-BOXES.—One of the simplest forms of the common instrument for measuring water is described in the report upon the placers of Boisé basin, Idaho. In this particular case the box, made of 1½-inch pine boards, is 48 inches wide, inside measurement, by 16-inch sides. Across the bottom, at the delivery end of the box, is nailed a 1-inch cleat or strip, which serves the double purpose of holding the lower part of the gauge-box in place and of raising the aperture above the bottom of the box. Six inches above the upper surface of this cleat is a wooden bar nailed across the box and parallel to the cleat beneath. The bar is 3 inches high, and is roughly marked at intervals of 1 inch across the upper edge of the supply side by saw-notches, which may be numbered by pencil-marks. The orifice is therefore 6 inches high, and when fully open is 48 inches wide. If the water in the box rises to the top of the cross-bar, the head is 3 inches above the top of the orifice, or 6 inches above its center. Each inch in width of the aperture delivers 6 miner's inches, or a total of 288 miner's inches for the cross-section of the whole aperture. The quantity of water allowed to pass through the box is determined by a gauge-board split to the required width and inserted vertically behind the cross-bar and bottom cleat, which hold it in position. In using the box in a ditch any space outside of it is securely caulked with clay. It is a convenient form of movable gauge, which may be modified to accord with any of the various accepted definitions of the miner's inch.