THE LONG DISTANCE TRANSMISSION PLANT AT FRESNO, CAL.

One of the latest and, in many respects, one of the most remarkable long distance transmission plants is that which has been built by the San Joaquin Electric Company to supply the town of Fresno with light and power. Nature has made abundant provision for furnishing electric power along the valleys of the Pacific coast, the many streams which flow down the Sierra and the Cascade Mountains providing an abundant and never failing supply of water for this purpose.

Fresno is a thriving agricultural town of about 15,000 inhabitants, which lies in the midst of the far famed San Joaquin Valley, in Southern California. Founded about twenty-five years ago, its growth and present prosperity are due almost entirely to its agricultural interests. Manufacture on a large scale has been handicapped by the prohibitive cost of transportation and particularly by the high price of coal, which costs delivered in Fresno about $9 per ton.

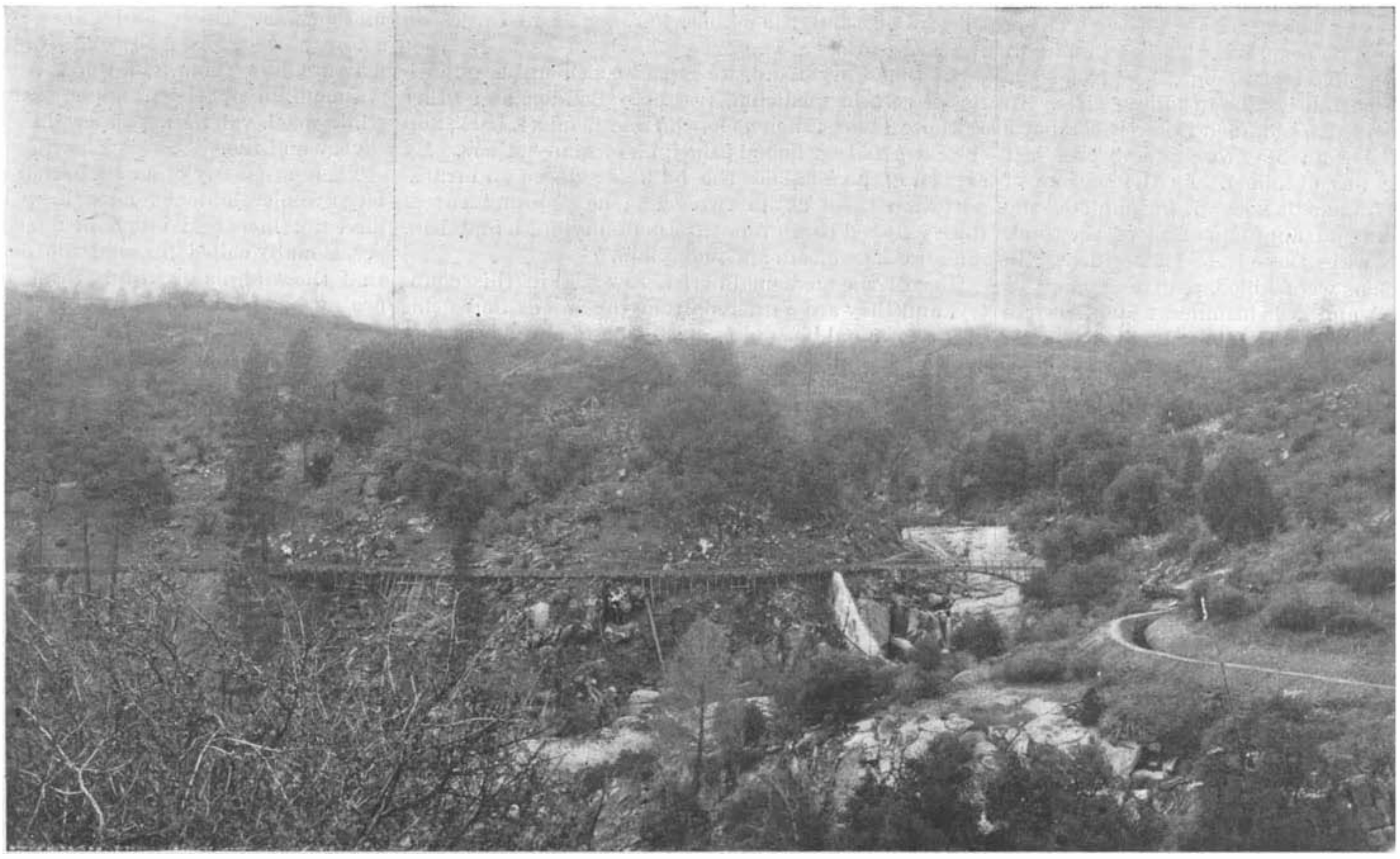


Fig. 8.—JUNCTION OF THE TWO DIVERSION FLUMES AT THE NORTH FORK—DITCH OF THE SOUTH BRANCH SEEN TO THE RIGHT.

Like many another town in the Sacramento and San Joaquin Valleys, Fresno has for many years looked with longing eyes to the magnificent water supply of the neighboring mountains, and the present transmission plant is the outcome of a very determined and equally successful effort on the part of the citizens which first took practical shape in the formation of the present company on April 2, 1895. The headwaters of the streams which supply the power are situated well up above the winter snow line, and the points of diversion from the north fork of the San Joaquin River and from a tributary known as the South Branch are about forty miles distant from Fresno. The water is taken from these rivers by wooden flumes of the usual construction, which are solidly bolted to the bed rock of the river to prevent their being washed away by the winter freshets.

They are fastened down by means of anchor bolts which are split open at the end and have a steel wedge inserted which, as the bolt is driven home in the rock, spreads out the metal and wedges it securely in place. Additional security is given by running melted lead into the holes. Two of our illustrations, Figs. 8 and 10, show the junction of the two flumes, at the north fork of the San Joaquin River.

The total length of the ditch is about seven miles, and of this some 3,000 feet is wooden flume. At every 4,000 feet of the distance there is a waste gate, one of which will be noticed in the illustration showing the junction of the diversion flumes. The ditch leads ultimately into a reservoir whose area is about eight acres. The site chosen for this work is a natural table land or plateau on the summit of Reservoir Mountain. The plateau is surrounded on three sides by rising ground, and on the fourth side it was merely necessary to throw up a ten foot embankment for a distance of about 500 feet. The reservoir has sufficient capacity to run the transmission plant for five and a half days. The pipe line, Fig. 1, leads from the reservoir down the side of the mountain to the power house, a distance of 4,000 feet, the total fall being 1,411 feet. The water is led into the pipe line through a series of bell-shaped mouths or openings, six feet in diameter, which are covered by a screen for preventing the passage of gravel and other debris. Water may be conveyed to the pipe line either directly from the ditch or the reservoir, the large admission gates being shown in Fig. 7.

The pipe line itself is built in three sections; the first, which is 1,820 feet long, consists of 24 inch riveted pipe, the first half being constructed of No. 12 steel, and the second half of steel ¼ of an inch thick. The second section contains 400 feet of welded pipe, which is 20 inches in diameter and lock jointed. The third section, 1,800 feet long, consists of 20 inch lap-welded pipe, with flange joints and rubber packing, the metal at the lower end being ⅝ inch in thickness.

The construction of the pipe line was commenced at both ends, and considerable difficulty was experienced in closing the gap at the center of the line. This was due to the alteration in length, resulting from the change of temperature. Before sunrise the opening was 7 feet 8 inches, but in the afternoon this gap would close to 7 feet, the change being due, of course, to expansion under the heat of the sun's rays. This difficulty was met by fitting a length of 20 inch lap-welded pipe to the adjoining ends of the pipe line before sunrise. The joint was leaded and calked, and the pipe filled with water before the heat could produce any expansion.

Some portions of the pipe line are laid from 5 to 8 feet underground; elsewhere it is carried on bridgework; but for the greater part of its length it is bolted to the solid rock. It is held in place by means of bolts, fastened in the manner above mentioned into the bed rock, the bolts having a screwed attachment to flat iron bands, ⅝ of an inch thick by 2½ inches wide, which pass over the top of the pipe. The pipe line terminates in a receiver, 30 inches in diameter and 57 feet long, which is secured over the wheel pit at the side of the power house, as shown in Figs. 3 and 5. The end thrust which comes upon the receiver is, of course, enormous, the pressure per square inch being 609 pounds, and the total thrust of the column of water no less than 93 tons. It is resisted by a heavy stone abutment, to which the receiver is attached by four heavy steel bolts, 2½ inches in diameter.

It is not surprising that in handling water under the enormous head of 1,411 feet some new and unexpected difficulties should have presented themselves. The greatest head with which engineers had hitherto been familiar was between 500 and 600 feet, but in the present case the head was between two and three times as great and the column of water was about 4,000 feet long and weighed about 317 tons. It might be said that in a certain sense the water lost its fluidity, and that when it issued from the 1⅛ inch nozzle at a speed of over 9,000 feet per minute it had some of the characteristics of a solid bar of metal. It was presumed that in the absence of any experience with a head of 1,400 feet it would be best to use large gates and relief valves of the same type as were used for a head of 500 and 600 feet. As a matter of fact, however, such was the great pressure upon them, and the resulting surface friction of the metal, that they proved to be quite inadequate.

With the gates at first installed, it was found that great difficulty and some measure of risk arose from the momentum of the column of water whenever the gates were opened or closed. The "water hammer" was sufficient to cause a fluctuation in the pressure of

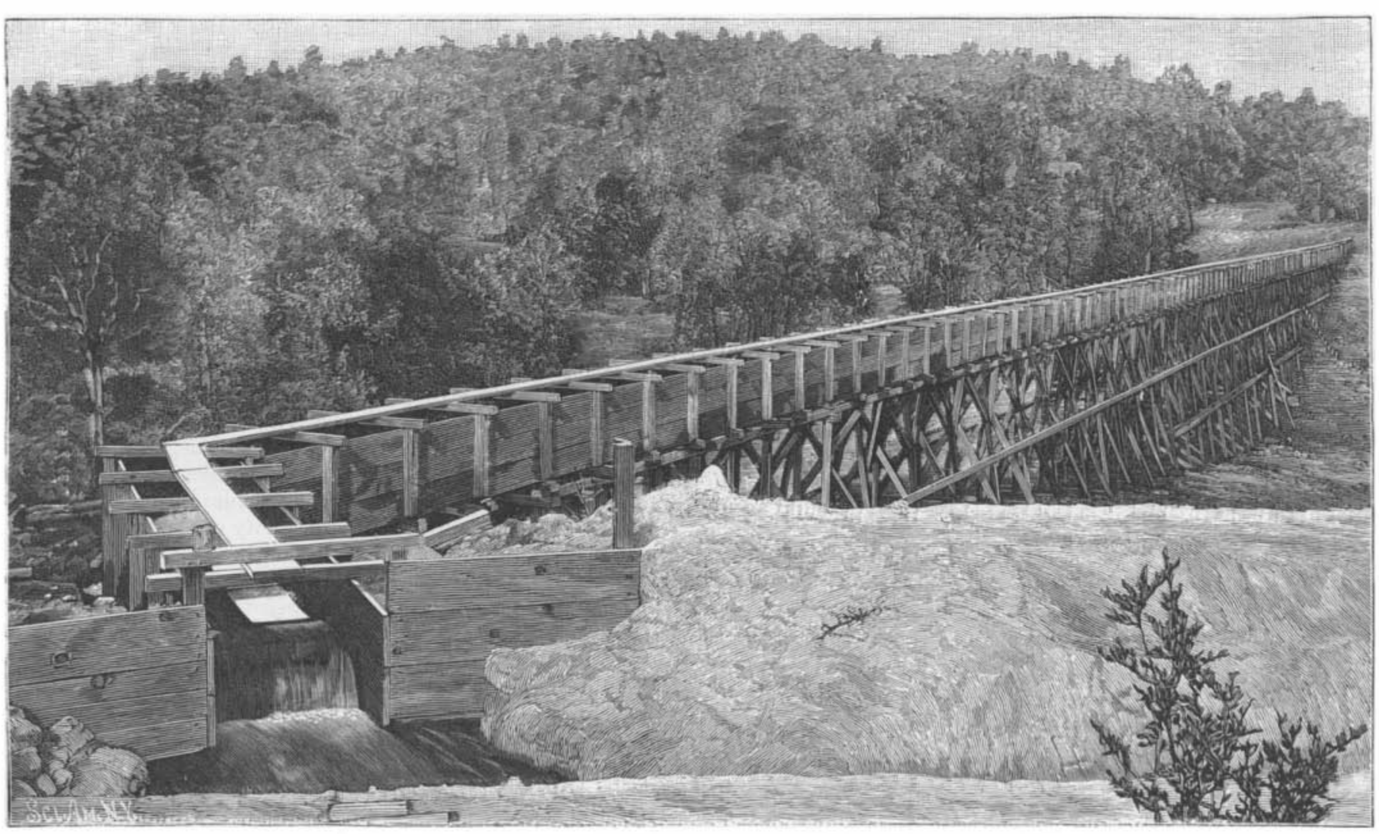


Fig. 9.—DIVERSION FLUME FOR BRINGING WATER TO THE RESERVOIR.

THE LONG DISTANCE ELECTRIC POWER TRANSMISSION PLANT AT FRESNO, CALIFORNIA

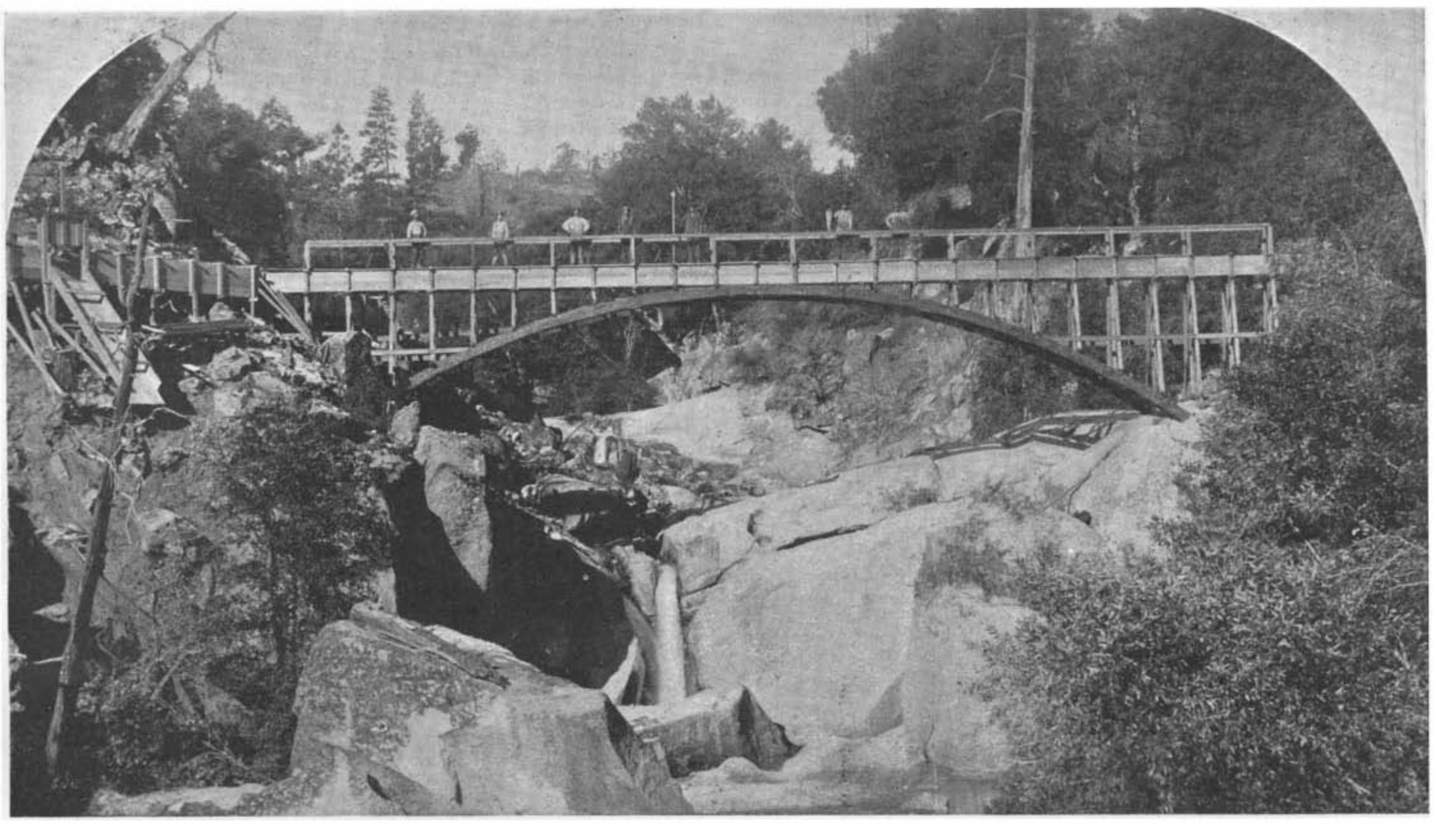


Fig. 10.—WOODEN ARCH FLUME ACROSS THE NORTH FORK OF THE SAN JOAQUIN RIVER.

THE LONG DISTANCE ELECTRIC POWER TRANSMISSION PLANT AT FRESNO, CALIFORNIA.

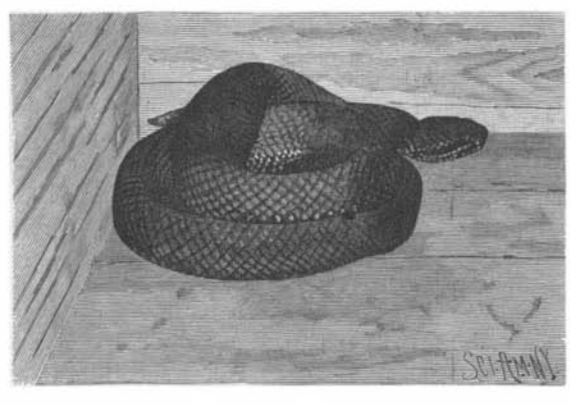
90 pounds from the normal. Upon opening the gate the pressure would fall 90 pounds below the normal, then rise to 80 pounds above normal, dropping again to 75 pounds below normal, the fluctuation continuing for about half a minute, or until the normal pressure was reached. An attempt was then made to control the gates by hydraulic rams, the power being taken from the pipe line. The rams opened and closed the gates so expeditiously that a fluctuation in pressure of 170 pounds each way from the normal was recorded. To check the speed the exhaust outlets of the rams were reduced in size to $\frac{3}{32}$ of an inch — an arrangement which increased the time of opening or closing to half a minute, and reduced the variation of pressure to 30 pounds. The hydraulic gates were eventually discarded in favor of a set of gates which are operated by means of a hand wheel. These have proved very successful, and there has been no further trouble from water shock.

By reference to Figs. 3 and 5 it will be seen that the receiver is carried upon I beams which extend across the wheel pit. There are three single jet Pelton wheels for driving the generators, two for driving the exciters, and two smaller wheels which operate the governor mechanism. The main Pelton wheels are 57 inches in outside diameter and each wheel has 27 buckets. On the same shaft with the wheel is a three ton fly wheel, 5 feet in diameter, and as the speed of revolution is 600 per minute, the disruption of the fly wheel by centrifugal force is provided against by shrinking on a 2 inch steel band around its periphery. The enormous force of the water is shown by its behavior in the wheel pit. When the water was first turned on, instead of falling from the buckets into the tailrace, it followed the wheels to the plank covering of the pit, along which it rushed, finally leaping out horizontally a distance of 60 feet. Where it struck the bottom of the pit, it tore up the concrete and attacked the underlying rock. A cushion pipe 14 inches diameter and 14 feet long was placed in line with the jet, but it merely reversed the direction of the water, which was spurted out upon the roof of the power house. The floor was then covered with ⅜ inch steel plates, but the sand and fine gravel in the water cut through the plate. Finally, a 1½ inch cast iron plate was placed at the point of impact, the idea being to replace it as soon as the water had worn it away.

The power house, which is a handsome structure of granite 36 feet in width by 70 feet long, contains three 340 K. W. multipolar General Electric 3-phase generators, which deliver current at 700 volts to a low potential switchboard, from which it is carried to six 125 K. W. transformers, which deliver 3-phase current at 11,000 volts through a high potential switchboard to the line. There are also two 12½ K. W. multipolar exciters, each of which can take care of the whole plant. The transformers are of what is known as the air blast type. They are placed upon an inclosed platform, through which air is forced, issuing through holes in the floor and thence to ventilating ducts in the cores of the transformers themselves. The power house and the substation at Fresno are protected by lightning arresters and choke coils.

The pole line from the power house to the city is built of square sawed redwood poles 12 by 12 inches at the butt and 6 by 6 inches at the top, the length varying from 35 to 40 feet. The 11,000 volt circuit is made up of two 3-phase 3 wire sets of No. 3 B. & S. soft drawn copper. The insulators are arranged on two arms, there being four on the top arm, two on each side of the pole and two on the bottom arm, each of which is placed centrally beneath the two on the upper pole. It will be seen that the insulators thus form a triangle on each side of the pole, each triangle carrying one complete circuit. The insulators are of the well known "triple petticoat" type. They are of helmet shape, with a groove at the top and wings on each side, and the transmission wire is carried by the groove, which is tied to the wings by soft copper wire. The course of the line for ten miles is through a rolling country which is situated below the snow line and is easily accessible. From the foothills the line runs through the wheat fields and vineyards which are characteristic of this part of the valley.

At the substation at Fresno the line enters through choking coils, lightning arresters, and the high tension switchboard, which stands some eight feet above the floor. The choke coils are made up of 150 feet of insulated wire which is coiled into a ring and thoroughly taped. The self-induction of these rings obliges the lightning to take the required path. The current after leaving the switchboard is carried to step-down transformers, whose construction is similar to the step-up transformers at the power house. There are nine of these arranged in three sets. Three 125 K. W. transformers deliver current at 115 volts to the commercial incandescent circuits. Another set of three 75 K. W. transformers delivers current at 1,000 volts for operating the power circuits, and the third set of three 40 K. W. transformers delivers a 3,000 volt current for the suburban and outlying districts. A five horse power induction motor drives a blower which furnishes the air blast for cooling the transformers.



WATER MOCCASIN.

The San Joaquin Electric Company has established a price of $64 per horse power per year for its electric power. The current for lighting purposes is furnished at fifteen cents per K.W. hour, measured by meter, with discounts of from five to twenty-five per cent, or it is furnished at a fixed rate of from thirty cents per sixteen candle power lamp per month to ten cents per lamp for bedrooms, bathrooms, etc.

A visitor to the power house will be startled by the loud detonations which accompany the starting of the water wheels. The noise is described as being similar to a heavy bombardment by artillery, and to an inexperienced ear it would sound as though the whole plant were in danger of violent disruption. The explanation of these concussions is that the air which is collected in the receiver and the pipes is subject to the enormous pressure of 609 pounds to the square inch, and on its escaping from the nozzle in the form of bubbles it expands with an explosive force. So loud are the reverberations through the hills that the farmers who live six miles from the power house can tell the hour at which the water is being turned on. The total length of the work is forty-five miles. The length of the ditch, as before stated, is seven miles, and its capacity sixty cubic feet per second. The reservoir above the pipe line has a capacity of four million cubic feet, and covers an a ea of eight acres. Altogether there is a constant supply of water in sight sufficient to provide fully fifty thousand horse power to the city.

The plant has been in active operation since June 12, 1896, and is giving the very best of satisfaction. It is now supplying current for 165 arc lights, over 5,000 incandescent lamps, and 460 horse power in motors.

The original conception and the plans of this very successful work are due to Mr. John S. Eastwood, civil engineer of Fresno, to whom we are indebted for the photographs and data used in the preparation of the present article.

COLLECTORS OF SNAKES.

BY L. P. GRATACAP.

Human curiosity is excited by few subjects in the animal world more keenly than by snakes. The ancient associations of these singular creatures, the peculiar innate instinct of dread and repulsion aroused by them, and the deadly power possessed by a few genera among them contribute to make them perennial objects of interest. The popular feelings of alarm and fascination in their presence were vividly shown at the winter reception of the Microscopical Society at the American Museum of Natural History, where Mr. R. L. Dittmars, of this city, exhibited microscopical preparations of the fangs of rattlesnakes, and by way of ad captandum two glass covered boxes containing respectively a water moccasin and young and a copperhead and young. The breathless interest of the spectators, their incessant storm of inquiry, and the congested crowd that poured in and around the basilisk eyed reptiles were eloquent testimony to the peculiar attraction exerted by them upon the average visitor. The exhibition made by Mr. Dittmars was a very faint suggestion of the remarkable display which the favored guest of his hospitality may enjoy at his own home. In a room of moderate dimensions this collector has arranged his ophidian pets in lines of boxes with glass covers placed around the walls. A remarkable and rather startling effect is produced, one not altogether reassuring when the expectant visitor enters this singular domestic den of reptiles, and observes the excitement of the rattlesnakes, unpleasantly accentuated by the keen sibilant hum of their tail buttons.

Here a Florida diamond back rattler, a Goliath in strength and of monstrous size, rolls himself in ominous coils, and with depressed nostrils and erect rattle seems the impersonation of stifled fury, his sinister expression giving a frightful ferocity from the glittering eyes and the singularly expressive sculpture and markings of his broad head. The delicate and featherlike scales over his body impart to it a softness and velvet beauty which accentuates the fiendlike bitterness of his aspect. There a number of Texan rattlers are twisted into a graceful group, bristling with alert heads and sonorous with the peculiar sharp whirr of their vibrating tails. Another case shows a torpid mass of water moccasins. Their careless attention, as the visitor approaches, seems more reassuring, but though less nervously irritable, their bite is almost as venomous as that of the rattler, and their rage and gloating rapacity, when they seize their prey, more terrifying.

The banded rattlesnake (Crotalus horridus) of this latitude is represented by a number of smaller specimens, gathered, almost picturesquely, about their water tub or stretched indolently over a few stones, while