tions, the altitude descends toward the north, the country being lower in northern Montana than in eastern Colorado. This fact is emphasized because of the commonly expressed opinion that water might be diverted from Missouri River and carried out southerly along the upper edge of the Great Plains, furnishing an abundant supply for this vast area. It is, however, impracticable to divert the Missouri River to cover any considerable portion of these dry lands.

Montana, like Colorado, extends from the Great Plains westerly across the Continental Divide, fully two-thirds of the state consisting of rolling lands and plateaus broken by occasional mountain masses. Here the water supply is scanty, although this part of the state is traversed by two large rivers — on the south by the Yellowstone, and on the north by the Missouri, these uniting at the eastern border. The western third of the state is mountainous and comparatively well-watered, these high mountain masses furnishing perennial streams, necessary to the utilization of the low-lying valleys with fertile soil and genial climate. The great problems of the development of Montana relate to the possibilities of obtaining water for the vast extent of great plains away from the mountains.

The ease with which water could be brought upon land and the presence of a market at the mines within the mountains have caused western Montana to be the most thickly populated and

well-cultivated part of the state, while the great eastern plain or prairie region, with its almost boundless extent of rich soil and its great rivers, the Missouri and Yellowstone, is almost unsettled.

The most important agricultural area is in Gallatin Valley, of which Bozeman is the principal town. Here alfalfa and cereals are raised, barley especially being of superior excellence and value. East of this, and along the Yellowstone River, in the vicinity of Billings and other towns, are numerous areas under cultivation. Northerly from these localities and extending across the state are various points where irrigation has been introduced, especially in connection with stock raising, water being taken principally from the smaller streams which can be readily controlled.

Along Milk River, which flows from the northwest into Missouri River, settlement has progressed rapidly and irrigation has been attempted, but the supply of water is far below the demands. To remedy this condition, surveys have been made to ascertain the practicability of diverting the water from Saint Mary River, which receives the drainage of a part of the snow-clad Rocky Mountains, and flows northerly into Canada, being separated from Milk River by low gravel ridges of glacial origin. It has been found possible to bring a large canal through these ridges, restoring to its eastern course the water which, until prevented by glacial deposits, presumably flowed easterly across the plains.

Mining is the principal industry of the state, this being confined to the mountains in the western end. Next to this in importance is stock raising; the greater part of the state is devoted to this business, the great herds of cattle fattening on the open public land for the Eastern market. Irrigation has been carried on largely as an adjunct to the cattle business, in order to furnish hay for the winter feed. Proper control of the free grazing is one of the great problems now presented.

The importance of irrigation is steadily increasing as settlers push in, and the open ranges are being more and more crowded with cattle, horses, and sheep. The resulting overgrazing necessitates occasional feeding, especially in winter, and this in turn calls for an increase of irrigated area, in order that hay and particularly alfalfa may be produced. The necessity of winter feeding and the greater labor thus involved tend to reduce the large herds, as noted on p. 40, and to increase the number of small ranches, whose owners can give personal attention to their cattle grazing on the surrounding lands.

NEVADA.

Nevada, although of great extent, enjoys the unenviable reputation of being, in population, the smallest state in the Union, and of having decreased rapidly in this respect. The number of persons in 1890, about 45,000, has in ten years diminished to a little over 42,000, there being fewer people than

in Alaska or in any of the seven territories now under the control of the United States. The decrease in population has resulted mainly from the lessened output of the mines and neglect to make use of the agricultural possibilities.

The total land surface of the state is 109,740 square miles, almost exactly that of Italy, which has a population 750 times as great. In 1900 there were irrigated 510,000 acres, most of this being devoted to raising hay. A considerable portion of this half-million acres is made up of lands partly overflowed by the Humboldt and other rivers, the flooding being assisted in a relatively small degree by ditches and by dams placed in the stream. In point of cost and value, such irrigation is by no means comparable to that practised in many other states, being little more than an attempt at assisting nature in spreading water over the surface during spring floods.

The state lies almost wholly within the Great Basin, a region from which no streams escape to the sea. The rivers, flowing from lofty mountains, continue out upon broad valleys, and their waters are finally lost in extensive marshes or open lakes, the evaporation from the surface balancing the inflow. In former geologic ages, when the rainfall was presumably greater, these valleys were occupied by large bodies of fresh water, which discharged probably toward the north, increasing the flow of Columbia River. The Great Basin

extends easterly beyond the boundaries of Nevada and includes a large part of the state of Utah.

On the western border of the state are the high mountains, the Sierra Nevada, which are almost wholly within the state of California, the boundary line being drawn along the eastern slope below the main summits. These mountains fend off the moisture coming from the Pacific Ocean, and as a result the state of Nevada is as a whole the driest of all the arid states. High mountain masses irregularly distributed over the Great Basin break up the surface, and from these flow small streams, the larger uniting to form the Humboldt River, which crosses the northern end of the state from east to west. The other important rivers are the Truckee, Carson, and Walker, which flow westerly from the Sierra Nevada.

Because of the extreme dryness of the country, the sections numbered 16 and 36, which in other states were devoted to educational purposes, have been in the case of Nevada left in the hands of the government, and in their stead a grant of 2,000,000 acres of public land has been made to the state. Most of this has been selected by cattle companies, lands being chosen in such a way as to include nearly all of the springs and smaller sources of water. Thus the cattlemen have been enabled to control practically the entire agricultural area through the ownership of the water, and settlement has been retarded.

The problem of transportation has also been one of fundamental importance to Nevada. There is only one main line of railroad, the Central Pacific, controlled by the Southern Pacific Company. The managers of this line have in the past apparently regarded the space between Utah and California as a great unavoidable gap to be bridged, and the development of population in this space has been practically accidental as far as the railroad is concerned. Few, if any, efforts have been made to facilitate settlement, and local traffic rates have been almost prohibitory. Thus it results that the natural aridity, preventing dry farming, the aggressions of the cattlemen, making settlement almost perilous, and the unfavorable attitude of the railroad, adding to the cost of home building, have deterred settlers and left the state to consist mainly of the remnants of a mining population.

The Truckee, Carson, and Walker rivers, flowing from the Sierra Nevada in California easterly into the valleys of Nevada, furnish by far the greater part of the water supply for the state. In the relatively small area along these rivers, adjacent to the California boundary, are the principal towns and most of the people. Scattered along Humboldt River, crossing the northern end of the state, are a number of small settlements, a few outlying mining camps being found farther south. Stock ranches for headquarters and supply places for the sheep and cattlemen are located at remote

points near springs, or at the mouths of canyons from which water issues upon valley land. Here small areas are irrigated, mainly for winter forage.

The development of the state will be possible by constructing reservoirs on the tributaries of Humboldt River, and even on the main stream, and particularly on the head waters of the rivers flowing from California. Interstate problems are involved in the latter undertaking, but surveys have demonstrated that works can be built at feasible cost to reclaim many thousand acres, making possible homestead settlement on the lands now valueless. The reservoir which has attracted the greatest amount of public attention is Lake Tahoe, at the head of Truckee River, and it has been shown that by holding its waters back by means of a suitable dam, water can be retained for the irrigation of thousands of acres.

In addition to the reservoir sites occupied in part by lakes and to which public attention has been especially drawn, there are broad valleys in which artesian water can possibly be had, and also many localities scattered through the mountains suitable for holding water. These are mainly small valleys, in some cases formerly occupied by glaciers, and later by lakes, which in course of time have cut an outlet through the lower rims. A comparatively small expenditure of labor and capital will close the outlets, and by this means bodies of water of considerable size can be held.

The rain and snow fall on these high mountains aggregates from 30 to 40 inches or more annually, this being sufficient to replenish the reservoirs if constructed.

NEW MEXICO.

New Mexico, although well within the arid region, presents many contrasts to Nevada. This results largely from the difference in population, and the way in which lands have been held and agriculture has been practised. The population of the state consists largely of Mexicans, and the cultivation of the soil is almost wholly in their hands. The territorial form of government still prevails, although the population, 195,310 in 1900, surpasses that of the states of Delaware, Idaho, Nevada, and Wyoming. The territory is three times the size of Ohio and has less than a twentieth of the population.

The oldest irrigation works in the United States are in this territory, having been built by the Pueblo Indians or their Mexican neighbors. The average size of an irrigated farm is small, the lands under ditch having been subdivided among the sons of the family instead of additional areas being brought under cultivation. The farmers, especially those of mixed Spanish and Indian descent, have followed the customs of their fathers, and show little energy or skill. The lands are tilled in a most laborious fashion, largely by hand, and the returns are small.

The eastern part of the territory has been, until recent times, the paradise of cattlemen and of outlaws, many of whom have taken temporary service in the retinue of one or another of the great cattle kings, and have alternated the business of "rounding up" cattle with that of keeping out settlers or evading the officers of the law. Within recent times, however, much of the lawlessness has been broken up, particularly since the introduction of irrigation along Pecos River, the advent of farmers, and the extension of railroads from the East and the South.

The Rio Grande, rising in southern Colorado, enters the territory from the north through deep canyons. These widen in places, allowing room for bottom lands, and again the walls die down, forming low mesas. The proportion of open land increases toward the south, and here are the principal towns and agricultural communities. The river itself tends to spread out over the bottom lands, and the greater part of its water gradually disappears by evaporation or by diversion into ditches, so that in the lower part of its course, above El Paso, Texas, the stream channel is frequently dry. There are very few large canals, but a great number of small community ditches supply lands held by the Indians and Mexicans. The origin of these ditches is lost even in local tradition, and it is probable that many of them were in use before the advent of white men. The

waters of the river are extremely muddy, especially after spring rains, and the sediment, carried in suspension, fills the ditches, necessitating frequent cleaning, especially of those having slight grade.

The development of the resources of New Mexico rests largely upon the control of the Rio Grande. On the head waters of this stream, in Colorado, are a number of large canals, the capacity of these being sufficient to take all of the river at that point. The seepage and inflow from small streams maintain the river at a moderate volume in northern New Mexico, but practically no water penetrates to the southern end of the territory during the irrigation season. There are a number of open valleys along the course of the Rio Grande and on its principal tributaries, where by building large dams great quantities of water can be held. Several of these localities have been surveyed.

The principal storage project is that above El Paso, where it has been proposed to construct a great international dam to regulate the flow of the Rio Grande where it forms the boundary between the state of Texas and the republic of Mexico. The periodical drying of the river and the shifting which takes place during occasional floods make the boundary a matter of great uncertainty, and result in continual irritation between the authorities on both sides.

There are few notable irrigation works along the Rio Grande, the ditches for the most part being

small and having temporary dams of brush and stone. These are swept away in time of flood and must be replaced after the spring freshets. The ditches do not, as a rule, extend beyond the lower land, and the terraces or mesas along the stream, usually having better soil, are not as yet cultivated. A considerable portion of the bottom land is alkaline, and many small farms have been abandoned and even towns deserted because of the accumulation of earthy salts. Drainage is in many localities almost as necessary as irrigation.

The typical Mexican farms consist of long, narrow strips extending from the foothills to the river and crossed by a ditch. The peculiar shape of these farms is due to the fact that, in dividing the inheritance, it is customary to give each heir an equal amount of the hill land and the frontage on the ditch and river; the result is that these tracts may be from 25 to 300 yards in width on the stream and a thousand or more yards long, extending up the slope to the ditch or beyond it to the hills. This causes much inconvenience in cultivating, and is accompanied by lack of economy in irrigating.

The ditches, as a rule, are owned in common by the farmers of each community, and one of the irrigators is annually elected superintendent, or majordomo. His business is to attend to all necessary repairs, regulate the distribution of water, largely according to his own judgment and experience, and in case of extensive work call upon all

of the farmers to contribute each his share of labor.

The largest irrigation system is that on Pecos River, in the southeastern part of the state, supplying land in the vicinity of Carlsbad, formerly known as Eddy. Here dams have been built across Pecos River, forming reservoirs, the largest of which is known as Lake McMillan. From the latter a canal extends along the river, branching to cover lands on both sides of the stream.

OREGON.

The western portion of Oregon, bordering on the Pacific Ocean, is humid. The belt of well-watered land extends easterly to the Cascade Range, which forms a barrier to the progress of the moist winds on their journey inland. About two-thirds of the state is on the eastern or dry side of the mountains, and in this portion irrigation is necessary for most crops, although wheat, barley, and rye are successfully cultivated by dry farming on the uplands around the Blue Mountains and near the Columbia River.

The country east of the Cascade Mountains may be pictured as a series of broad plains and mesas, covered with lava of various ages, from that outpoured recently to the ancient flows whose surface has largely changed into soil. This supports a dense growth of sage brush, and also juniper near the mountains, these being intermingled with forage plants. The vegetation becomes sparse out on the broad valleys, but nearly everywhere furnishes good grazing.

The erupted material forming the plains is similar in many respects to the vast sheets of lava or basalt covering the valleys of southern Idaho. These lavas occur around the Blue Mountains, and are apparently continuous from southern Idaho to the Great Bend country of the Columbia in central Washington. Volcanic cones rise from these plains, and the general level is interrupted in places by mountain masses whose lower portions have apparently been buried by the outpouring of fluid rocks. The altitude of this land is from 3000 to 4000 feet, the mountains rising to 8000 feet or over. The most important of these are the Blue Mountains, in the northeastern part of the state, which consist largely of extremely steep, rugged peaks, snow-capped for a considerable part of the year. The foothills of these mountains, at altitudes of from 5000 to 7000 feet and over, are covered with timber, much of it being pine of considerable value. From these highlands come the streams important in irrigation development.

Water storage is highly essential for the growth of agriculture in central Oregon. The streams are small and intermittent in character. Reservoir sites are known to exist on them, but none have been surveyed. Crooked River, which receives its supply from the Blue Mountains, is typical. It

has spring floods, which rapidly subside toward summer, until the channel of the stream is nearly dry. By building dams at a number of localities along its course it is probable that the summer flow can be increased to an extent sufficient to irrigate many thousand acres.

Similar to this is Silvies River, which flows out upon the northern edge of the Harney plain or desert. Where this stream leaves the canyon it has built a broad delta, through which the water meanders in a number of channels. Much of the ground is overflowed during the spring flood, and considerable areas, originally marshy, have been utilized as hay lands by slightly regulating the flow of the stream and by annually cutting the native grasses and weeds. The quality and quantity of these are greatly improved by this regular treatment. The area of valuable hay land has been increased by check dams placed in the diverging channels, causing the floods to spread on the low lands. The cultivation of more valuable crops can be made feasible by enlarging the canals from Silvies River, and especially by insuring ample water for summer through the construction of storage works. The same thing is true to a greater or less degree of the various tributaries of Malheur River and other streams issuing from the Blue Mountains.

Where a sufficient supply cannot be had from surface streams, it may be practicable to obtain

water from underground, particularly from artesian wells sunk in the broad desert valleys. The structure of some of these is known to be favorable to the accumulation of water, and it is highly important to make a thorough geologic examination, if necessary by the drilling of one or two wells of such depth as to penetrate the recent deposits and definitely determine whether flowing water can be had. By so doing maps can be prepared showing the depth to the water-bearing horizon and the probable height to which the water will rise. This is true of the broad valleys of central Washington, as well as of the Harney and Malheur valleys of Oregon. The soil of these is very fertile, and in many places the forage plants furnish good grazing; but the distance from springs or streams is so great that cattle cannot graze except during the winter season, when pools of water are occasionally formed. If a supply could be had from deep wells, the cattle and sheep industry would be greatly benefited and it is possible that considerable areas might be irrigated. With improved transportation facilities there will be opportunities for making many farms on the vacant land of central Oregon.

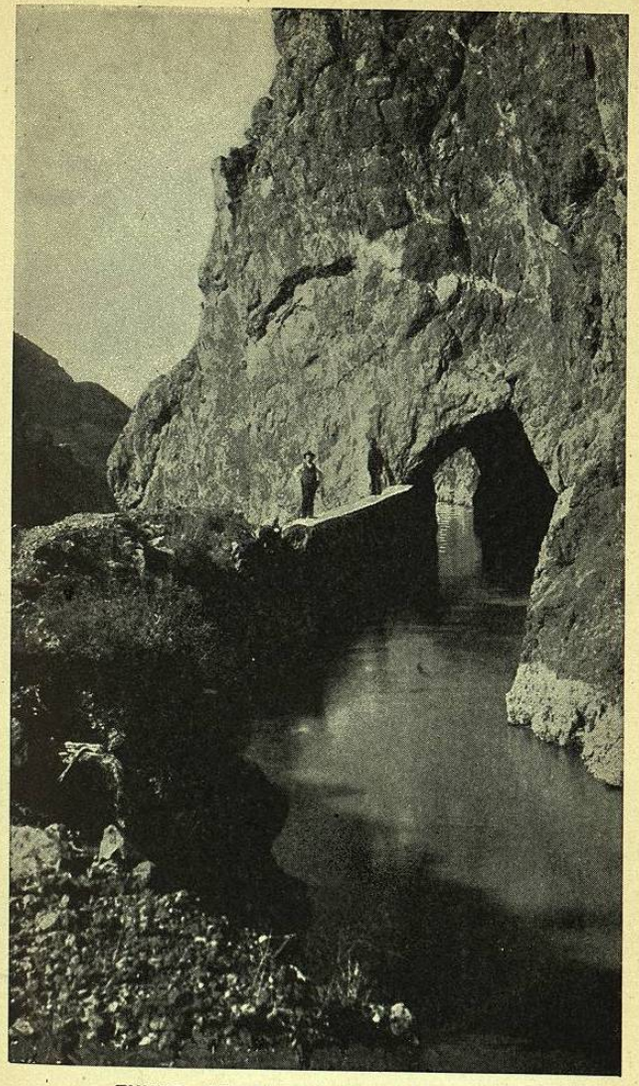
UTAH.

This state, occupying the central portion of the arid region, has led in the development of irrigation by associations of farmers tilling small areas.

The average size of an irrigated farm is less than in any other part of the country, and consequently the number of persons supported per acre is greatest. This has been due to the peculiar system of organization growing out of Mormon practices. The excellent results attained demonstrate the practicability of industrious pioneers supporting themselves and attaining prosperous homes on small tracts.

The land surface of the state has an area of 82,190 square miles — over ten times the size of Massachusetts — and the population in 1900 was 276,749, or one-tenth that of the latter state. The principal part of the population is on the narrow strip of land at the foot of the mountains east of Great Salt Lake and of the smaller body of fresh water, Utah Lake. Agriculture is dependent upon irrigation, except in the case of wheat and barley, which are raised by dry farming on some of the higher bench lands. In localities where snow covers the ground, it has been found possible, by summer fallowing and by planting hardy varieties of cereals in the fall, to obtain a good crop; and with skill gained by experience the area thus planted is being extended. For alfalfa and other forage plants, and for general farm crops, as well as for orchards, irrigation is essential.

The water supply of the state is relatively well distributed in a number of creeks and small rivers issuing from the Wasatch Range. These moun-



TUNNEL OF BEAR RIVER CANAL, UTAH.