## WATER STERILIZATION.

BY DR. ALFRED GRADENWITZ.

Whereas chemical analysis alone was formerly relied upon to determine the degree of purity of water, a still more important investigation has been found of late years in bacterioscopic examination. In fact it has been shown that water may contain all kinds of bacteria through which infectious diseases are produced

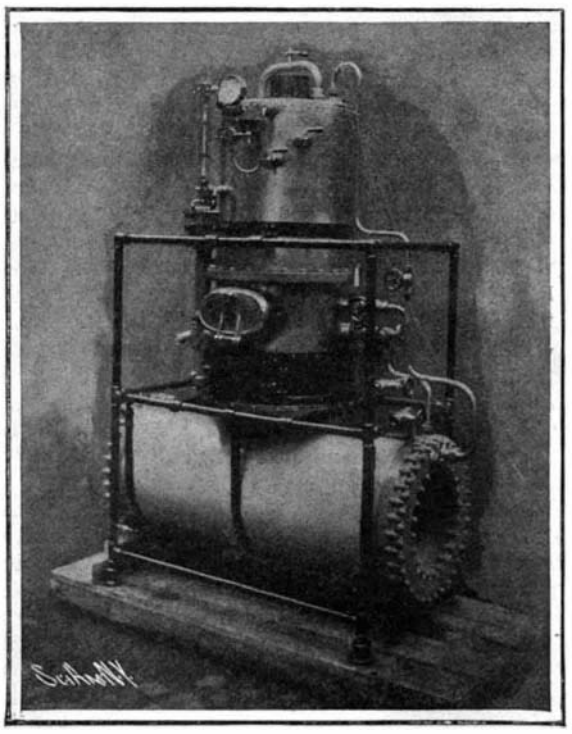


**Fig. 3.—Stationary Sterilizer Having a Capacity of 66 Gallons per Hour.**

and spread. Recent experiments have proven beyond doubt that bacteria liable to injure the health of man are rapidly killed at a temperature of 221 to 230 deg. F., and, provided each drop of the water be submitted to such a temperature, even if for but a short interval of time, the water in question may be safely said to be sterile. It will not, however, be fit for use as drinking water, before being cooled down to a temperature suitable for its consumption, while the well-known vapid after-taste should be eliminated by mixing the water with air free from bacteria in order to restore to it the character of fresh water. Filtration will, moreover, be likewise necessary in many cases.

A suitable type of sterilizing apparatus where these various operations are carried out effectively has been patented by Messrs. Rietschel & Henneberg, of Berlin, and is described herewith and illustrated in the accompanying engravings.

Each of these outfits consists essentially of a boiler, where the water is heated; a cooler, where it is brought down to a suitable temperature, and a filter for cleaning and aerating it. In the boiler, which may be heated by any kind of fuel or by steam from another source, the temperature of the feed water is raised to a temperature of 221 to 230 deg. F., corresponding to a pressure of the steam of 0.3 to 0.5 atmosphere. Now, as in any other boiler, owing to the difference in the specific weights of the cold and warm waters, there is a more or less rapid circulation, and any shock throwing the feed water from the filter into the boiler will produce a cold current up to the boiling surface, the cold and warm waters not being susceptible of immediate mixture owing to their difference in density. If in a similar boiler water be drawn from the warmest place, there will always be the risk of obtaining water that has just come to the surface under the action of the currents referred to, before having undergone the amount of heating required to kill the bacteria.

In the Rietschel & Henneberg boiler, however, no drop of water leaves the boiler before having reached the proper temperature and without having been maintained at the same during a certain period. This result is obtained by arranging within the water compartment a coil which causes the steam pressure above the water surface to act upon the water discharged from the warmest part of the boiler. The latter requires some time to traverse the coil, and thus the boiling water that surrounds the latter will prevent any loss of heat, while in some cases it will even supply to the water further heat. As the coil carries a thermometer immersed in the discharged water, a means is provided readily to control the operation.

A special feature is a valve by means of which steam may be conveyed from the sterilizing boiler through all the conduits and apparatus, that is to say, throughout the path of sterilization, and which allows the whole of the conduits to become sterilized before the plant is started. In the case of the intermittent operation of the plant a special arrangement is provided in the shape of a double-seated diaphragm valve to replace the serpentine above described.

The second part of a sterilizing plant is the cooler. This permits of a calorific exchange between the highly heated sterilized water issuing from the boiler and the feed water used for cooling the latter, thus raising the feed water to a temperature as high as possible. By means of the return current principle, the sterilized water can be cooled to a temperature which lies only 5 to 9 deg. F. above the initial temperature of the feed water, while the feed water supplied to the boiler is preheated at the same time to the boiling point. This recovery of heat is unquestionably an advantageous feature, and the amount of heat to be produced in the boiler corresponds to the difference only between the admission and discharge temperatures of the boiler, i. e., to but a few degrees. The third part of the plant is the filter, where the sterilized and cooled water which still contains impurities of an earthy and vegetable nature, as well as iron precipitates and the like, is purified. The water which has acquired a disagreeable

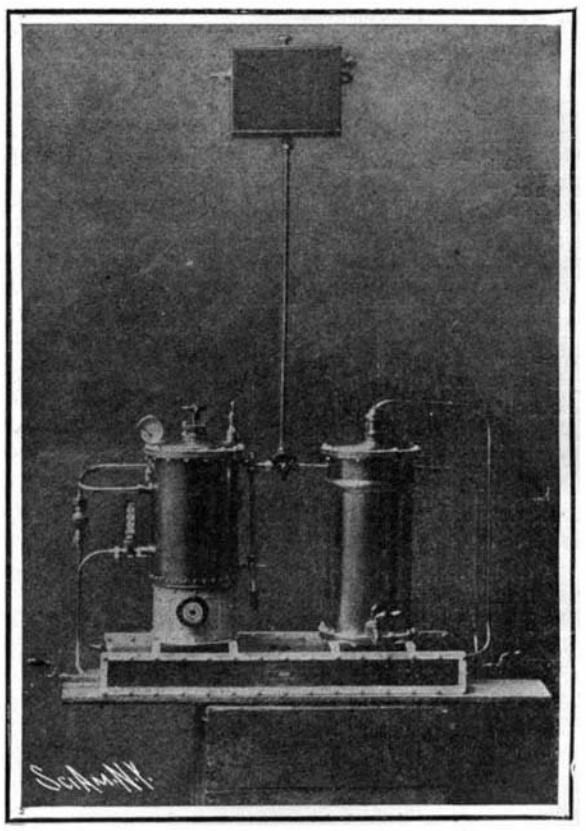


**Fig. 4.—Steam-Operated Water-Sterilizer Producing 26.4 Gallons of Sterilized Water per Honr.**

aftertaste due to the boiling process is finally saturated with air in the filter and is passed over substances which destroy the vapid boiling taste and restore to it the character of real potable water. After entering the filter from a kind of rose, the sterilized water falls in the form of a spray on the dense filtering material placed underneath, thus coming into intimate contact with the sterilized air fed through a special filter. A strong addition of bone charcoal has been found to be the best means of destroying any taste in the water due to boiling.

A perfectly sterilized water can, it is true, be also obtained by distillation, but the above-discussed sterilizing process is much less costly, while it is just as efficient. In fact, one liter at 0 deg. requires for distillation about 640 calories, while 110 calories, that is to say, about one-sixth as much, are necessitated for sterilizing the same amount. Furthermore, about 90 per cent of this heat is recovered by the cooling process in preheating the feed water. Wherever the freeing from noxious germs (bacteria) is the most important point, sterilization will moreover prove more satisfactory, while distillation should be resorted to only for chemical purposes, where soluble salts, for instance, are also to be eliminated.

By the courtesy of Mr. R. A. Hartmann, of Berlin, who is the constructor of the apparatus, we are enabled to illustrate and briefly describe some of the most interesting special types showing the large variety of applications of which the apparatus is susceptible.

For use in time of war, transportable sterilizers have been constructed having a capacity of 500 liters of pure water per hour. Figs. 1 and 2. This capacity may be said to correspond to the re-

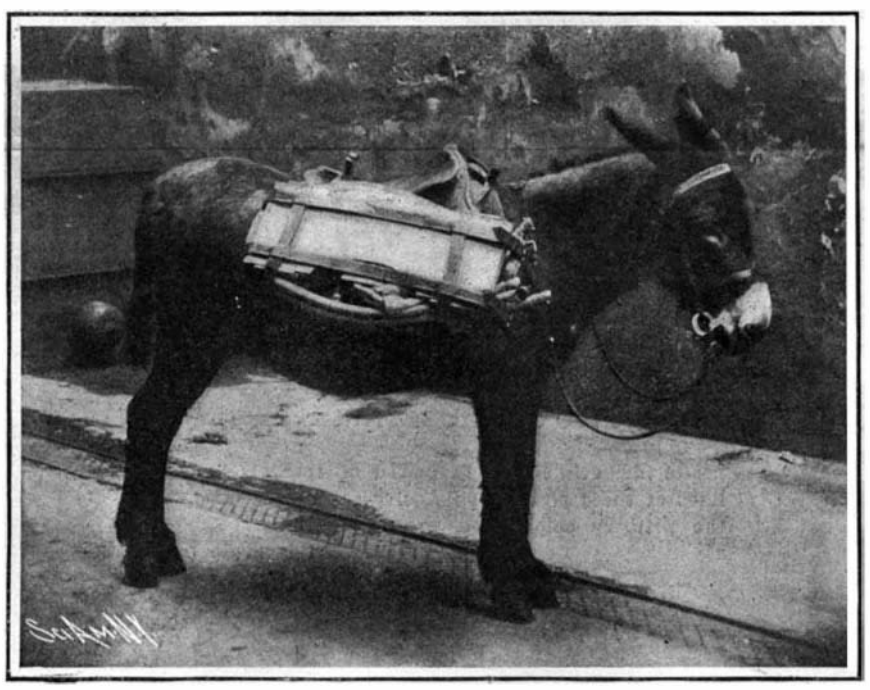


**Fig. 7.—The Sterilizing Outfit Packed on a Mnle.**

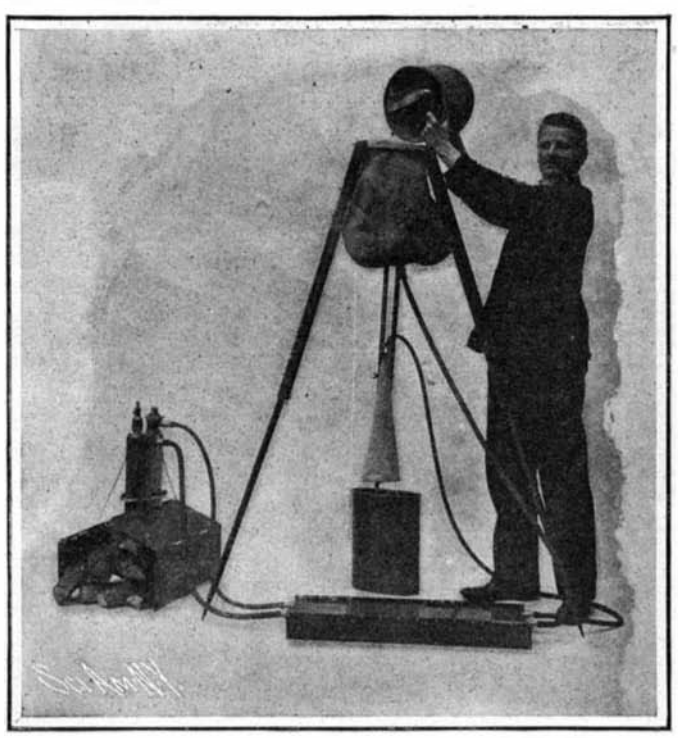


**Fig. 6.—Portable Sterilizer for Producing 26.4 Gallons per Honr.**

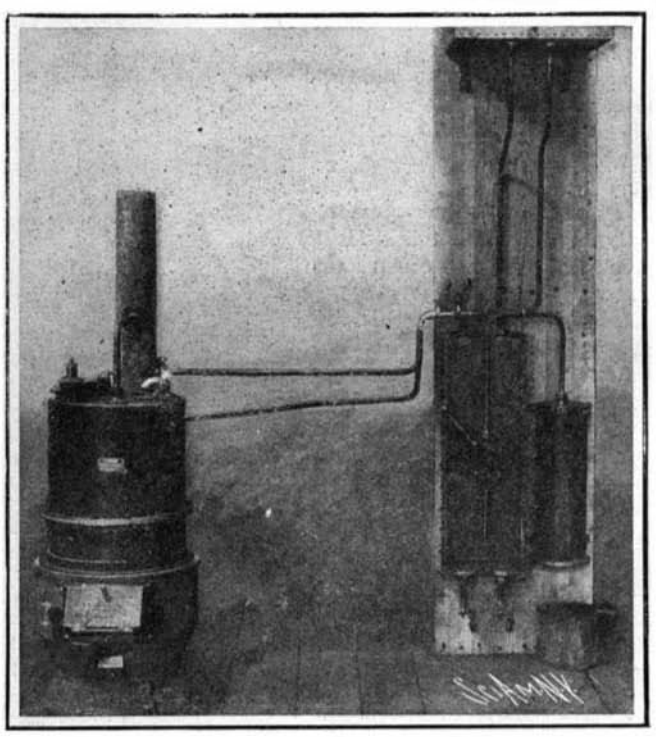


**Fig. 5.—Direct-Heated Sterilizer of 26.4 Gallons per Honr Capacity.**

**VARIOUS FORMS OF STATIONARY AND PORTABLE WATER STERILIZING APPARATUS.**

quirements of one battalion. Two pumps, *P* and *P'*, draw the water into the mechanism through a suction nozzle, where any larger impurities are retained. By the convenient arrangement of two three-way cocks, *D*, *D*, the water entering can be conducted at will either into the boiler, there to be sterilized, or into the cooler, *C*. In normal operation, the pump, *P*, is used as boiler feed pump while *P'* is connected to the cooler. After entering through the feed pump, *P*, the cold feed water is raised rapidly to the proper temperature in the boiler and should be left there for about 10 to 15 minutes at a steam pressure of about 0.5 atmosphere. In the type of sterilizer represented in Figs. 1 and 2, which is of 500 liters output, the cooling water is fully utilized for feeding so as to involve no consumption of the same, a fact which obviously reduces greatly the cost of operation.

Though these sterilizers are intended primarily for use in connection with transportable plants, stationary installations are also constructed on the same principle. The stationary sterilizer represented in Fig. 3 has a capacity of 66 gallons per hour. A special feature of this type of apparatus is an electrically operated minimum thermometer located at the outlet of the coil. As soon as this thermometer registers below a given temperature, it will ring an alarm, thus informing the operator of the fact that the outlet water has fallen below the admissible minimum temperature. Similar plants of about 26 gallons output will be found suitable for the use of single houses or special sections in hospitals (see Fig. 4). A like apparatus, but for intermittent operation, is shown in Fig. 6. The apparatus will prove especially useful in connection with scientific and military expeditions, and a special outfit having a total weight of about 100 pounds has been constructed for such purposes. This can be either loaded on pack animals or can be carried in sections by two men (see Figs. 7 and 8). It may be mentioned that similar types of apparatus have been used to advantage in connection with the present military operations of the German troops in Southwestern Africa.

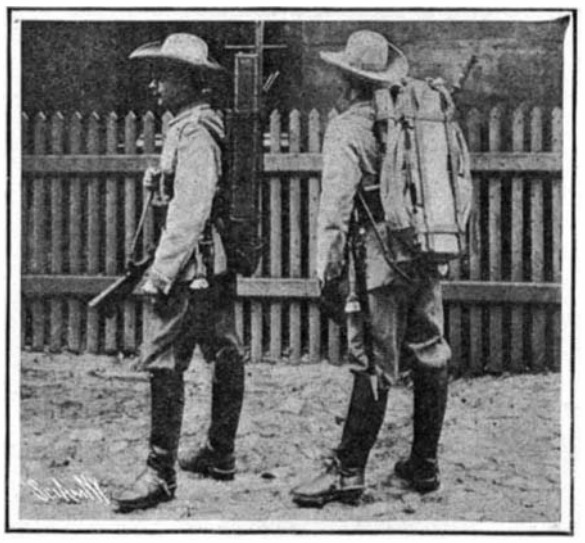


**Fig. 8.—Portable Sterilizer Carried by Two Men.**

**Fig. 9.—Portable Sterilizer in Operation.**

### Irrigation in California.

Southern California leads the United States in diversity of methods of application, in scientific distribution and conservation, and in the extensive character and boldness of design of its irrigation works. Surface water, drainage water, seepage water, water from artesian wells, and from tunnels penetrating the mountains, and water impounded in large and costly reservoirs are alike utilized.

The irrigation systems of this part of the State are known all over the world, and have created a prosperous commonwealth in a region which would be a scene of utter desolation without them. The concrete examples of intensive farming with this climate and soil are such charming settlements as Riverside and Redlands, whose praises are sung everywhere. North of this section, and from an irrigation standpoint considered almost equally important, is the San Joaquin Valley. The San Joaquin River supplies 54 per cent of all the lands irrigated in this State, but only 30 per cent of the total number of farms and 8 per cent of the irrigation canals. These percentages indicate an entirely different type of farm from that which prevails in the southern region. In the latter the high-priced products produced, the heavy cost for water, and the necessity for careful and intensive farming have resulted in the smallest farm units in the West. The farm units in the San Joaquin Valley average more than 100 acres, while in the southern region they are less than 23. In the valley of the San Joaquin the methods of irrigation have been more nearly typical of those of other sections of the West. Water has been wasted, extensive areas of the valley have been damaged and must be drained to be made productive.

The tendency in the northern valley has been to cultivate general crops and to retain large areas for grazing, with the result that farming has not been so profitable as in sections where special crops are grown and all of the land cultivated. A recent investigation of the agricultural, climatic, soil, and power possibilities within and about the borders of this valley furnishes an important contribution to our knowledge of this section of California. This investigation has been carried on by the Division of Hydrology in the United States Reclamation Service, and extended from the southern end of the valley northward to the southern line of Madera County, covering approximately 7,880 square miles. Within this area it was found that the amount of underground water which lies near the surface, and is available for irrigation purposes, is enormous, and that its value is but little realized. Thus far only about 250 second-feet have been developed for municipal and agricultural purposes, which is a very small percentage of the total amount available. The valley is filled largely with granitic sands and gravels, and there are large surface deposits of silt and rich alluvial mold. This filling is saturated with the flood waters and the returning irrigation waters, which thus constitute an extensive underground reservoir which, properly developed, will serve to reclaim thousands of acres now barren or in stock ranges. The situation of this section in relation to adjacent non-productive portions of the West is such that it will inevitably become of increasing importance from an agricultural point of view. It is the conviction of the board of engineers which considered the data obtained by this investigation, that the greatest increase in the agricultural development of this valley will come from a proper utilization of this available water power. This was doubtless impressed upon them in some measure by the fact that in Southern California underground waters to-day supply more than half as many farms as are irrigated by all of the ditches of the San Joaquin River. In order to develop these underground waters, cheap power is necessary. The cheapest power available is that which is developed by the transformation of the water power of the Sierras into electrical energy, and its distribution in this form to points where it is needed. Of the numerous streams that flow from the Sierras to the valley, upon which electrical power can be developed, the only one that remains available for the Reclamation Service is the Tuolumne. Upon all of the others the important reservoir sites and rights of way are in the hands of private or corporate interests. In fact, a monopoly of power now exists, fostered and encouraged by the unwise policy of giving away without restriction or reservation these most valuable power sites. The people of the valley and of the whole State in general are now awakening to the fact that they have a direct interest in the preservation of these reservoir sites, in order that they may be available for future use by the government in irrigation development. They recognize that these valuable power sites should no longer be permitted to pass from the government into the hands of monopolists, who exact from the people undue profits from a few which they develop, and prevent the development of the rest; that these public utilities should be so guarded that the benefits arising from their development shall accrue to all, and not to the few. These conditions do not alone prevail in California; they exist in every mountain State. There is a great demand from the people that these valuable power possibilities should be retained for the use of the whole people until further development can be undertaken by communities or by the government.

The San Joaquin Valley offers one of the most important situations for the development of large water power at small expense found anywhere in the United States, and there have been extensive developments of this power on many of the more important streams. A peculiar condition arises from the fact that the lands of the valley are all private lands, many of them in large holdings; while the Sierra Nevada Mountains, which border the valley on the east, are practically all covered by Forest Reserve withdrawals and are largely public lands. The normal flow of all the rivers of the valley (the summer flow in this valley is greater than the winter flow) is now diverted for irrigation purposes. Aside from the increase which may come from more careful and systematic irrigation and cultivation, agriculture cannot be extended materially from the surface water supply. It is the undivided opinion of the engineers that the greatest increase of irrigation in the future will result from pumping rather than from impounding and regulation of flood waters.

So much impressed were they with the possibilities of this section, that they recommended that the investigation of the underground waters be completed, and that all reservoir sites within the Tuolumne basin, together with the necessary lands for rights of way for power conduits, be withdrawn from entry pending further investigation, and held for future use by the United States in the development of irrigation in the valley. They also recommended that if any of these rights of way or reservoir sites are released for necessary public use, it shall only be upon the condition that the

**Fig. 1.—Portable Military Sterilizer. Capacity, 500 Liters per Hour.**

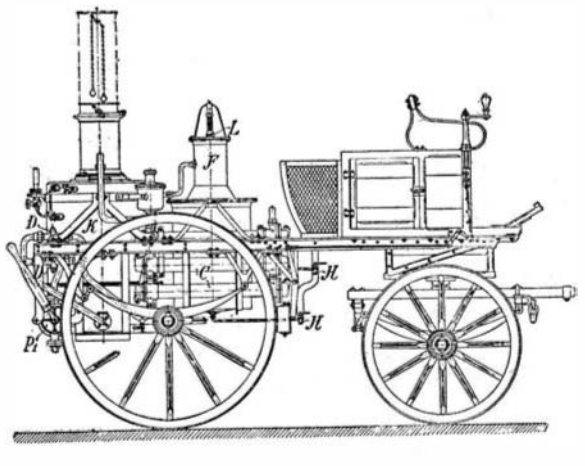


**Fig. 2.—Diagrammatic View of the Portable Military Apparatus.**

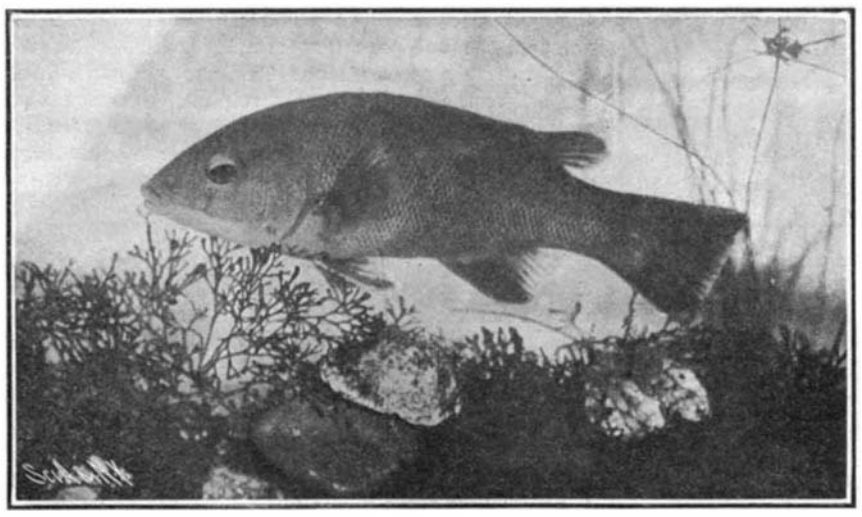
**VARIOUS FORMS OF STATIONARY AND PORTABLE WATER-STERILIZING APPARATUS.**

United States may at any time take control of them by paying a fair price for the works alone, exclusive of the value of the location and water rights.

## THROUGH A WINDOW OF THE SEA.

BY CHARLES FREDERICK HOLDER.

Along the great blue current of Japan that sweeps down the California coast, a climatic peacemaker, is strung a chain of gemlike islands. They are the summits of offshore Sierras, a coast range of California that has been partly overwhelmed by the sea, their tops now crested with verdure, and washed by the warm stream that modifies the entire coast. These islands, from twenty to sixty miles offshore, rise from very deep water without premonitory shoals or reefs,



**The California Sheepshead.**

and could we see them divested of the ocean they would appear like gigantic needles rising from the bottom. All have a peculiar beard, or protecting growth of weed, that constitutes a perfect laminarian forest about them, a giant seaweed growing in water sixty or more feet in depth, and forming a natural wave brake and a home for countless marine animals.

The vines are sometimes one hundred feet in length, vast cables, with broad crimpled leaves of a dark olive hue, which assume graceful shapes in the tide; and when one peers down into the turquoise water the scene is often a revelation. A new world is opened up, and the real beauties of oceanic or submarine scenery are appreciated. The great leaves are carried by the fitful currents that sweep these islands in every direction. Sometimes they are extended at full length and appear like a horde of green snakes; again they lie upon the surface, listless and drooping, taking myriads of shapes, and forming nooks and corners of great beauty.

So attractive are these kelpian forests, so fascinating, that what is known as the water glass has been elaborated into a glass-bottomed boat, which virtually has several large plate glass windows through which the passengers may look down into the kelp forests and view a panorama of the sea. These glass-bottomed boats range in size from rowboats in which a dozen people can be taken out, to side-wheel steamers, so arranged that they can float over the forest and view its wonders up and down the coast. One of these odd craft is so large that several hundred passengers can look down through its windows at one time.

Avalon is the headquarters for the glass-bottom-boat men, and their vessels cruise up and down the smooth north coast of Santa Catalina, that appears to be admirably adapted for the purpose, being in the lee and abounding in coves and bays—the mouths of cañons that nearly always are smooth and often like disks of steel. There are no hackmen at Avalon; it is a sort of mountain Venice, and carriages are at a discount. The captains of the glass-bottom boats replace the hackmen of the mainland and cry the merits of their strange craft, each of whom claims to the knowledge of some especially attractive sea meadow or glade over which he will take one.

What the voyager in the glass-bottom boat generally sees, and with the same surroundings, is shown in the accompanying illustrations of animals, taken from the kelp forests of Avalon and adjoining waters under the direction of the writer; in other words, each photograph shows the animal as it has been seen by the writer; and as the various forms have never before been photographed and some have never figured in books, they have an especial interest as a contribution to popular entertainment and exact zoological knowledge.

When the glass-bottom boat starts the passengers are at first regaled with the sandy beach. In three or four feet of water the wave lines are seen, the effect of sea on soft sand, the delicate shading of the bottom in grays innumerable. Now the collarlike egg of a univalve, or the sharp eye of a sole or halibut protruding from the sand. A school of smelt darts by, pursued by bass, and as the water deepens flocks of surf fish, gleaming like silver, appear; then a cormorant dashing after them, or perchance a sea lion browsing on the bottom, or in pursuit of prey. Suddenly the light grows dimmer and almost without warning the craft is in the depth of the kelpian forest. The fitness of the term "hanging gardens" is apparent, as the great leaves appear to rise near the surface, then droop over, forming arches, parterres, and loops, conveying the impression of being suspended at the surface. The color is a deep olive grading to yellow, the leaves a foot or two wide and very long, their edges crimpled. Each is seen to be covered with a lacelike network of great delicacy. Fragile plumes wave to and fro, telling of worms or minute Sertularians. Here the tracery is white, the deposit of some animal, gleaming like frosted silver, while others are of lavender hues. The vagrant beams of light that strike the surface bring out the tints and shades in strong relief. Through a loop of kelp is seen the blue of the deep water, and poised in it, an angel fish of vivid orange tint that persists in taking black through the camera. A school of these fishes swim into view, turning their gorgeous shapes upward and eyeing the strange window in which are mirrored many faces. With them are small fishes of brilliant blue iridescence suggesting the strange vagaries of nature, as the very young angel fishes are almost entirely blue, and called by the skipper electric fishes; but as they grow the blue merges into yellow and the adult blossoms out in its perfect coat of gold or orange.

On the leaves are singular crabs, red and olive, with square shells, and deeper, in the crevices of the moss-covered rocks, are gigantic spider crabs, mimicking the rocks in shape and hue. The nature of the forest is ever changing. Now great pompons of a dark weed appear, a tint born of the deep sea. It waves gracefully as the slight swell comes in, and as it turns aside, displays the very giant of the starfishes, a huge creature garbed in red with white spikes or tubercles scattered over it, making it a most conspicuous object among the greens. In the crevices are smaller stars; some a vivid red, others dark, with arms like snakes.

Among the weeds long serrated waving spines are seen—the antennæ of the California crawfish, or spiny lobster, which takes the place of the lobster here. Its red, yellow, and brown tints so harmonize with the weed that it is almost impossible for the novice to see it, although he has the word of the skipper that the spines are waving beneath his eyes. At night the crawfish comes out and wanders abroad in these pastures of the sea, and even now he can be seen as the kelp is brushed aside, trim, debonair, ready to dart backward at the slightest warning.

The bottom changes to a finer moss or weed—a deep velvet green, with here and there iridescent tints, and in it lie great sluglike sea cucumbers in brick-red shades. Presto! the captain of the glass-bottom boat transports his passengers to a deep glen in which lacelike weeds rise and poise, forming a natural canopy for long-spined black echini, or sea urchins—formidable creatures, sea porcupines which recognize the presence of some possible enemy and attempt to hide among the weed by plunging deeper into its mazes. Splashes of white tell of a smaller sea urchin, and nearly every nook and corner of this sea forest is inhabited by these aggressive creatures.

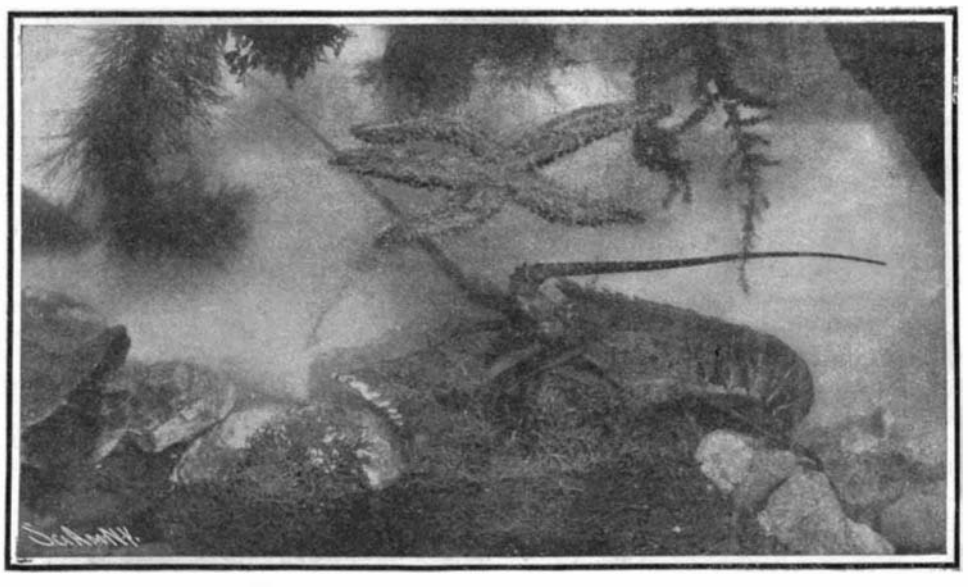
The bottom of the sea along this rocky shore is a color scheme of marvelous beauty. Green is the predominating tone, but green in countless shades and expressions. Sometimes a short wiry weed covers the bottom, constantly being waved aside to display other and more attractive colors: weeds in purple and brown, rocks of lavender incrusted with a flaming red sponge, or a mass of pink barnacles from which rises the delicate mauve tracery of their breathing organs. This sea tapestry is constantly in motion, so has the appearance of changing light, shade, and tint, and displaying some new creature to the voyagers of the curious craft with windows looking down into the sea.

The window drifts past strange holothurians, like monster slugs lying on painted rocks, the *bêche de mer* of the Chinese, in which lives the glasslike fish, Fierasfer; by hordes of mimic flowers, Serpulæ, with crowns of red, white, blue, and seeming gold. The lightest jar on the boat and they are gone, to appear slowly, unfolding like flowers. Near them are tube-building worms, with slender organs; and out from beneath a rock wave the tentacles of the octopus, or perhaps the paper nautilus.

The animals of the hanging gardens are not confined to the kelp in its variety, or to the rocks of the bottom. The blue water where the sunlight enters brings out myriads of fairylike forms, poising, drifting, swimming, the veritable gems of the sea. Some are red as rubies, others blue, like the sapphire; some yellow, white, topaz, green as emerald; or emitting flashes of seeming phosphorescent light. Ocean sapphires they are called, minute crustaceans (Sapphirinæ), that are in such numbers that some lavish hand might have strewn the water with gems. Sweeping by, in classic shapes, are the smaller jelly fishes; crystal vases, moon-shaped bodies, so delicate that the rich tone of the ocean can be seen through them, then changing their colors to steely blue. Some are mere specters, a tracery of lace; others rich in colors and flaunting long trains. Now the glass floats over a giant four or more feet in length, its body white, blue, with dark chocolate lines radiating upward, while from below swing magnificent coils and flutings, the tail of this living comet that has been seen in Avalon Bay nearly thirty feet in length with a disk nearly two feet across, calling to mind the giant jelly seen by Louis Agassiz that was 125 feet long. Nearly all these pellucid craft move by slow flapping of the edge of the umbrella-like disk; but here is a jelly, the Physophora, that has a series of pumps by which it shoots along through the water. No more beautiful object can be conceived than this, ablaze with colors—pink, blue, and quicksilver—darting through the azure waters that form the interstices of the floating garden.

As the boat moves out into deeper water the purity of the aqueous sky is evident, as forty feet below the rocks are seen and the dim shapes of kelp leaves faintly outlined beyond. Here large fishes hide—the graceful sheepshead peculiar to the region, the male with enormous red and black stripes, blunt forehead, the lower jaw white. The female is a radiant creature with beautiful eyes and often red, brown, or white, the colors fading in confinement. These fishes are easily drawn near the boat by judicious display of bait and their graceful postures plainly observed.

Now the window is out over deep water to see the passing of a migratory school of barracuda, thousands of long slender pike-shaped fishes all headed in one direction, swimming slowly. Suddenly they disappear,



**California Crawfish (*Palinurus interruptus*).**

**THROUGH A WINDOW OF THE SEA.**

as though some shutter had been snapped, and onto the field dash a school of large sea bass, the game fish of this locality. Again the window approaches shoal water, and for several miles follows along the fishes' highway, regaling the passengers with an ever-changing panorama of marine scenery. Now it will be a shoal of myriads of blue perch (chromis), a fish that affects the kelp forest, and presents a sharp contrast to it in its vivid blue tint. These fishes delight to bask and sport near the surface, and the window appears full of them as it moves along. Rock bass, singly and in schools, are seen poised in the leaves of the kelp, striped brown and black; spotted rock fish, and here the radiant whitefish, as blue as the water, with long fins, while in the depths other interesting