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THE LAST CRUISE
OF THE
CARNEGIE

THE *CARNEGIE*

From a water-color by William J. Peters

THE LAST CRUISE
OF THE
CARNEGIE

BY

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Surgeon and Observer

WITH A FOREWORD BY

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Dedication

TO

CAPTAIN JAMES PERCY AULT

whose world-wide scientific service

has enriched geophysical knowledge

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FOREWORD

The *Carnegie*—the world's only sea-going non-magnetic observatory—was constructed by the Carnegie Institution of Washington to obtain geophysical data over the oceans. This vessel was part of the equipment of the Institution's Department of Terrestrial Magnetism, founded April 1, 1904, realizing a plan for an international magnetic bureau submitted by Dr. Louis A. Bauer, the Department's director from 1904 and its director emeritus from 1930. The purpose of the Department, set forth in the plan, is "to investigate such problems of world-wide interest as relate to the magnetic and electric condition of the Earth and its atmosphere, not specifically the subject of inquiry of any one country, but of international concern and benefit." Among the problems proposed was the magnetic survey of ocean-areas and magnetically unexplored regions, so that more accurate and comprehensive charts might be constructed. It was in the realization of this part of the plan that the *Carnegie* did such useful service during 1909 to 1929. The first six cruises were made almost exclusively for the surveys of the Earth's magnetism and electricity for which she was designed. The seventh cruise was to be unique in the vessel's history, as its program contemplated besides these survey-operations extensive researches in oceanography, including the exploration of the ocean-depths for the physical, chemical, and biological conditions found there.

In May 1928 the *Carnegie* left the United States for a three-year cruise of all oceans—the seventh since her launching in 1909—to further increase the store of geophysical data. Captain James Percy Ault, and the staff under his command, had completed one year and a half of this voyage when disaster struck suddenly. The ship and its unique equipment—evolved in twenty-five years of active endeavor of the Department—were totally destroyed, and the Captain lost his life together with the Cabin-Boy. The tragedy took place November 29, 1929, at

Apia, Western Samoa, when a gasoline explosion occurred while supplies of fuel were being stored aboard.

The following pages sketch briefly the earlier work of this famous research ship in her quest for scientific facts, and give a narrative of the seventh and last cruise.

There was a scientific staff of eight, in addition to a full complement of sailing officers and crew, numbering seventeen. On leaving Washington, May 1, 1928, the members of the party and their fields of research were: Captain J. P. Ault, commander of the *Carnegie*, and chief of scientific staff; Wilfred C. Parkinson, senior scientific officer, atmospheric electricity and photography; Oscar W. Torreson, navigator and executive officer, magnetism and navigation; Floyd M. Soule, observer and electrical expert, magnetism and physical oceanography; H. R. Seiwell, chemist and biologist, oceanography; J. H. Paul, surgeon and observer, meteorology and oceanography; W. E. Scott, observer, nagivation, magnetism, and commissary; and Lawrence A. Jones, radio operator and observer, radio investigations and magnetism.

The sailing staff included Albert Erickson, first mate, C. E. Leyer, chief engineer, and F. Lyngdorf, steward—all three had served throughout the previous cruise.

The scientific program was carried out successfully; computed values of the various observations were forwarded from port to port in such a form that they could be immediately utilized by workers ashore, and by the hydrographic offices of the world. The prompt publication of results necessitated continuous application to duty on the part of the staff, whether at sea or in port. But this also made the expedition scientifically successful, although the vessel and all its equipment were later destroyed. On the other hand, it may be said that the work during the cruise was only a beginning, for it will take several years to analyze and correlate further these data.

Captain Ault's death deprives the sciences of oceanography and terrestrial magnetism of a promising leader at the height of his powers. No more fitting monument can be erected to the memory of a man than the imperishable records of his service for science. In twenty-five years of research as one of the staff

of the Department of Terrestrial Magnetism Captain Ault made notable contributions in the varied fields of geophysics. He led many expeditions to far ends of the world and commanded the *Carnegie* on four of her world-wide cruises. Those who had the good fortune to serve science with him and to sail under his skillful and inspiring leadership know how completely he met his responsibilities and realized his ideals. His death deprives the public of his own fascinating story of the cruise. A charming book indeed would have resulted from his rich background in oceanic surveys, his contagious enthusiasm, and his ability to interpret fundamental scientific researches in popular terms.

The preparation of the narative of the cruise has devolved, therefore, upon Dr. J. Harland Paul, who so creditably carried his dual responsibilities as surgeon and observer throughout the cruise, and to whose constructive and loyal service Captain Ault so frequently made appreciative reference in his official correspondence, as was also the case for every other man of his staff. In some of the more intimate details, Dr. Paul has had the privilege of abstracting from Captain Ault's letters to his wife and daughters detailed accounts of many incidents of the cruise not forming part of or entering into the official reports.

The story of the expedition is a record of diligent and continuous application to duty on a pre-arranged schedule. But few passages will be found describing the wonders or terrors of the deep, and but few romantic pages of brilliant exploits of physical daring—for the simple reason that the cruise was carefully planned to avoid digressions that might interrupt the discharge of important routine. How faithfully and loyally the plans and observations were carried out by each and every one concerned on board the vessel is abundantly evidenced by the vast number of observations made, samples collected, and data derived, the discussion of and the interpretations from which are real contributions to the physics of the Earth—geophysics.

John A. Fleming.

PREVIOUS CRUISES OF THE *CARNEGIE* AND PURPOSES OF CRUISE VII

The history of the *Carnegie* has been so closely bound up with recent developments in magnetism, that it will be justifiable to recite briefly some of the salient facts of this science. The story begins, of course, with the introduction of the compass for navigation, some hundred years before the voyages of Columbus. He was the first, however, to note that the compass does not point to true north except at a few points on the Earth.

This bewildering behavior of the trusted instrument more than once got him into difficulties. On his first passage to America, the crew was greatly disturbed, and on the point of mutiny, when they saw the needle point ten degrees west of true north. They did not wish to trust the compass any longer, for fear they should never find their way home. Columbus allayed their fears by saying that the officers must have made some mistake in the bearings of the Pole Star, and that in the morning he would investigate.

Sure enough, when morning came the compass was seen to read correctly again. The wily Columbus had no doubt shifted the compass-card under the needle, as he admitted having done on a previous expedition. He writes: "Being unable to force the crew's inclination, I yielded to their wish, and, having first changed the points of the compass, spread all sail, for it was evening; and at daybreak we were within the Cape of Carthagena while all believed for a certainty that they were going to Marseilles."

In doing this Columbus was taking chances, for laws had been framed against falsifying the compass. In one of these curious statutes, mariners were charged not to eat onions or garlic, lest the odor "deprive the lodestone of its virtue by weakening it and prevent them from perceiving their correct course." The punishment for violations seem barbarous in the extreme, for the

Captain James Percy Ault

culprit, "if his life be spared, must be punished by having the hand which he most uses fastened by a dagger thrust through it to the mast, to be withdrawn only by tearing it free."

Early experiences with the compass soon showed that it was necessary to know the angle by which the geographical north differed from the north as indicated by the needle, that is, the mag-

THE SCIENTIFIC STAFF ABOARD THE *Carnegie*

(Front row, left to right: W. C. Parkinson, senior scientific officer; Captain J. P. Ault, commander and chief of scientific staff; J. H. Paul, surgeon and observer; back row, left to right: F. M. Soule, electrical expert; L. A. Jones, radio operator and observer; W. E. Scott, navigator and commissary; H. R. Seiwell, chemist and biologist; O. W. Torreson, navigator and executive officer.)

netic declination or variation. This was the beginning of the science of terrestrial magnetism. One of the earliest methods for finding this angle was to take bearings of the Sun as it rose and set, the mid-point being true south. It was a modification of this method which was used throughout the cruises of the *Carnegie*.

So far, only the declination had been discovered. In 1576

another practical seaman, Norman, published an interesting paper entitled "a newe discovered secret and subtill propertie concerning the Declyning of the Needle, touched therewith under the plaine of the Horizon." This discovery of magnetic "dip," or inclination as it is now called, gave us the first hint that the source of magnetic force might be in the Earth and not in the

THE WATCH-OFFICERS AND THE ENGINEER

(Left to right: Jentoft, third mate; Leyer, engineer; Erickson, first mate; Unander, second mate.)

stars, as had previously been supposed. Even today we do not know the origin of this mysterious force.

In the seventeenth century a very discomforting fact came to light. Up to this time it had been assumed that the magnetic declination and dip, though differing for various localities, was constant at any one place. But now it was shown that the Earth's magnetism undergoes changes in the course of time—irregular changes at that. The effects of this discovery were far-

CRUISE VII OF THE *Carnegie*, MAY 1928 TO NOVEMBER 1929

Broken lines show portion not completed; the uncompleted seventh cruise added 52,000 statute miles to the 291,000 miles covered during the first six cruises between 1909 and 1921—a total of 343,000 miles in all oceans.

EDMUND HALLEY

This noted astronomer made the first magnetic variation-chart of the Atlantic from observations secured on the *Paramour Pink* from 1698–1701.

reaching. For example, the compass-bearing of lines surveyed in London in 1580 differed 35° from their compass-bearings in 1812.

Besides this, the dream of the mariner had to be abandoned that some day longitude might be determined by simply noting the declination of the compass. This was a great disappointment indeed, for chronometers keeping accurate time had not yet been discovered, and there was no satisfactory method for finding longitude at sea. In fact, there were large prizes offered to anyone who could solve this pressing problem. The only known method was to rely on estimations of each day's run and the course followed; and there were uncharted currents in the ocean which might carry one unawares many miles a day in an unknown direction. Even Halley, the noted astronomer, was three hundred miles out of his reckoning from this cause, on one of his voyages.

The first to construct a chart showing the declination of the compass was Edmund Halley, whose name is associated in our minds with the great comet. At the expense of the English Government, he sailed over the Atlantic Ocean in the *Paramour Pink*, between 1698 and 1701, and his cruises were thus the forerunners of those of the *Carnegie*. He brought his important work to the attention of the Royal Society by modestly presenting to them "my magnetic chart and some barnacles which I observed to be of quick growth."

Halley's excellent chart could not be used for finding longitude at sea, since no one knew how much the declination changed from year to year in any one place. Dr. Bauer, the founder of our Department, used to give the following illustration to show the change in the pointing of the compass in the course of time:

> "The *Carnegie* on her maiden voyage in 1909, in sailing from St. John's, Newfoundland, to Falmouth, England, followed almost the identical path of Halley's *Paramour Pink*. The observations on board the *Carnegie* showed that the variation of the compass as observed by Halley had changed to such an extent that if the *Carnegie* had followed the same compass-courses as those of the *Paramour Pink*, instead of coming to anchor in Falmouth Harbor, in the south of England, she would have

> made a landfall somewhere on the northwest coast of Scotland. In brief, while the sailing directions as governed by the winds and currents on the Atlantic Ocean are the same now as they were in Halley's time, the magnetic directions or bearings of the compass that a vessel must follow across the Atlantic to reach a given point, have greatly altered."

More recent observations have brought out many new facts about the magnetism of the Earth. Apparently the Earth is far from being simply magnetized. The so-called magnetic poles are over one thousand miles from the geographic poles; they are not diametrically opposite, for a straight line drawn between them passes some seven hundred and fifty miles from the center of the Earth. Moreover, mathematicians tell us that the actual magnetic poles are really not at the surface of the Earth at all, but near its center. It was once thought that an iron ship should not risk sailing near a magnetic pole, lest she should be unable to free herself from the attraction, much as iron filings are fixed to a bar magnet. This apprehension was groundless, as the real poles are so near the center of the globe that iron weighs practically no more at the north magnetic pole than at the equator because of magnetic attraction.

Then there are numerous areas on the Earth's surface, where certain mineral deposits affect a compass in an anomalous way. Some of these local disturbances are very intense, as in Kursk, Russia, and in Iceland. In fact, these variations in magnetic manifestations of subterranean masses have been used in mining to locate ore.

The forces directing the compass have also been found subject to short-period changes, as distinct from the secular changes mentioned above, such as the so-called annual, lunar, and diurnal changes which have a degree of regularity. Besides these, times of great activity on the surface of the Sun, as indicated by number of "sunspots," are in general times of an unsteady behavior of the compass. When these disturbances become violent, they are known as magnetic storms and may be so intense as to paralyze cable and telegraph communication.

It may be appropriate here to give from eminent authorities one or two quotations relating to terrestrial magnetism. Helmholtz and Maxwell, two of the greatest physicists, have considered magnetism, next to gravity, as "the most puzzling of natural forces." And Professor Fleming of England, referring to the practical importance of research in this field, has said: "That great empire which has its center in these islands (Great Britain), but its dominions scattered over the distant seas, has been built primarily on the art of navigation, in which the magnetism of the Earth is a central fact. Neither its world-wide commerce, nor the naval power which defends its coasts, could exist for a day without the aid of the magnetic compass."

The whole subject is thus exceedingly complex, and its complexity has been increasingly made evident with the development of observations and theories involving them offered in the past century. To learn anything worth while of the nature of the Earth's magnetic field, record of all these changes simultaneously at many points on the Earth's surface was required. Accordingly magnetic observatories have been set up throughout the world, but these are not numerous and had therefore to be amplified by establishing temporary stations in magnetically unexplored countries. Furthermore, almost three-fourths the surface of the globe is covered by the oceans, over which it was important to collect information as well.

This led to the plans made in 1904 and the formation of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington under the energetic and resourceful directorship of Dr. Louis A. Bauer for a world-wide magnetic and electric survey.

The magnetic survey was begun immediately. Land parties were organized to penetrate to the remotest corners of the Earth: through the heart of Australia and the Sahara, over the top of Central Asia, across the watersheds of South America, and through the forests of the Congo, and on the northern plains of Canada. Expeditions into polar regions were supplied with magnetic observers. In fact, stations were occupied wherever camel or canoe, mule or riverboat, motor or railway, could transport the instruments.

To make a beginning in the exploration of the vast ocean-areas, a brigantine was chartered, the *Galilee*. She set out from San Francisco Bay in 1905 into the almost uncharted Pacific to make three cruises, one under the command of J. F. Pratt and two under W. J. Peters. In three years she cruised the waters between Alaska and New Zealand and between China and the coasts of the Americas. Conditions for observing were very unfavorable on this ship. The instruments were mounted on an open platform on deck, where rain or seas interrupted the work for days at a time. Since she was not free from magnetic materials, it was necessary to "swing ship" for deviation-errors as often as circumstances permitted. These errors occasioned delay in reporting results, and made the computations of final values most laborious.

It was apparent that a non-magnetic vessel with observatory domes would be able to do the work far more efficiently. It was in answer to these needs that the *Carnegie* was built in 1909. The experience with the *Galilee* had been invaluable; old instruments were adapted to marine use, new ones were invented, and methods were compared with the aim of finding those which gave the greatest accuracy under ever changing conditions at sea.

The *Carnegie* made six cruises between 1909 and 1921, I and II under the command of W. J. Peters, III, IV, and VI under J. P. Ault, and V under H. M. W. Edmonds. During these she sailed more than a quarter of a million nautical miles, making some of the longest voyages in history, and traversing all waters between 80° north and 60° south. She had met ice and fogs around Spitzbergen and the South Orkneys, typhoons off Japan, harmattans along African coasts, pamperos near Argentina, hurricanes in the South Seas—and had come through unscathed. She had visited the most unfrequented islands, and was without doubt better known the world over than any ship that sailed the seas.

Perhaps the most notable achievement in her history was a sub-polar circumnavigation of the Southern Ocean in her fourth cruise in 1915–1916. This perilous voyage was made in a single season—a unique chapter in the annals of sailing. She made

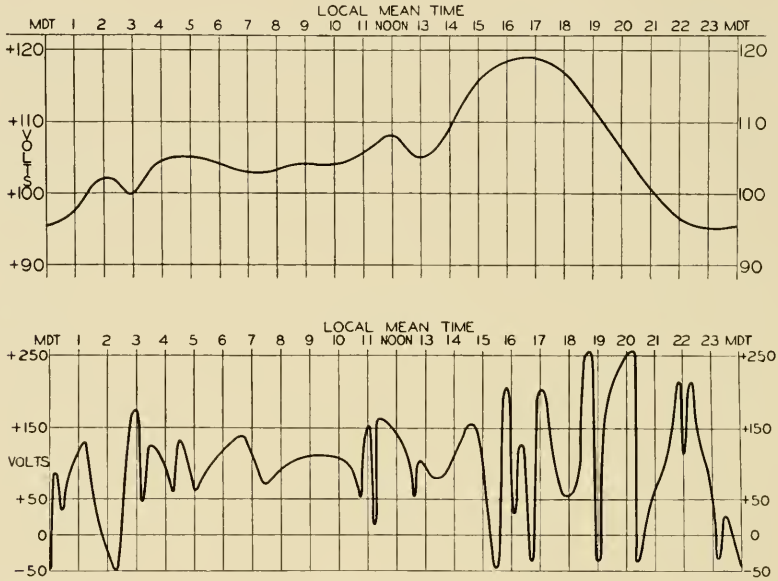
only one stop, desolate South Georgia at that! Gales blew on 52 of the 118 days required for the 17,000-mile journey through ice and snow. Some of the bergs were as much as five miles long and five hundred feet high. Captain Ault refers to them as "unpleasant sailing companions amidst the almost continuous fogs and blizzards of the Southern Ocean." To reduce the speed and to give the lookout an unobstructed view, the foresail was constructed in the shape of a triangle.

Probably the fastest voyage the *Carnegie* ever made was from New York to Hammerfest—4800 miles in 24 days. Not a reef was taken, as she ploughed through the rough seas of the North Atlantic. On this same cruise she very nearly came to grief off Spitzbergen, when a strong southerly gale almost bottled her up in an ice-pack to the north. She managed to clear this and proceeded to Iceland, where the party first learned that the Great War had been declared.

After every cruise there were tales of unusual and thrilling experiences. The vessel has scudded along at nine knots under bare poles near Wake Island. She once passed a corpse at 60° south, far both from land and from trade-routes; this had been the only sight of a human being encountered in four months, except for the whalers of South Georgia. On another occasion she set mail adrift in a copper box near Kerguelen Island containing abstracts of the scientific results during the first part of the sub-antarctic cruise; this was done so that if the ship were lost the records at least might be picked up. Again she had to navigate close to shore on the west coast of Africa through a red fog, caused by a harmattan, which brought the visible horizon to within less than half a mile from the ship. And after successfully making port at Dakar, she found the city so riddled with plague that she was forced to leave at once for Buenos Aires.

Another branch of geophysics is the study of the electric state of the Earth and its atmosphere. The entire Earth is charged with negative electricity. Although this charge is constantly being dissipated into the air, its total is not permanently diminished. Here we are face to face with a mystery, and we must find the source of this negative charge of the Earth.

Because of its relation to magnetism, a survey of terrestrial electricity was added to the observational programs of the *Galilee* and of the *Carnegie*. On board and ashore measurements were made of the elements of atmospheric electricity. These included the determination of the atmospheric potential-gradient or the change in voltage with distance above the Earth's surface and of conductivity or ability of the air to transport electricity. These



Hourly Values in Atmospheric-electric Potential on Normal Day and on Disturbed Day

From observations made aboard the *Carnegie* in the Atlantic Ocean on Cruise VII.

two measurements give us an idea of the rate at which the Earth loses its negative charge.

But if we are to seek out the source of this charge, many other factors must be observed. For example: counts of the number of air-molecules carrying a charge (ions); measurement of the amount of penetrating-radiation coming to the Earth from outer space (since this force is capable of producing ions in the air); measurement of the amount of radioactive matter in the air; and counts of the so-called Aitken nuclei, or "dust-particles."

In some respects conditions of electric study at sea are more favorable than on land and the vessel does not have to be non-magnetic for these investigations. The potential gradient of the atmosphere undergoes daily variations which are simultaneous over the whole Earth, and are thus independent of local time. This important fact had been hidden for years in the data collected ashore, because local disturbances of the atmosphere are almost the rule. The phenomenon was apparent when records from all the oceans were compared.

Important advances may be expected in these subjects when the upper air is investigated, for until now observations have been confined largely to the Earth's surface. In fact, plans for using dirigibles, balloons, and even rockets for this work are now being made.

We have already made reference to the oceanographic studies made on the *Carnegie* on her seventh cruise. A brief orientation will make the following narrative more intelligible; although, due to the great number of separate sciences concentrated here, this field of research is even more confusing than magnetism and electricity.

Aside from its importance to many branches of science, a knowledge of the oceans has a practical value for mankind. The intelligent development of our fishing industries, the laying of oceanic cables, the proper construction of harbor-works, oceanic commerce and navigation, as well as long-range weather forecasting, are all dependent on an understanding of oceanic conditions.

Changes in the physical properties of sea-water affect profoundly the life of the sea, and have even brought about evolutionary processes through changes of ocean-currents. Physics, chemistry, physical geography, meteorology, astronomy, zoölogy, botany, bacteriology, and physiology, all play their part in developing a proper picture of the water-world around us. To indicate how large a part of the Earth is covered by the oceans, we might call attention to the fact that a whole hemisphere, with its center near New Zealand, would have only one-tenth of its area as dry land! And the average depth of the seas is over two miles.

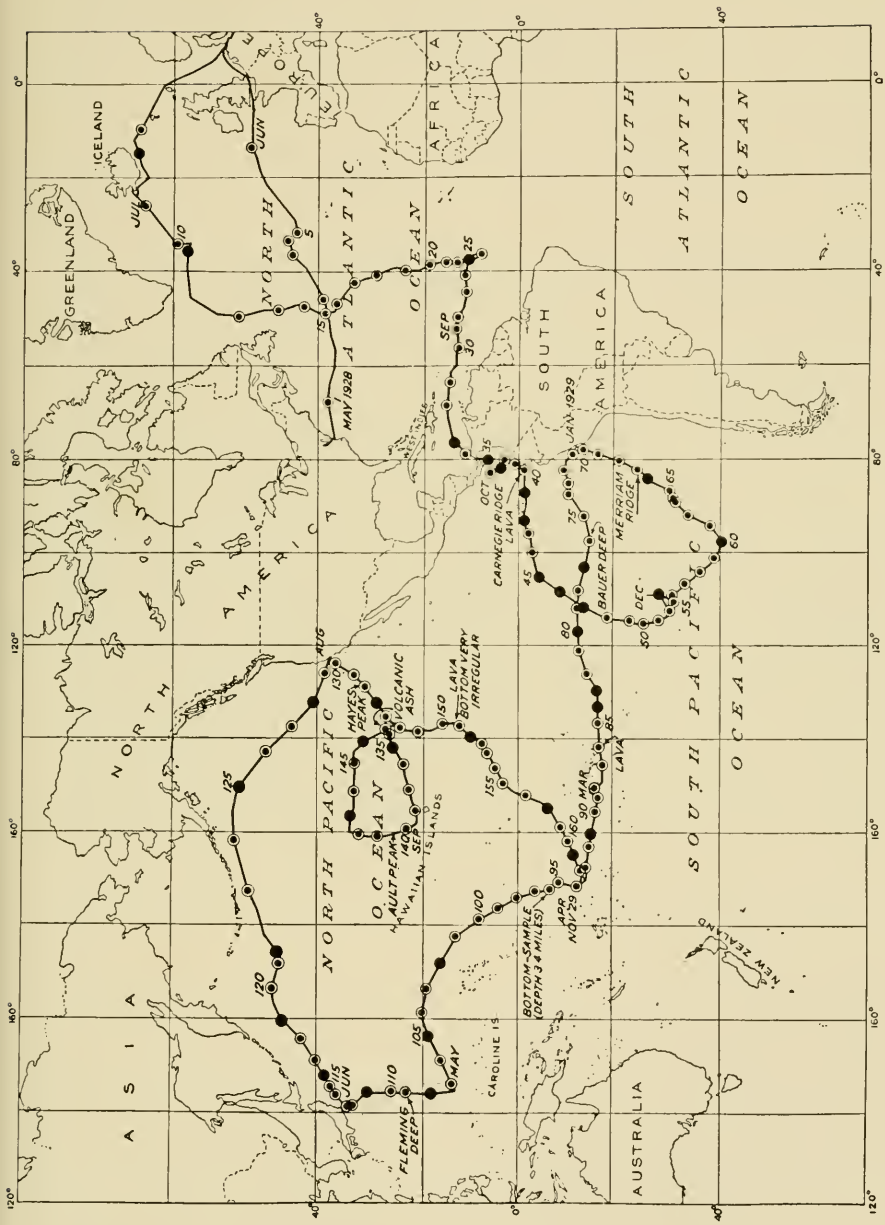
Oceanography as we have described it is not an ancient study. Its development has depended on the invention of methods in the other sciences. For instance, in recent years the perfection of echo-sounding has given to physical geography a magnificent tool for charting the oceanic floor. With this method one could easily make as many soundings in a year as had been made in all previous centuries.

The first true oceanographic expedition set out from England under James Cook in 1768 in the *Endeavour*. His primary purpose was to make astronomical and geographical investigations. However, a noted biologist was a member of the party, and deep-sea soundings and temperatures were recorded. In his day no one dreamed that life could exist under the great pressures existing in the depths of the ocean.

During the following hundred years, a multitude of new instruments was devised by men of all nationalities, and an increasing interest in the ocean was shown by great scientists. Charles Darwin and Thomas Huxley were two of this company. And the interest in marine biology was intensified when the telegraph companies began to report broken cables showing clear evidence of marine life even in the greatest depths. By this time Sir John Ross had invented a bottom-sampler which he called a "deep-sea clamm." With this he brought up some starfish and marine worms from two thousand meters.

This was the first direct evidence that life could exist under enormous pressures. An equally important contribution to the science was the invention of the deep-sea reversing thermometer protected against pressure. With these thermometers it could be shown that as we go deeper in the sea the temperature diminishes, and that on the bottom the water is not far from the freezing point—the reverse of conditions in a mine-shaft on land.

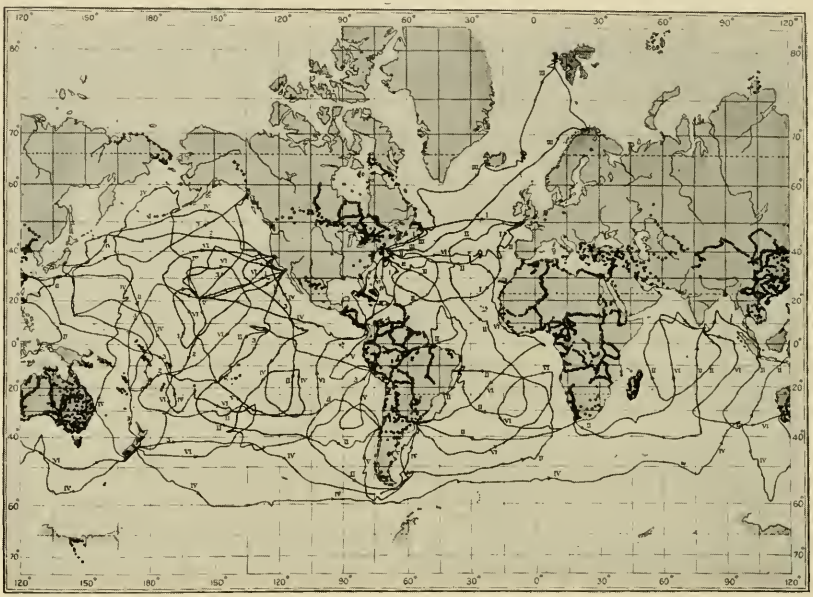
It was apparent from these advances that the time had come for a world-wide survey of the ocean and its floor. Until then research had been limited to areas near the coasts. Accordingly, the H.M.S. *Challenger* set out in 1872 on a great exploring expedition under the noted Sir Wyville-Thompson. This ship covered sixty-nine thousand miles in all oceans, making soundings,



OCEANOGRAPHIC STATIONS, CRUISE VII

dredgings, temperature and chemical determinations on samples collected from great depths, and biological studies of the floating forms of life. So thoroughly the work was done that since then oceanographers have limited their operations to some special region or some particular problem.

The United States had made many important contributions to the new science both before and after this voyage. Wilkes



MAGNETIC-SURVEY WORK OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM DURING 1905–1926

Cruises of the *Galilee* are indicated by Arabic numerals, those of the *Carnegie* by Roman numerals; black dots show the land stations.

made dredgings and soundings. Dana, the great naturalist, carried on biological and geological studies. Maury made the first systematic depth-charts, and may be said to have created meteorological oceanography. Agassiz, like Dana, prosecuted the biological end of the program. The larger part of this work was done on ships of the United States Coast Survey.

In recent times the advance of oceanography has been marked by the establishment of marine biological laboratories through-

out the world as well as by numerous expeditions. In these shore stations highly important experimental work can be done to supplement the discoveries of research vessels. Major contributions to the science are now coming from these institutions. Among the important oceanographic voyages completed just prior to the sailing of the *Carnegie* may be mentioned the German Atlantic Expedition of the *Meteor*, which covered the South Atlantic in a very systematic way between 1925 and 1927. Our staff had the great privilege of meeting the members of this party when we called at Hamburg in 1928.

Although much information has already been obtained about the sea, comprehensive, systematic studies have only begun. The projected cruise of the *Carnegie* was to cover the oceans so completely that it seemed highly desirable to take advantage of this fact by equipping her for work in oceanography.

THE VESSEL

The *Carnegie* was designed by Henry J. Gielow of New York, who had turned out many of the world's fine yachts. She was built by the Tebo Yacht Basin Company of Brooklyn in 1909. The architect succeeded in combining the graceful lines of a yacht with the requirements of strength and steadiness—the latter being paramount, since delicate instruments were to be used in all weathers.

She was built of white oak, yellow and Oregon pine. Copper or bronze-composition metal was used for all fastenings in the hull or rigging, in place of iron or steel. The rigging was of hemp, while manila hawsers replaced the usual anchor-chains. The fuel tanks were made of copper and the anchors, davits, galley-ranges, and even the engine and propeller-shaft were specially cast of bronze. There was an old-style fisherman's wooden windlass in the bow; and it required the brawn of all hands to up-anchor. Throughout every detail of fitting and commissioning, she was kept free from materials that might introduce errors in the magnetic measurements.

It is curious to note that Andrew Carnegie, who had acquired his wealth from steel, furnished the funds for constructing a ship in which every effort was made to *avoid* steel. Someone has said that the *Carnegie* fulfilled a prophecy by Thomas Hood, the British poet and humorist, which he made early last century in a poem entitled "The Compass, with Variations." The following lines occur:

> "They found no gun—no iron, none
> To vary its direction."

We did carry a small cannon—for shooting out a breeches-buoy line in case of shipwreck—but it was cast of bronze!

The unique features of the ship have been the cause of innumerable quips in ports the world over. It was once reported that

an otherwise capable watch-officer was refused a position on board because of his "iron constitution," and was informed that only "bronzed sailors" were acceptable. Several visitors have even asked if we have had to exclude raisins or spinach from our diet because of their high iron-content!

The principle dimensions of the vessel were: overall length, 155 feet; load water-line, 128 feet; beam, 33 feet; draft, 14 feet; displacement, 568 tons. The foremast stood 122 feet above the

Under a Full Spread of Canvas in the Pacific

water-line; and the length from the forward end of the bowsprit to the after end of the main boom was 197 feet. Registered as a brigantine yacht to facilitate port entries, the *Carnegie* was really a hermaphrodite brig, with a spread of some 13,000 square feet of canvas. While cruising the original mainsail and gaff-topsail were replaced by the more handy leg-of-mutton mainsail.

Aside from her unique non-magnetic construction, the vessel presented another curious feature, namely, the two revolving glass domes mounted in the fore-and-aft line amidships. These housed the instruments for measuring the magnetic elements.

THE LOFTY FORE-RIGGING
As seen from the quarter-deck with the wind dead astern.

They communicated directly with the chart-room, so that, with their protection, the observers could go about their work regardless of wind or rain or spray. On the *Galilee*, an ordinary sailing vessel chartered for a magnetic survey of the Pacific between 1905 and 1908, instruments had been mounted on an open platform above the deck. These domes were partly responsible for the choice of the square-rigged foremast, for they would have interfered with the handling of a boom forward. This choice of sail was of course unfavorable when sailing close to the wind for long passages, but with a light breeze blowing from astern she was more than a match for a schooner.

Besides these observatories, the super-structures included: A chart-room housing the "standard" compass, navigating instruments and charts; three laboratories for the atmospheric-electric, chemical, and radio investigations; and a "control-room" on the quarter-deck housing the observation-control apparatus of the sonic depth-finder together with certain parts of the magnetic and meteorological equipment.

Below deck, from the bow toward the stern, were the forecastle, the forward galley, the wardroom with officers' quarters, the cabin with staterooms, the after galley, the fuel tanks, the engine-room, and the lazarette in which provisions were stowed.

Before we describe the scientific instruments, we might answer the first question asked by the average visitor to the ship: Why was the *Carnegie* built non-magnetic? Iron in a vessel's hull, or carried on board, affects the compass-needle in two ways. First, it alters the normal direction of the needle and introduces an error known as the "deviation of the compass." Secondly, it weakens the *force* of the Earth's magnetic field acting on the compass. Both of these effects vary with place, time, and course of the vessel. A change of cargo, or the buffeting of an iron ship by the waves, will change the "deviation."

Ordinarily a ship-master has his compass "adjusted" by placing magnets or pieces of iron in the neighborhood of it in such a way as to counteract the effects of the iron ship. But to make this adjustment, he must first know where the compass would point on a non-magnetic vessel like the *Carnegie*. With this information

THE WOODEN WINDLASS AND MANILA HAWSER

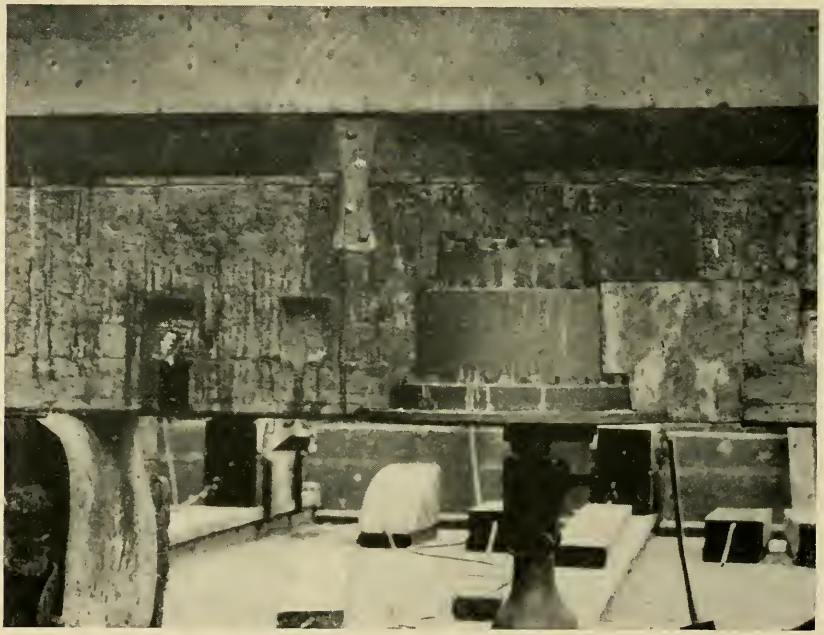
A necessary, if cumbersome, part of a non-magnetic vessel's ground-tackle—view on an early cruise of the *Carnegie*.

he knows what correction to make on his disturbed compass. Many a shipwreck can undoubtedly be laid to an improperly adjusted compass, or to the use of faulty magnetic charts. The *Carnegie* was made non-magnetic so that observations as free as possible from local disturbances due to iron or steel in the vicinity of the instruments could be supplied from which correct charts would be drawn, and at the same time furnish the facts demanded by science.

The non-magnetic features of the *Carnegie* entailed large expenses in building and in repair work, and introduced some serious difficulties in navigation. Our unhappy experience at Easter Island may be cited as an example where the manila anchor-hawsers were chafed through by coral heads, almost putting us on the rocks. The clumsy windlass, made necessary by the non-magnetic requirements of the ship, was unsuited to such passages as the Straits of Magellan. In negotiating these narrow waters, one must heave up the anchor at a moment's notice to take advantage of a sudden change of wind or tide. It might take as much as one or two hours to get away with the fisherman's windlass, so it can be realized how much we were handicapped. In fact, the farther we were from land the safer we felt.

RECOMMISSIONING THE *CARNEGIE*

The summer of 1927 was a happy one for the *Carnegie*. She must have been restless indeed in her berth on the Potomac River, where for six years she had watched the seasons come and go without the tramping of sailors on her deck, or the tang of

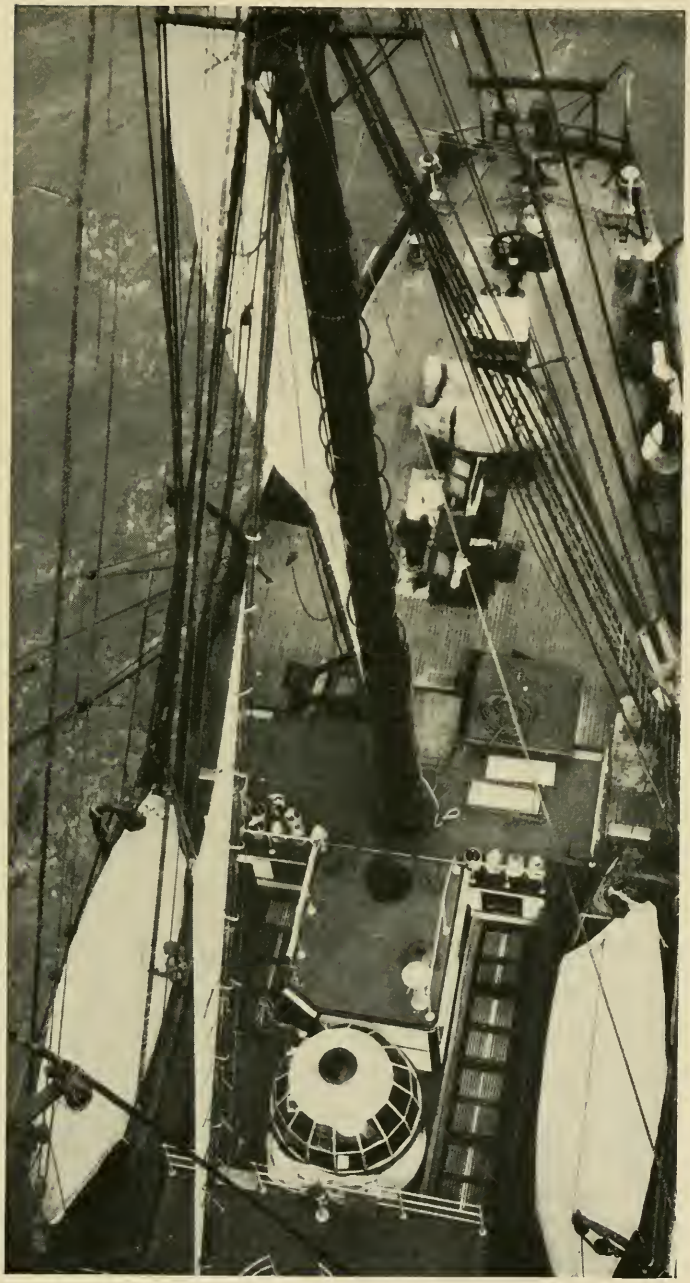


THE OSCILLATOR OF THE SONIC DEPTH-FINDER

Installed in the keel—the vibration of this heavy diaphragm sends to the bottom the sound-wave whose echo is picked up by the microphones.

salt spray on her bow. And now she was to be recommissioned for the grandest cruise of all, over the oceans she knew so well.

Tugs of the United States Coast Guard took her safely to dry-dock in New York, and brought her back to Washington in the fall. Captain Ault and Mr. Erickson, her mate, supervised the installation of new masts and rigging. Only the old royal-yard



THE WAIST AND QUARTER-DECK VIEWED FROM THE ROYAL-YARD

remained aloft to tell its tales of squalls and of creaking calms. New sheathing was applied to the bottom, new laboratories were built on deck. A host of new instruments was put on board: winch and sonic depth-finder, recording thermometer and refrigerator, generators and batteries. Whale-boats that had hung on the quarter-deck were now raised to platforms amidships, to clear the deck for sounding wires.

When they had finished her, the *Carnegie* must have felt a little self-conscious, dressed as she was in the latest styles in scientific apparel—much of it imported from Berlin and London, Norway and Denmark. The United States Navy had given her the means for sounding the bottom without heaving to, and had supplied a radio to keep her in touch with home. And it had commissioned her Captain a Lieutenant Commander in the Naval Reserve, as a further mark of its interest in the coming cruise.

With all the new work in oceanography and radio, it was necessary to abbreviate the usual magnetic program and to add two members to the staff. On previous cruises duplicate methods had been employed for measuring the three magnetic elements, so it was now possible to select the most trustworthy and to dispense with the others. Also, it was decided to occupy complete magnetic stations only on alternate days, although declination-values were to be obtained daily. This allowed the necessary time for oceanographic work and for a considerable expansion of the meteorological program.

As much of the work as possible was done by specially made automatic recording-devices; thus continuous records of potential-gradient and conductivity were obtained photographically, and humidity-changes at various levels above the sea were recorded electrically. The observer had then only to compare these instruments frequently using standard methods, and was free to take up other duties. Only the long experience of the Department in ocean-surveys, and the use of these recorders, made it humanly possible for the staff of eight men to carry on the heavy program outlined.

The magnetic survey of the ocean which had been initiated in 1905 had been brought to practical completion by the end of

Cruise VI in 1921. The chief aim in the present voyage was to reoccupy many of the former positions in order to note the changes which had occurred with the lapse of time. There had been disclosed on earlier expeditions areas of local magnetic disturbances, and these too must be studied again. These considerations determined to a large extent the course we followed in traversing the oceans; but here and there a compromise with the requirements of the ocean-studies had to be effected.

THE EQUIPMENT

While docked in San Francisco after our first year at sea, a celebration was held aboard the *Carnegie* commemorating the twenty-fifth anniversary of the Department of Terrestrial Magnetism. Following the ceremonies, the vessel was open for public inspection for a period of several days. The popular interest shown in the ship and its scientific equipment was keen—three thousand visitors having made the rounds in two days. This experience suggests that the reader of the following narrative may also find of interest such a conducted tour. It will certainly give a more concrete idea of what we set out to accomplish.

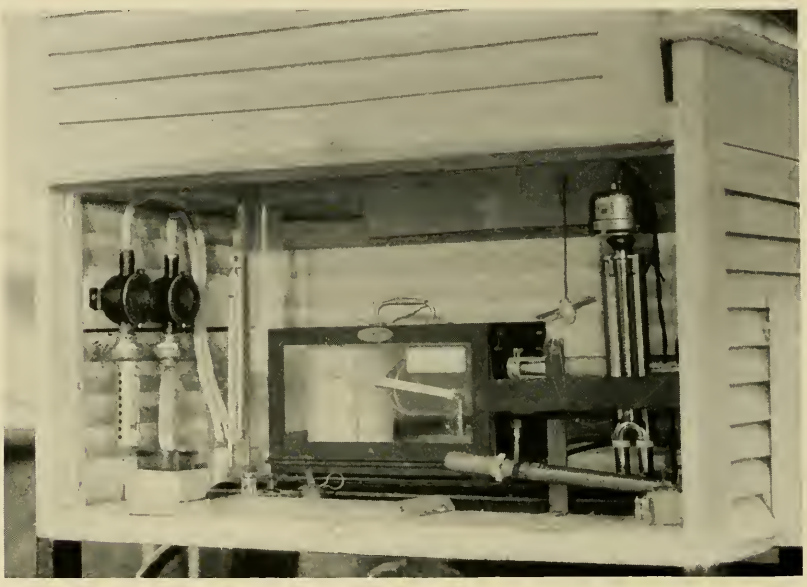
Coming upon the quarter-deck from the pier one's attention is drawn to the shiny three-ton bronze winch and its two reels of aluminum-bronze wire. With this electrically driven "gold-hoist," as the sailors call it, deep-sea soundings can be made, water samples collected, and temperatures taken down to a depth of three or four miles. From the winch the wires lead through blocks, over meter-wheels to davits over-hanging the water. One of the winch-heads was cut down to hold the steel piano-wire, which was used later in the cruise for collecting samples of the bottom, and for getting temperatures at depths greater than could be reached with the bronze cable. Although this steel wire was very long it weighed little, and was so far removed from the magnetic instruments as to have no observable effect on them. The drums and heads of this winch were ingeniously constructed to work independently, so that to save time several operations might be under way simultaneously: for example, paying out on the bottle-wire, and hauling in on the bottom-sample. Aluminum-bronze wire had previously been used by the German Atlantic Expedition of the *Meteor*, on which it had been shown superior to any other cable for deep-sea purposes and fitted in admirably with our non-magnetic requirements.

Mounted over an outboard platform near the winch is the

PAUL AT THE PLANKTON-PUMP

This device makes a census of the microscopic life floating at any desired depth.

"plankton-pump." This apparatus is lowered to various depths to count the number of microscopic animals and plants existing at each water-level. Due to an insufficiency of power, our biological work was limited to the study of these minute, drifting organisms found everywhere in the oceans. A small conical net made of very fine-meshed silk bolting-cloth, such as millers use in sifting flour, is attached to the end of the bronze cylinder. A pump actuated by a falling lead weight forces a measured



THE STEVENSON METEOROLOGICAL SHELTER

On the quarter-deck housing instruments to measure temperature and humidity of the air.

volume of sea-water through the net. One has only to lower the apparatus to the desired depth, drop a brass "messenger" down the wire to release the catch on the pump, and gravity does the rest. The cylinder is closed while being lowered and raised. This avoids contamination of the desired sample by plankton living in the upper layers of the water.

From this description, the plankton-pump seems to be a clever little mechanism which does its appointed task uncomplainingly.

But of all the pieces of machinery aboard, this one required the greatest display of ingenuity and the most severe strain on one's

Erickson, the First Mate

good humor, to keep it in operation. Wires and valves, rubber bands and springs, weights and releasing forks—all had an abomi-

nable habit of getting tangled up once the mechanism was safely hidden from view in the waters under the vessel. It was a rare day when three consecutive hauls were successful. Nevertheless, with its aid we were able to make a census of the sea's population in various regions and at the various depths—a valuable contribution to our knowledge of life in the ocean. The pump was designed by Dr. Petterssen of Norway, and had been tested off the coast of that country by Dr. Sverdrup, a Research Associate of the Carnegie Institution.

Immediately inboard from the plankton-pump platform is a large "gear-box" filled with oceanographic instruments. Standing on the outside in ranks, like well drilled veterans, are the reversing water-sampling bottles, designed by the late explorer Nansen. These remarkable brass cylinders may be attached in series to the bronze wire, lowered to the desired depths, and reversed by dropping a brass messenger down the cable from the ship. Each bottle has a messenger hanging at its lower end, so that when the first bottle reverses end-over-end, its messenger continues down the wire to upset the next. The two valves at the ends of each bottle close automatically when reversal takes place, imprisoning about a quart of water, to be analyzed by the chemist in the laboratory on deck. To each of these bottles is attached a small frame containing the all-important deep-sea reversing pressure thermometers.

Inside the gear-box are several types of "bottom-samplers." Some consist of brass tubes surrounded with lead weights which fall off after the apparatus plunges into the ocean-floor. Others operate like a clamshell or turtle's jaws, snapping up a sample of bottom-deposit. A third kind is a long, glass-lined metal tube with a heavy weight permanently attached to it, which procures a vertical section of the mud or ooze, showing the successive layers in which it has been deposited. But the sampler most commonly used is a modification of the telegraph "snapper" of the clamshell type. Like the plankton-pump, this mechanism required considerable nursing, and even some surgical operations as time went on.

On the basis of these samples a study of the nature and origin

of marine bottom-deposits will be made ashore. This collection will prove of great interest, due to the scarcity of material,

PARKINSON TESTING THE PHOTOGRAPHIC RECORDER
This instrument measures the potential gradient of the atmosphere.

especially from the Pacific. Workers in the Geophysical Laboratory of the Carnegie Institution in Washington are interested in the chemical analyses. From the amount of radioactive material

found in them, thorium and radium, they hope to get some idea of the age of the Earth. Scientists studying the origin of oil-deposits will be furnished samples. The American Telephone and Telegraph Company wishes to determine the corrosive effects on their cables. Then too, it is now known that bottom-living creatures feed on organic matter found in muds.

In this same box is kept the brass bucket for collecting diatoms from the harbors we visit. These exquisite microscopic plants, displaying inexhaustible patterns of form, are present in all the waters of the Earth from pole to pole. They are almost the sole food for the larval stages of fish, and are therefore of immense importance. Some of the largest marine creatures use these tiny plants as food. So minute are they that a hundred of them might be placed side by side on the head of a common pin. The harvest of fish has been noticeably increased by adding silicates and phosphates to the water to augment the supply of diatoms, just as nitrates and phosphates are used in agriculture. The work on board was planned to include a study of the relation of these chemicals to the abundance of diatoms and plankton. In fact, the source of the silica in the surface-layers of the ocean, where the diatoms thrive, is not well known, for the great red-clay silica deposits are sometimes several miles below and seem to be increasing in extent.

In higher latitudes the diatoms show great changes in abundance with change of season, for they are plants and depend directly on sunlight as their source of energy. It is for this reason that they are found in a living state only in the uppermost few hundred meters of the sea, and on the bottom of shallow shore-waters. It is not always realized that sunlight is totally absorbed in the clearest sea-water in less than a mile from the surface.

Leaving the gear-box we walk aft to the Stevenson meteorological shelter, which gets its name from its designer, the father of Robert Louis Stevenson. Here are housed some of the various instruments used in studying the circulation of the atmosphere, just as the oceanographic equipment is used to give us a picture of currents in the ocean. There are three forms of apparatus for measuring the changes of humidity. One is a motor-venti-

THE CASE CONTAINING THE DELICATE DEEP-SEA REVERSING-THERMOMETERS

Used not only to measure the temperature of the sea at different levels but also the depth.

lated recording psychrometer procured in England designed to give a continuous record of "wet" and "dry" bulb temperatures and from this record is calculated the degree of saturation of the air by water-vapor. Another is one unit of an electrical resistance-psychrometer, which measures the humidity at three heights over the ocean—on deck, at the main crosstrees, and at the masthead. In the control-room, which we shall visit later, is the automatic recorder for these three pairs of electric thermometers which registers at intervals of thirty seconds the six wet- and dry-bulb temperatures in consecutive order. The third is of German make, and has very accurate thermometers. It is ventilated by clock-work, and is read directly by the eye of the observer. This is used daily to check the accuracy of the other two.

In the shelter is also kept the little instrument for measuring wind-velocity—the anemometer—as well as the standard sea-surface thermometer and other meteorological equipment.

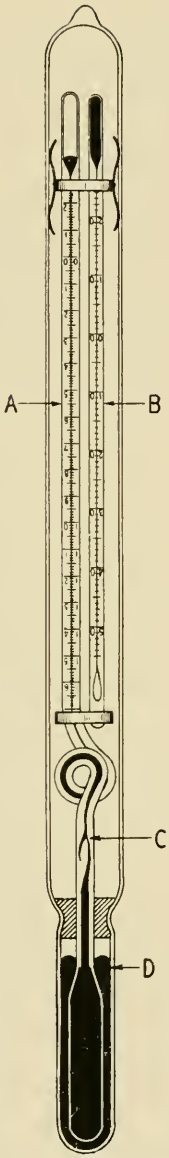
Walking aft a few feet we stand at the steering gear of the ship. There is no cozy wheel-house on the bridge for the quartermaster of a sailing ship! He must stand at the very stern, with an unobstructed view of the sails. When sailing "by the wind" his eye is glued to the weather-side of the uppermost sail; he keeps it drawing a trace of wind, but never lets it fill. It is true that the *Carnegie* had a "bridge," but this was used only by the pilot when entering or leaving port, and by the lookout during the night.

The steering gear itself is a constant source of interest to visitors, for it is one of the many features of the old-time windjammer to be found on the *Carnegie*. The whole mechanism is operated by hand; a whirl of the wheel to starboard brings the helm to port and turns the ship itself to starboard. The old-fashioned method of giving orders to the steersman, calling "port" or "starboard," almost wrecked us one day in Samoa, when a shore pilot in a tight place overlooked the fact that we did not use the modern code in which the order refers to the ship's head and not to the helm. The binnacle, which stands before the man at the wheel, is also a carry-over from bygone days, for the com-

pass reads in "points" and not degrees. As each man finishes his two-hour trick at the wheel, he calls out to his reliever: "East by south half south," and not "107 degrees."

On one side of the wheel, mounted near the rail, stands the rain-gauge; and on the other, the evaporimeter. The latter is made of glass, and is used to measure the rate of evaporation of sea-water from day to day. This subject is part of the general investigations made of the influence on climate of movements of large bodies of warm or cold water. We wished to study the transfer of heat between the sea and the atmosphere; and the evaporimeter, together with the electric resistance-thermometers, gave us much needed information.

On the taffrail around the stern is the automatic recorder for the potential gradient of the atmosphere's electricity. The negative charge on the Earth's surface causes an electric pressure in the air increasing with height above the Earth's surface. Ordinarily this rate of increase or gradient is in the neighborhood of one hundred volts per meter near sea-level. There are daily variations, aside from the local changes due to disturbances in the atmosphere near the ship. We have already referred to the mysterious surge in the potential gradient which occurs simultaneously over the whole Earth. It was discovered after examining observations obtained on previous cruises of the *Carnegie*, and our aim was now to collect records from widely separated geographical



A Richter and Wiese Deep-sea Reversing-thermometer

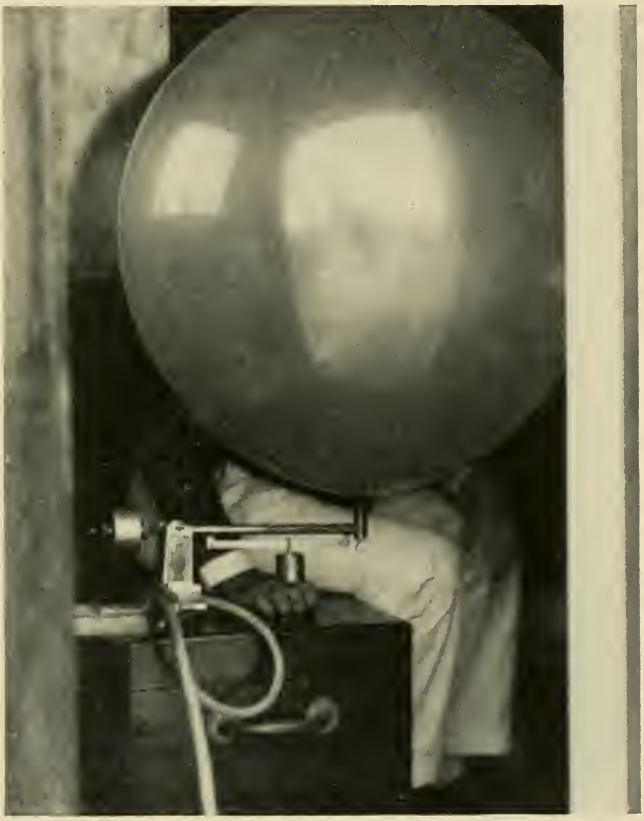
Protected against pressures encountered in the depths of the ocean—(A) Sea-water thermometer, (B) auxiliary thermometer for making correction for air-temperature on deck, (C) point at which mercury-capillary breaks on reversal, (D) mercury-shield which protects bulb from pressure of sea.

regions to confirm this. Any attempt to discover the cause for the Earth's permanent negative charge must be based upon a knowledge of potential gradient.

This automatic recorder gives us traces at about tenfold the rate possible with the eye-reading apparatus used on former voyages. It is also very sensitive to changes in the electric conditions of the air, because ionium-collectors are used. Ionium is an element which has the property of giving "air-molecules" in its neighborhood an electric charge, thus turning them into "ions." These ions acting as carriers facilitate the transfer of electricity from the air to the instrument, and eliminate any lag during rapidly changing conditions.

We shall now walk forward on the port side of the quarter-deck past the jaunty little dinghy hanging in its davits. The control-room built alongside the companionway contains many essential parts of our equipment. The time-measuring device for the sonic depth-finder with its control-panel is located here. This electric sounding-device, loaned by the United States Navy, is made up of three important units, the oscillator, the microphones, and the timing mechanism. A large steel-diaphragm oscillator, set face downwards in the keel of the ship near the stern, is put into periodic vibration by electromagnets and produces a sound-wave which is reflected from the ocean-bottom. The echo is picked up by microphones set in the vessel's hull, and carried to the head-phones of the observer, who sits at the control-panel. An accurate time-measuring device gives us the exact time-interval between outgoing signal and returning echo. With this information we can easily calculate the depth, for the velocity of sound in sea-water is known. It is roughly one mile a second, depending however on the temperature and salinity. But as these factors for each water-level are determined on board, we are able to sound with an unusual degree of precision. For example, the observer reports that it took two seconds for the echo to return. This means that the sound-wave traveled about two miles, and the sea is one mile deep. This is the underlying principle, although actually the procedure is somewhat more complicated.

The great advantage of this method is that the ship need not heave to and consume one or two hours for a sounding with line and lead. A sonic depth may be made with the ship on her course in from five to ten minutes. We are able to check these soundings by the old-fashioned lead weight, and do so on alternate days.



Weighing the Hydrogen-filled Balloon
Followed in ascent to a height of from two to seven miles in order to plot the air-currents.

In the large box on the floor are our pressure thermometers. With these we have an ingenious method for checking the depths recorded sonically and by wire. Besides this, the marvelous instruments can tell us precisely at what distance from the surface each of the "Nansen bottles" was reversed.

These German-made thermometers are of two types. Some are protected from the enormous pressures encountered in the deeps, and give the true temperature. Others are unprotected, and give a fictitious reading: the sum of the true temperature and the effect of the pressure exerted mechanically on the naked bulb by the weight of the water-column above it. The difference between the readings of such a pair is then a measure of the pressure. By rather complicated calculations we may then convert this to meters of depth.

The thermometers are sent down, inverted, in their frames on the side of the Nansen bottles. They are given time to assume the temperature of the surrounding water, and are then reversed along with the bottle, when the messenger comes down the wire from the surface. This reversal breaks the mercury-thread in the tiny capillaries in such a way that the changes in temperature and pressure encountered on the way back to the surface will not be registered, and the observer on deck can get a true picture of conditions at the desired depth.

By the use of these readings and the salinity-values for each sample, we are able to calculate "dynamic pressures" for each water-level to the bottom. Plotting the figures on a chart we can determine the speed and direction of the ocean-currents below the ship—a subject of great importance to oceanography. These charts are made in much the same way as weather-maps prepared by the Weather Bureau—based as they are on pressure readings taken at a multitude of stations, and from which winds can be predicted.

There are more direct means for measuring ocean-currents. We may trace the course, speed, and direction of floating objects. This is not satisfactory, for only the surface-current is represented, and the effect of changing winds on the object may confuse the true picture. A more useful method is to lower from an anchored ship an instrument similar to an anemometer. We had insufficient power for hauling in a deep-sea anchor, and so we relied entirely on the "dynamic-pressure" computations.

The configuration of the ocean-floor is of great interest to seismologists studying the movements of the Earth's crust.

Oceanographers are also able to explain certain peculiarities of ocean-currents by the contour of the ocean-bed. But enormous areas are still unexplored.

On the wall of the control-room hangs the German multithermograph which was referred to when we looked into the Stevenson

Torreson Observing a Pilot-balloon
With the specially designed theodolite loaned by the United States Navy.

meteorological shelter. Below it is an inflation-balance for use in connection with soundings of the upper atmosphere. Rubber balloons filled with hydrogen are released from the deck. These extremely light globes are deflected from their upward course by

every breath of air they meet. By following them with a theodolite, an instrument for measuring elevation and direction through vertical and horizontal angles, we can study the air-currents at heights up to six or seven miles. Besides the general scientific interest in the movements of the Earth's atmosphere, the aviator will some day come to rely on pilot-charts based on these soundings, just as the mariner relies on wind- and current-charts for the ocean-surface.

Before leaving the control-room we must glance at the long array of switches, galvanometers, batteries, and ammeters stretched along a table against the starboard wall. Although it is part of the equipment for measuring the elements of the Earth's magnetic field, some of this apparatus contains small pieces of steel, and must be set up well away from the observatory-domes. One observer sits at this table to control the constant-speed motor for the "marine earth-inductor" which we shall see later. He is in communication through a brass speaking tube with the second observer in the dome. At given signals he records the readings of the ammeters of galvanometers before him.

In the control-room we also find the Sperry gyroscopic pitch-and-roll recorder. Magnetic measurements at sea are usually affected by small errors caused by rolling, pitching, and scending of the vessel. Though small, these errors are important where accurate determinations are desired of the distribution and of progressive changes in the Earth's magnetism—as on the *Carnegie*. A study based on records from this instrument has shown that when the vessel heads on any one of the four cardinal points of the compass, no error is introduced into the measurements. A record of the rolling and pitching of the ship during magnetic stations can be studied later at headquarters to detect these disturbing effects.

We have spent a long time in the cramped quarters of this little room, but one can see that in it lies the central nervous system of the magnetic and oceanographic equipment. A few steps down and we have left the quarter-deck. Standing in the waist of the ship we see curious nets hanging from the whale-boat platforms. These long cones of silk bolting-cloth are used to collect plankton.

A Silk-net Coming Up after Being Towed from the Ship
Used to collect the microscopic forms of life floating in the ocean.

They are towed from the ship during oceanographic stations, and may be lowered to any depth desired.

It is true that the lack of fishing and dredging equipment deprived us of the excitement of bringing up fantastically shaped monsters from the deep. But in the plankton-nets we can catch a hundred bizarre forms to every one recovered from a dredge; we can find animals painted with all the colors of the rainbow, whereas the deep-sea organisms are either black or red. Anyone who has once seen these exquisite creatures through a microscope will never again envy the man with a deep-sea dredge.

A double boat-boom projects over the water from the fore rigging—a glorified pirates' plank, as someone has suggested. This boom-walk was similar to that used on Beebe's expedition. On calm days it may be lowered for the use of the biologist, who is thus able to dip up floating objects beyond the wash of the vessel.

A step over the high doorsill and we are in the chemical laboratory. Here each water-sample is analyzed for salinity, phosphates, silicates, oxygen, and hydrogen ions. All these substances are intimately related to the life of plankton. We limited ourselves to such determinations as could be made on board, for we had no room to stow away samples for study ashore.

There were several unusual features about our chemical work. The salt-content of the sea-water was measured electrically by a resistance-bridge designed for our use by Dr. Wenner of the Bureau of Standards in Washington. By measuring the electrical resistance of a sample of sea-water, we are able to calculate its salinity. This method was regularly checked by the conventional titration of samples with silver-nitrate solutions.

The apparatus for measuring the so-called "hydrogen-ion concentration" of sea-water at various depths was ingenious. It avoided the use of permanent color standards in test-tubes, and gave more accurate readings than are ordinarily obtained at sea. It was a modification of the double-wedge comparator described in technical journals by Barnett and Barnett.

To analyze for phosphates and silicates, chemicals are added to the specimen to bring about the development of a certain color, the intensity of which is a measure of the phosphate or silicate

SEIWELL AT WORK IN THE CHEMICAL LABORATORY

Analyses were made for many substances, like phosphates and oxygen, which are concerned in the life of the plankton.

present. After treating with the same chemicals a second solution (whose composition is known) we have only to match the intensity of one color against the other to obtain a value for the unknown sample. The presence of as little as one part of phosphate per billion parts of water can be detected in this way.

When the reports of the oceanographer, the chemist, the biologist are correlated, we have a good picture of the life of plankton. We can see what limits of temperature and salinity they tolerate; what substances they need for food; and what influence variations in sunlight, oxygen, and acidity have on their growth.

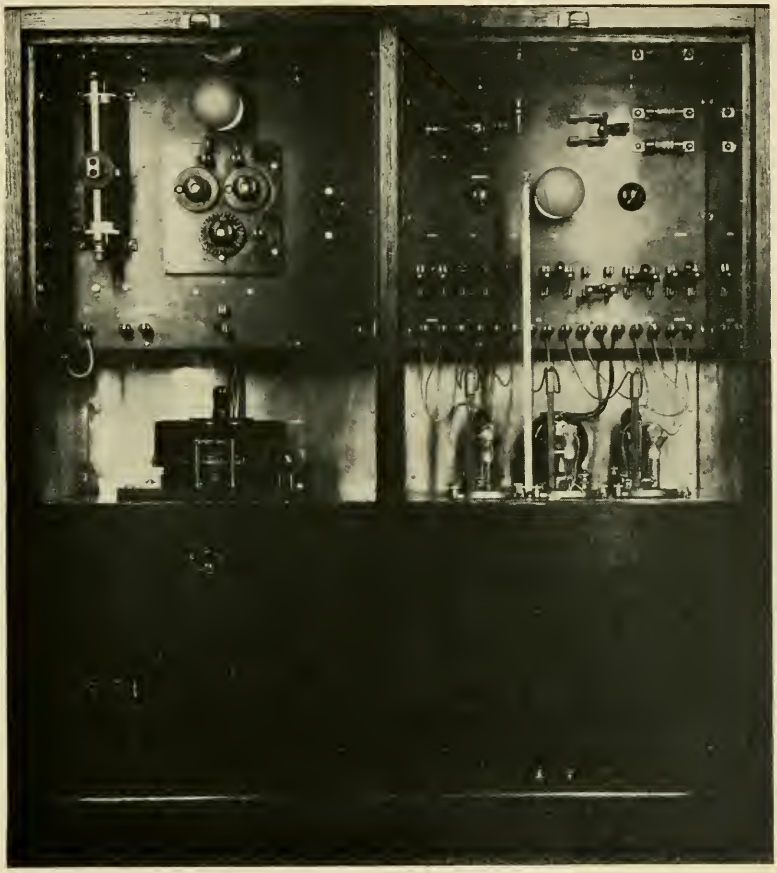
The usual equipment of a chemical laboratory is more familiar and will be passed by. But there are, besides this, microscopes, dissecting instruments, and preservatives for the use of the biologist.

Over in the corner of the room is a self-recording sea-water thermograph. This device keeps a continuous record of the changes in surface-temperature as we sail down the latitudes. A large bulb of mercury is mounted on the outside of the vessel's hull. It communicates with the recorder through a capillary tube. Any changes in the volume of the mercury in the system, due to changes in sea-temperature, are transmitted through a hollow coil-spring to a recording pen.

A short walk forward, a few steps up, and we are on the "bridge." From here we can look upward at the lofty rigging, more bewildering in detail than many of our instruments. Or, we may look toward the forecastle-head and see, coiled on the deck, the two great hawsers which serve us for anchor-chains. But a weird object, suggesting an automaton in a brass helmet, stands at the center of the bridge, challenging attention. This is the "marine collimating-compass." It gives us the magnetic declination, or "compass-variation" as sailors call it.

The principles on which it operates are simple enough. We wish to find the angular difference between true geographic north and the magnetic north as indicated by the compass. We can use the Sun as our point of reference, since we know its true bearing from the ship by using the Nautical Almanac. In the

collimating-compass, the card ordinarily viewed from above is replaced by a set of vertical scales which may be seen by looking horizontally through openings in the sides of the compass-bowl. An observer brings the image of the rising Sun, let us say, to one



THE WENNER SALINITY-BRIDGE

An apparatus giving the salt-content in a sample of sea-water by measuring the resistance it offers to the passage of an electric current.

of these vertical scales with an ordinary sextant and measures the horizontal angle between them. With the Sun's image on the vertical scale he can make continuous readings of its position, as the compass swings back and forth with the roll of the

ship. By taking the mean of several hundred such readings he has made an accurate measurement from which the declination may be computed.

This instrument was designed by Peters and Fleming of the Department of Terrestrial Magnetism, and was made in its shop. The method is superior to older methods used at sea which depended on hasty readings taken as the Sun's image, or a shadow, flits across a moving compass-card on a rolling ship. Three observers are required to take a declination-measurement. One man's duty has been described. A second reads the *altitude* of the Sun from time to time, for it seldom happens that weather-conditions are perfect exactly at sunrise or sunset, and corrections for altitude must be applied. The third observer is the recorder. He must be a sleight of hand artist, because he had to write down the readings of the other two and keep a second-to-second record of the time when each of these is made.

On the starboard wing of the bridge is located an apparatus for collecting the radioactive materials in the atmosphere, which are present in only infinitesimal amounts. When a measured volume of air is drawn through the collector over negatively charged metal foil, the desired particles are deposited on the foil because they carry a positive charge. Let us now follow the observer into the atmospheric-electric laboratory, where he will measure the amount of radioactive material collected. This electric laboratory is located just abaft the bridge, directly amidships. It is entered from the foot of the steps leading to the bridge. The observer places the metal foil in an ionization-chamber where the rate at which the radioactive material produces electrified particles or ions is measured. This rate is a direct measure of the amount of radioactive material collected.

Another instrument counts the ions normally present in the atmosphere, by extracting them from a measured volume of air. There are usually about 30,000 of these per cubic inch, but their origin is unknown. Under the action of the Earth's electric field, positive ions are traveling toward the Earth and negative ions upward into the air, giving rise to an air-earth electric current which makes no impression on our senses. The rate at

which this interchange takes place would neutralize the Earth's negative charge in a very short time, were there no recharging agent. But radioactivity alone accounts for only a small part of the ions produced in the air.

THE FORE-RIGGING
Looks very complicated from this angle—it is!

Recently, penetrating-radiation of "cosmic rays" have been shown to ionize the air. These exceedingly powerful rays can penetrate several feet of lead, and seem to originate entirely outside our solar system. An apparatus carried on board measures the amount of this energy received by the Earth. However, it does not appear that this accounts for more than another fraction

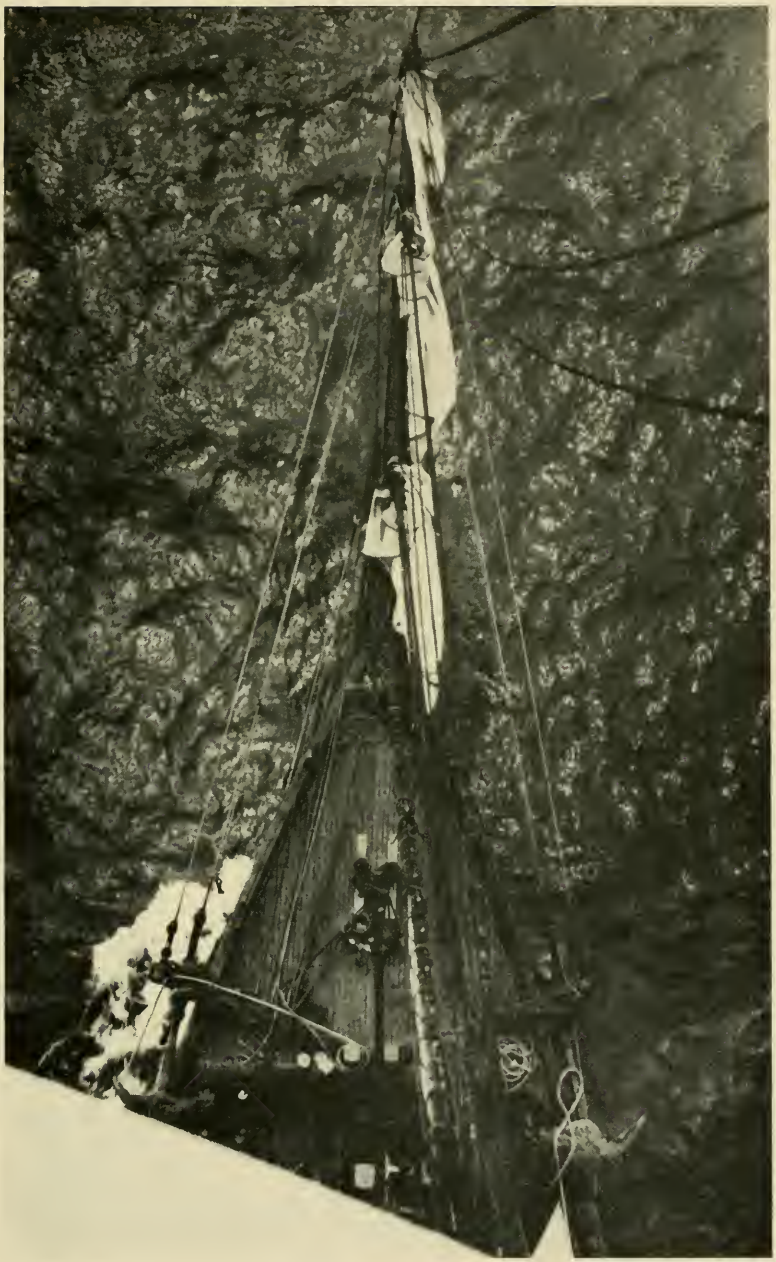
of the ionization of the atmosphere or of the permanent negative charge of the Earth.

Intimately connected with the number of ions in the air is its electrical conductivity, or its ability to carry an electric current. It is measured in this laboratory with an automatic photographic recorder. A stream of air is drawn through a duct past a cylinder at its center. A small battery causes a current of one millionth of a millionth of an ampere to pass through the air, and a delicate electrometer measures the air's conductivity.

The air over the sea is much more free of dust than over land, but the influence of this pollution on the elements of atmospheric electricity is so great that systematic "dust-counts" must be made even far from land. Some years ago, when the volcano Krakotoa erupted, such quantities of dust were blown into the atmosphere that it took two years for it to settle over the Earth. Even in normal years pollution may vary from 1,000,000 particles per cubic inch to a few thousand. When dust is abundant the atmospheric conductivity is decreased and the potential gradient rises to as much as 300 volts per meter. The Aitken counter is used to determine the pollution of the atmosphere. When moist air is suddenly expanded, the water present condenses as droplets, provided some dust-particles are present to act as centers of condensation. In the Aitken counter, the droplets so formed are enumerated and not the dust-particles themselves. Not all dust is visible under a microscope, for it is believed that such particles as salt-spicules, and even aggregates of water or ammonia molecules, may act as condensation-centers.

In the chart-room under the bridge is the navigational equipment including sextants (sixteen of them), barometers, log books, marine charts, and pilot-books. There are six desks where the observers do their computing. Complete sets of graphs, tables, and calculating books are at hand to facilitate the work. These desks are always filled except when a magnetic or oceanographic station is being occupied; for a large part of our duties consisted in preparation of records. Large windows supply plenty of air and light to the men at work.

In the center of the chart-room stands the "standard compass,"



Looking Down on the Bow from Aloft

which furnishes a correct reading for magnetic north. The "earth-inductor" in the forward dome, and the "deflector" in the after observatory, both use this compass for standard magnetic readings.

Visitors have often expressed surprise that such a well-equipped vessel had no gyroscopic compass, or "metal mike," as it is referred to by sailors. The apparatus may be employed to actuate an auxiliary device, which is fast becoming standard equipment on ocean-liners, and steers the ship automatically on any desired heading. But on a sailing ship the course must be constantly changed to take advantage of wind and squalls. The gyroscope would have required precious power for operation, and would have introduced magnetic materials on board. For these reasons it was out of the question. Besides this, we were seldom trying to make a bee-line from one port to another.

We shall now climb into the forward observatory-dome to inspect the marine earth-inductor. It determines the "dip" of the magnetic needle, or inclination. It is essentially a rotating coil of wire which is connected to current or potential meters in the control-room. Any coil rotating in a magnetic field, with its axis perpendicular to the lines of force, will generate a current in the circuit in which it is placed. It is on this principle that ordinary dynamos operate, except that they use either permanent magnets or electromagnets, whereas we use the feeble magnetic field of the Earth.

If we move the coil around to such a position that its rotation axis is parallel to the lines of force (pointing exactly to the magnetic pole), no current will be generated. This is true because the magnetic field is being cut so that the effect of one half of the coil exactly neutralizes the effect of the other. So when the observer in the control-room signals that no current is being produced, the man in the dome reads off the angle of inclination. In actual practice the procedure is somewhat more complicated than this.

In the after dome is the "deflector" which gives us the *strength* of the magnetic field acting on the compass-needle. Briefly, we balance the effect on the compass of a small magnet of known

USING A MARINE COLLIMATING-COMPASS

On Cruise VI—Dr. L. A. Bauer, Director of the Department of Terrestrial Magnetism (right), Capt. Ault standing at the instrument, and Dr. Franke recording.

strength against the effect of the Earth's magnetism. In other words, we find how far a measured artificial magnetic field deflects the compass from its normal position.

Modern magnetic charts of all oceans are based largely on the work of the *Carnegie*. So promptly are our observations computed and forwarded to the world's hydrographers, that the "Variation Chart for 1930," published in October, 1929, by the United States Navy, included our measurements through September. These charts are used, of course, by air-pilots as well as by mariners.

The cabin on the *Carnegie* occupies the space ordinarily used for cargo on a sailing ship. It can be entered by companionways from the quarter-deck or from the chart-room. Although there are no port-holes, because the room is below the water-line, good ventilation and light are afforded by several large skylights. Everything possible was done to make our living quarters comfortable. Each observer had his own stateroom, a wise provision, because the working hours for some of the men were very irregular. Each one could decorate his room in his own way, and could secure a semblance of privacy.

In the cabin is the ship's library. There are books of reference, technical handbooks, general literature, and an extraordinary collection of books of polar exploration and oceanography. In addition, each man has ample space in his stateroom for his personal choice of reading.

There is a splendid phonograph with a good assortment of records, bought chiefly by the observers themselves. A card-table near the library was occasionally swept clear of typewriters and account books for a game of bridge or poker. Photograph albums and a highly-prized guest-book lie in a corner of the book-shelf. This register contains many famous names from every corner of the Earth, and was one of the two books rescued from the flames in Samoa.

The center of the room is taken up by our dining-table. Around this are eight ordinary cane-bottomed bent-wood chairs, with brass screws instead of iron ones. They are not fixed to the floor as in most vessels. This little detail did much to disguise

PARKINSON MAKING A "DUST-COUNT"

Even over the oceans, far from land, the atmosphere is polluted by microscopic particles of dust—the presence of this material in the air affects the electrical conditions of the atmosphere.

the fact that we were cooped up in a ship. Anyone who has travelled in an ordinary steamer will know how uncomfortable the usual swivel-chair can be—made as it is to accomodate the

fattest passenger. Only on the very rough days was it necessary to brace ourselves at the table.

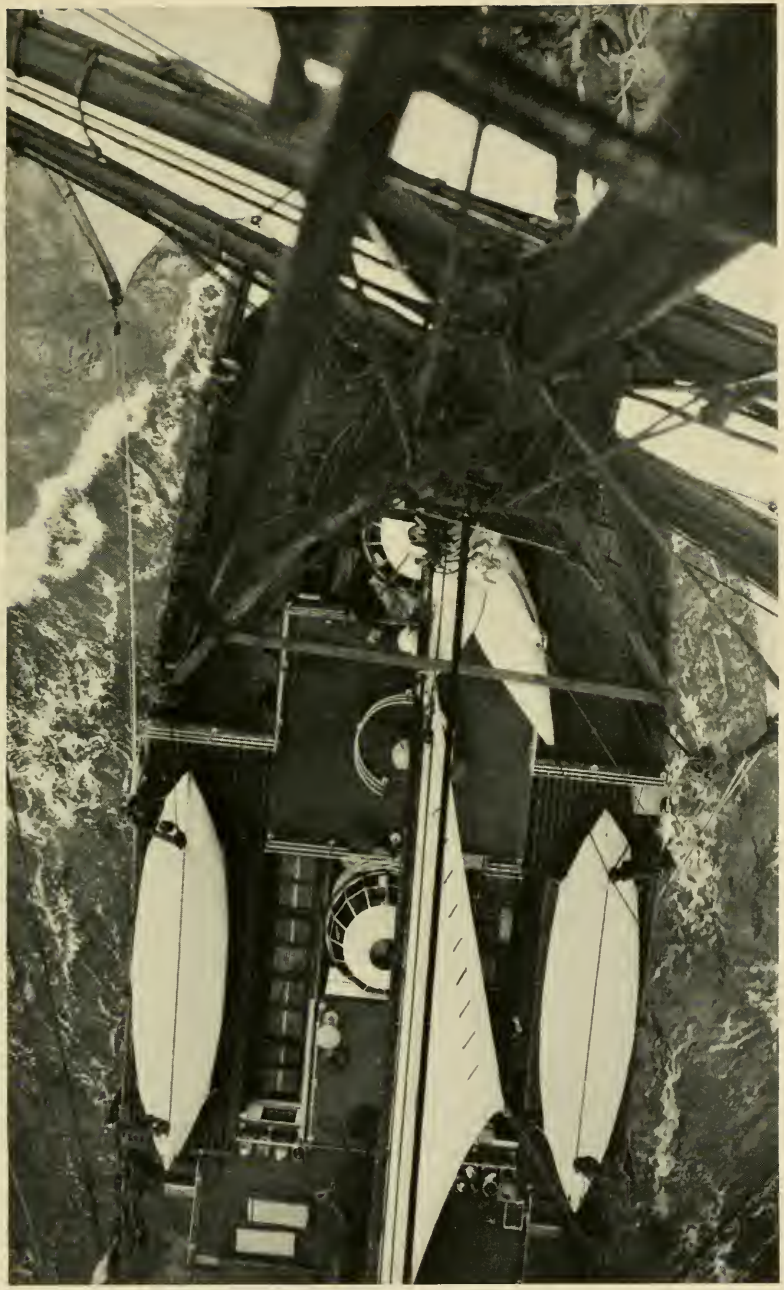
On the walls are several portraits, including one of Andrew Carnegie, autographed with the following inscription:

> "Success to the wandering Yacht
> *Carnegie* whose world wide mission is to correct the mistakes
> of others and ensure against
> shipwrecks."

But even the cabin cannot be kept free of scientific apparatus. Our chronometers lie in a row on green cushions under the book-shelves, with time-signal head-gear hanging above them. The constant-speed motor is here, with its shaft running forward to the earth-inductor. A barograph gives us a continuous record of changes in atmospheric pressure. And wedged between the dining-table and the book-shelves is the complicated pendulum-apparatus for measuring the force of gravity at sea.

This is no doubt the most delicate device on board. It has been long known that, in general, gravitational attraction varies with latitude, but certain irregularities which occur in the force of gravity over the face of the Earth still await explanation. Many determinations have been made on land, but only recently have successful attempts been made to measure the mysterious force at sea. Dr. Vening Meinesz of Holland, who designed this instrument, used it on a circumnavigation cruise in a submarine; and the United States Navy also loaned a similar vessel for this purpose. A sub-surface ship is free from the disturbing motion of the waves, and is much better suited to these studies than the *Carnegie*, although it was hoped that with smooth seas useful results might be obtained, even on a surface vessel.

Below the cabin and under the staterooms are water-tanks, specimen bottles, preservatives, tents, a diving-helmet, and a general assortment of ship's gear. The wooden water-tanks kept our fresh water very sweet even on such long stretches as from Panama to Callao, some three months at sea. The supply was carefully rationed, and a reserve tank always kept for emergencies. Each received about two quarts of fresh water daily for



The Waist as Seen from the Royal-yard

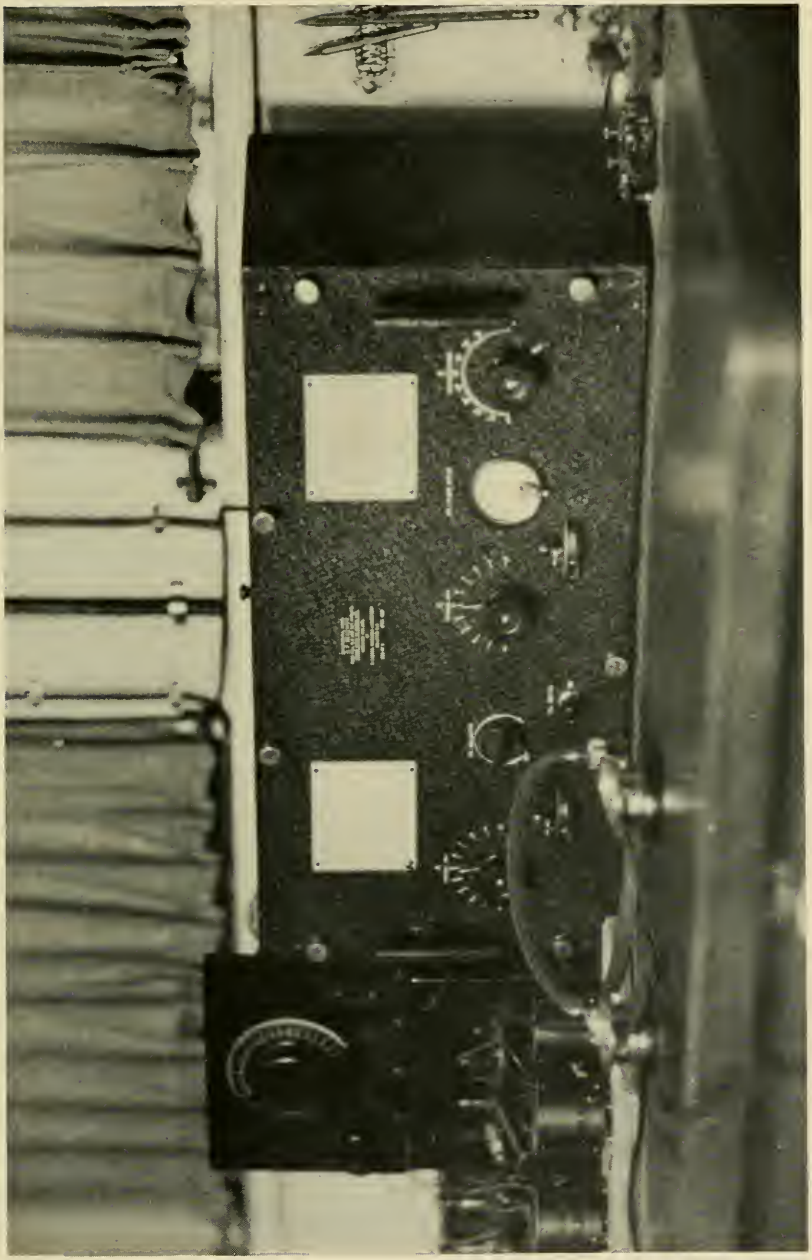
washing hands and face, and the steward issued all that was needed for the galleys. Every man was entitled to a full bucket once a week for washing clothes, or for a fresh-water bath. On the shorter trips there was an abundance for all hands, but when rationing was strict we relied on rain squalls.

The galley for the staff mess lies just abaft the cabin. It was always the center of attraction for feminine visitors, for they all wished to see what a non-magnetic kitchen would look like. The kerosene stove is bronze, and all kettles and pans are either of copper or aluminum. On earlier cruises the cook's knives and the table cutlery were placed in the lazarette during magnetic observations; later it was found that this small amount of magnetic material did not have any effect on the instruments situated in the domes. A small electric refrigerator is set back in a recess from the after-galley. It served to keep us in fresh food for only about a week after leaving port. Still, it was good to have cool water to drink for the remainder of the trip.

We now walk past the "office" on the opposite side of the companionway. Files of scientific records, correspondence, and accounts line the walls and smother the desk. There are also comptometers, typewriters, drafting instruments, and cupboards filled with blank forms for the observations. The bathroom is situated abaft the office. A great porcelain tub filling half the room served chiefly as a place to drain rain-soaked clothes, since we all preferred to take salt-water baths from a shower on deck.

Those who are interested in machinery might go up to the quarter-deck and descend through the hatch to the engine-room. The main engine is cast of bronze. It originally operated on gas produced from coal, but was later adapted to the use of gasoline for fuel. In fact, the *Carnegie* was the first ocean-vessel equipped with a "gas-producer." It could take the ship 144 miles a day without the use of sails, on seven dollars worth of coal.

A small auxiliary gasoline engine connected to an electric generator furnishes power for our oceanographic and magnetic operations, as well as for radio, lighting, sounding, and recording instruments. Large storage-batteries are provided, since the



THE RADIO RECEIVER

Designed by the Naval Research Laboratory and used on the *Carnegie*, bringing us messages from home and keeping us in touch with head-quarters through radio amateurs in all countries.

demand for electric current is very heavy for such a small vessel. As a matter of fact, a considerable part of the gasoline fuel we carried was devoted to electric requirements.

Switch-panels for the sonic depth-finder, radio generator, and bronze winch, line the walls. A machine-shop containing a lathe leads off to one side while the photographic dark-room is wedged in between the gasoline-tanks and the battery-recess. A sail-locker and storage space for spare instrumental equipment are also accessible from the engine-room.

It is always a relief to leave the engine-room, for it is infernally hot. We ascend to the quarter-deck, step down into the waist of the ship on the port side, and enter the radio cabin. A short-wave experimental receiving set, built for us by the United States Naval Research Laboratory, brings us time-signals, weather-reports, and news from home. Our transmitter was powerful enough to keep us in communication with the United States almost every day, through the cooperation of amateurs. Special apparatus for making investigations of radio signal-strength is set up on the work-benches. The equipment is very complete, because the radio operator had a unique opportunity for studying radio conditions at sea; he could correlate variations of signal-intensity with magnetic and atmospheric-electric changes. Regular short-wave schedules gave us information about radio "skip-distances" over the oceans.

In recent years there has been considerable interest in the so-called "Kennelly-Heaviside conducting layer." This zone, situated some fifty or more miles above the Earth, is thought to be the path by which radio signals travel from place to place. Experiments at the Laboratory of the Department in Washington show that this layer varies in height from time to time, and can be located by "echo-sounding." It is hoped that the radio investigations made on the *Carnegie* may add some information about this radio zone.

The American Radio Relay League with headquarters in Hartford recommended our first operator, Mr. Jones, and cooperated with us throughout the whole voyage. The value to us cannot be exaggerated of the services rendered by hundreds of amateurs throughout the world.

NARRATIVE OF THE CRUISE

WASHINGTON TO PLYMOUTH TO HAMBURG

The long months of planning and refitting were over. Sails were bent on the yards that for six years had been only roosts for the birds of the Potomac River. Provisions for six months were stowed in the lazarette aft. The whole array of scientific equipment had passed final tests. The carefully chosen crew of deep-water sailors had been broken in to new duties. All were impatient for the signal to cast off the lines which held us to the Seventh Street dock in Washington, our home port.

But it was not yet nine o'clock, our scheduled hour of departure. Every moment was precious. There were last-minute instuctions, last-minute purchases. Friends and relatives had collected on the little wharf, until it fairly groaned. Men and women who had labored for weeks to prepare us for the three-year voyage, were on hand to see us off.

So on May 1, 1928, the seventh cruise of the *Carnegie* began. Whistles roared from the harbor craft, and pleasure boats jockeyed for position to escort us down the Potomac. At midnight we reached the mouth of the St. Mary's River in Chesapeake Bay, and anchored till dawn. We were to spend four busy days here, "swinging ship," to be sure that our magnetic instruments and standard compass were not influenced by the new oceanographic equipment. A magnetic station had been set up on shore where simultaneous magnetic observations were made. To ensure ideal conditions for the land-station, a magnetic survey of both sides of Chesapeake Bay had been completed a few days previously. Six "swings" of the ship on different headings were made, before everyone was satisfied that all was well.

The radio outfit was given its first trials here. Schedules were made with the Naval Research Laboratory and with headquarters of the American Radio Relay League. And throughout these four days, the atmospheric-electric instruments were being compared with similar ones ashore whose accuracy was well known.

The days spent here in the St. Mary's River had given the new observers an opportunity to become acquainted with their

Captain Ault and His Family
Just before the *Carnegie* let go her moorings for the three-year cruise.

new duties. They now knew what a long day's work was involved in swinging ship, a procedure we were to repeat in many parts of the world. They learned the technique of intercomparison

Dr. John C. Merriam, President of the Carnegie Institution of Washington, Bidding Good-bye to Captain Ault

of instruments with those ashore, for in most of the ports of call this was to occupy a large portion of their time—especially where there were permanent observatories like those in Germany, Peru, Samoa, and Japan.

At dusk on May 5, all hands were summoned to heave up the anchor for the short trip to Hampton Roads—our first passage under sail. A stiff, steady breeze from astern bowled us along in grand style. Although we were not carrying full sail, we had the rare satisfaction of overtaking several steam vessels.

The three kittens prowled about over the sleeping forms of the members of the Laboratory staff in Washington, who had come along to test the instruments. There were no berths to spare, so these men had to sprawl over the deck on air-mattresses. But there were some of us who could not force ourselves to go below for well-earned sleep. The moonlight shone gorgeously on the smooth curves of the square sails, and the unthrobbing motion of the vessel was exhilarating.

We were anchored off Newport News by eight o'clock next morning, and were greeted at once by "bum-boats," little launches which were to be our inseparable companions in every port. They offered laundry service, taxis, provisions—everything we needed, and some things we did not.

Everyone was impatient to put to sea, so it was a great disappointment that we were forced to go into dry-dock here. The oscillator of the sonic depth-finder required some changes, and Mr. Russell of the Navy Yard in Washington had come to personally supervise the work. It rained incessantly, many of us caught colds, and there was little to do after work was finished but to poke around in the cold cabin, stowing our personal effects for the sea-voyage.

Mr. Gilbert, Administrative Secretary of the Carnegie Institution, and Mr. Fleming, the Acting Director of our Department in Washington, came down to see us off on May 10. We were towed out into the Roads, and set sails, while photographers on the tug made pictures. The breeze was just sufficient to give us steerage way. We had cast off our last ties with shore, and were at last headed for the open sea. Our last sight of land was Cape Henry at sunset.

It was a real relief to settle down to our ocean routine. The hectic past months gave place to as simple a life as possible. Meal hours were so arranged that in spite of their various duties, the staff could eat together. The radio-operator and atmospheric electric observers occasionally kept irregular schedules which made this not always possible. The watch-officers and the Engineer had their mess in the wardroom forward; and the forecastle was served from the same galley. The deck-force was separated into two watches, as is usual on a sailing ship; the men spending four hours on and four off, with two "dog-watches" of two hours each between four and eight in the evening.

Scientific Staff Waving Good-bye
On departure from Newport News, Virginia, for the three-year voyage.

Our first morning out, May 11, was chosen for the first magnetic station. The ship was now fifty miles off the coast and away from local disturbances ashore. At sunrise the officer on watch calls the observers to the bridge for the declination-observation. When they are assembled the ship's course is changed, if necessary, to keep the foresail from hiding the sun. Captain Ault and Torreson make readings of the marine collimating-compass; Erickson measures altitudes of the sun with his sextant; and Scott enters each reading on special forms, with a time-record for each observation.

From these measurements we could tell how much the "variation" of the compass had changed since former cruises.

After breakfast is over, and when time-sights on the sun have been made for longitude, the observers take their places at the magnetic instruments in the domes. Soule stands at the earth-inductor; Torreson sits in the control-room on the quarter-deck; and Paul reads aloud the heading of the ship from the standard compass in the chart-room. This allows Soule to keep the rotating coil properly oriented. As Soule places the coil in various positions, Torreson reads the ammeter or potentiometer in the control-room. From here he also starts and stops the constant-speed motor which rotates the coil. These observers determine the "dip" or inclination of the dipping-needle.

Meanwhile, Scott is in the after dome at the deflector. He places magnets of known strength near his compass and reads off their effect upon it. Jones makes simultaneous readings of the standard compass in the chart-room, and records for Scott. These two men measure the strength of the earth's magnetic field.

The afternoon is occupied in calculating the values for the magnetic elements. The observers were furnished special forms for recording, and these were so printed as to make the necessary tabulations as simple as possible. The formulae used in computing appeared in these, together with space for entering data derived from tables. By using these sheets it was practically impossible to overlook essential control-records, such as air-temperatures and chronometer-reading. It is very easy to make these omissions when the observer's attention is directed primarily to the operation of the instrument itself.

For some of us the time-keeping on board was at first quite confusing. The ship's routine was operated on Local Apparent Time, with a resetting of clocks every morning at eleven. Many records were kept on Local Mean Time, others in Greenwich Mean Time. Then there was 75th Meridian Time for certain radio schedules, while a Sidereal-Time chronometer later became part of our equipment for gravity-observations. In addition, for the most accurate time-signal comparisons, an "offset chronometer" was added, that loses one second in sixty-five of mean time.

THE *Carnegie* BEING TOWED OUT INTO THE POTOMAC
The start of Cruise VII.

After the evening time-sight and declination-observation, we noticed a change in the color of the sea. It lost its grayish-green tint and became clear blue. The seawater thermograph had shown great variations in temperature for several hours, and now read 75° Fahrenheit. At noon it had been only 46°. We were in the Gulf Stream.

Whole volumes have been written about this "mighty river in the ocean" first charted by Benjamin Franklin just prior to the Revolutionary War. It had long been noticed that the time consumed in a western passage from England to America was considerably greater than for the return. But the Nantucket sea-captains, who were all acquainted with this current, had consistently been able to bring their heavy laden cargo-vessels to Boston many days sooner than the crack English mail-packets.

This state of affairs annoyed Franklin, who was then postmaster, and he determined to investigate the cause. He conferred with the Nantucket whalers, and found that they were well aware of a "stream, on the edges of which they fish, and that if they do not find their game on one edge, they cross the stream, and try the opposite edge."

Franklin was not content with these reports, although the fishermen were able to give him the geographical limits of the current, in the neighborhood of New England. In his characteristic manner he set out to investigate it scientifically. He says: "A stranger may know when he is in the Gulf Stream by the warmth of the water; the warmth of that water, which the stream forms, being much greater than the warmth of the water on each side of it. If the navigator is bound to the westward, he should cross the stream, and get out of it as soon as possible; whereas, if you get into the Gulf Stream, you will be retarded by it at the rate of sixty to seventy miles a day. . . . . I have, in the course of my passages to and from America, made several experiments with the thermometer on the warmth of the water within the Gulf Stream; and of the difference at the edges."

Franklin plotted the course and limits of the current, as he had measured them, on the chart hanging on the walls of the post-office. He advised all American shipping to use this knowledge

in navigating the Atlantic. But when he forwarded such a map to the offices of the English mail-company, it was scorned; for did their captains not know more about sailing the Atlantic than a postmaster in the Colonies? When the Revolutionary War broke out, Franklin was well content that his advice was not followed.

SOME MEMBERS OF THE LABORATORY STAFF
Who helped to equip the ship for Cruise VII—Mr. Fleming, Acting Director of the Department of Terrestrial Magnetism, in the center.

It was one of our chief aims to study these currents, which determine to a large extent the climate of the coasts of the world. London is six hundred miles north of New York, yet it has a milder winter, due to the warm ocean-currents from the south and west bathing the shores of England. So vast a capacity has the ocean for carrying heat, that even in Spitzbergen the influence of the "Gulf Stream" is felt.

May 12 was for several reasons a memorable date in our calendar. We logged our best day's run of the cruise, 282 nautical miles, of which the current accounted for only six. Once out of sight of land we had met a glorious south wind which bounced us along over a smooth sea at ten to twelve knots—a propitious beginning for our three-year voyage.

In the afternoon we hove to for our first oceanographic station. The sea had become more choppy, and the wind was so strong that the ship drifted considerably. Nevertheless, we lowered our thermometers and collecting bottles in series to a depth of 2000 meters, and put out our silk-nets to capture plankton.

While we were hove to the giant Italian liner *Conte Grande* appeared on the horizon, and changed her course so as to pass our stern by a few hundred yards. The rails were lined with passengers who shouted their greetings and frantically waved their handkerchiefs. It seemed that they were as glad to see us as they would have been to see the Statue of Liberty—the American flag flying from our masthead was to them a symbol of the New World to which they were going. They would have been surprised indeed had they waited to see the "fish" we were catching with our long lines: temperatures, hydrogen ions, chemical salts, and plankton. Certainly less exciting game than bizarre deep-sea monsters, but more valuable to science.

We encountered difficulties at the very outset. The releasing devices for the tow-nets were found to be too feeble for the strain caused by the rapid drift of the ship. This meant that we could only determine the *kind* of plankton in the sea, but not the *number* of each kind—until we obtained our plankton-pump from Norway.

The thermometers chosen for the lowest Nansen bottles were of too low a range. We had expected much lower temperatures in the deeps than we actually encountered at this station. Ordinarily the water from the bottom is only two or three degrees above freezing, while the surface may be as warm as 82° Fahrenheit.

The sea was too rough for microscopic study of the plankton-catches. But we could get some idea of the gorgeous colors and

SCOTT AT THE "DEFLECTOR"

An instrument to measure the strength of the Earth's magnetic field in different parts of the world.

FRANKLIN'S CHART OF THE GULF STREAM

In the lower right-hand corner we see Franklin discussing this "mighty river in the ocean" with Neptune; the notation "4 minutes" means that the flow is four miles per hour in the direction indicated.

tremendous variety of form displayed by these tiny organisms, when we held the sample bottles to the light.

Since this Atlantic crossing was intended to be a "shake-down" cruise, and we were to take aboard several essential oceanographic instruments in Germany, we will not describe the routine of a station until later. Nevertheless, the salinity of each sample was measured by Soule, with the electric resistance-bridge; and Seiwell determined phosphates, silicates, and hydrogen-ion concentration.

While May 12 gave us our best day's run, May 13 demonstrated what strong currents may be encountered, for we made 69 sea-miles due east from this cause alone.

The ship had been supplied with a solarimeter, for measuring the quantity of radiation reaching the earth from the sun. We gave it a first trial on the 13th, but it was at once apparent that conditions would not be favorable for using it on a sailing ship. The effects of rolling and pitching were minimized by mounting in gimbals the sensitive photoelectric cell; but the greatest difficulty was shade cast by the rigging, and back reflection from the lofty sails. After a few more trials it was found impracticable. The information it gives is used in studies of world-weather. It would have made an excellent adjunct to our meteorological program, for we were concerned with heat-transfers between sea and air, and with evaporation-rates in various regions.

For a week following our first oceanographic station we had wretched weather and rough seas, and we did not risk losing equipment to occupy a second station. However, the observers were busy enough working up the results of the first, and getting acquainted with their new duties. Besides this, many of us had to restow our equipment to avoid breakage in the ugly seas we were entering. Fortunately, we suffered no serious damage from breakage during the whole cruise.

During this time echo-soundings were made at regular intervals, and the magnetic and electric observations were not seriously interrupted. Parkinson obtained valuable records of the electric state of the atmosphere, in spite of the miserable working conditions. He had also made many counts of the "dust-particles"

in the air. The automatic recording apparatus for potential gradient, which had been mounted at the masthead, was moved

Captain Ault about to Remove a "Nansen Bottle"
Contains a sample of sea-water obtained from the deep—the thermometers attached to the bottle give the temperature at the level at which the bottle was reversed.

to the taffrail over the stern, for the motion in the former location was too violent for smooth operation. Experiments with the

earth-inductor were continued. We hoped eventually to use it for determining the strength of the earth's magnetic field, as well as the inclination or "dip." This work promised favorable results, but only a long series of comparisons with the deflector would finally prove its reliability.

While we had been anchored in St. Mary's River, a gyroscopic stabilizer had been installed on the earth-inductor. It was hoped that this device, in addition to the gimbal-mountings, might make the coil more independent of the ship's motion than the gimbals alone. But all attempts to use it had failed, because the strain when the constant-speed motor was started or stopped was too severe on the shafting. Several changes in design would be necessary before it could have been employed, and after a few more trials it was discarded for the time being.

Living conditions aboard became more and more miserable, due to the continuous rains. The unusual strains on the deck amidships, occasioned by the weight of the whale-boats, had opened up tiny cracks which allowed a slow seepage into the staterooms. We ate, slept, and worked in wet quarters. It was almost more comfortable to don oilskins and fish for surface specimens with a dip-net, in the rain. We picked up a large number of interesting fish in this way.

Portuguese men-of-war would float by, always with a little colony of fish swimming beneath them. It appeared to us that that these fish fed on the tentacles of the "host." But when the creatures were scooped up together in a dip-net the fish became entangled in the stinging threads and paralyzed by the men of war. Again, we would drop the submarine light into the water at night and capture the floating life attracted to it. Jellyfish were very abundant, many of them luminous. They often responded like a flashlight chorus on the stage, when we switched on the depth-light for a moment. During these days, whenever the speed of the vessel was reduced, we dropped over standard silk plankton-nets to collect surface life.

On the morning of May 18 we occupied our second oceanographic station. It failed, because of the strong wind and rough seas. The ship was drifting as much as three miles per hour

SEIWELL INSPECTING A PLANKTON-CATCH

These minute animals and plants display every color of the rainbow and an infinite variety of forms

with only enough sail to keep her hove-to. The bottle wire stretched out to windward at an angle of 50° from the vertical, and it was not feasible to reach down more than 400 meters.

This meant that the messengers descended too slowly to reverse the bottles. Under conditions of this kind it is impossible to determine accurately the depth of each bottle from the length and angle of the wire, so the pressure-thermometers we carried became indispensable.

The first week had been wet, but the second was rough as well, for we struck a series of gales, some reaching storm force. When the first one came, on May 18, those who had boasted of having found their sea-legs had a disconcerting surprise. Torreson scored twice. During the afternoon, while taking the time-sight on the quarterdeck, he was thrown violently from his feet and landed with a crash against the rail. His presence of mind saved the sextant, for as he sprawled down the deck he thrust the instrument beneath the rail and held on until he could collect himself. Only a few hours later, in the cabin, he was thrown backward out of a chair, and against the bureau in his stateroom. Only the fact that his door was open saved him from serious injury.

Paul meanwhile had braced himself at a computing desk in the chart-room. When a sudden lurch hurled him out of his seat, he grabbed the table-top and saved himself from a crash. But his desk was wrecked, for the wood gave way and split clean down the middle, spilling ink and papers over chart-room floor.

By this time the first watch-officer had become disgusted with our unseamanlike behavior, and greeted each flop with picturesque language. It was a breach of etiquette to enter the chart-room from the windward side, as this invariably blew all the papers off the computers' desks. Occasionally one of the party would break the rule, only to meet Mr. Erickson's withering look, and to hear him mutter some remark about farmers on board!

The third oceanographic station, on May 23, brought its difficulties. The deep-series of sample bottles failed to reverse because some fibrous deep-sea organism, possibly a siphonophore, arrested the messenger on its way down. We thought this an unusual event at the time, but it was to prove one of our commonest annoyances.

That same night we watched the barograph make its first real

tumble. It was rough enough already, but some real weather was ahead. By dawn a fresh gale was whipping the sea into a frenzy, and we had to heave to for it to moderate. A torrent of rain fell after the blow, to trickle its way to our book-shelves and bunks. All attempts to stop the leaking failed; for permanent relief we must await repairs in port. Meanwhile the ingenuity of the party was directed to deflecting the streams of water to the floor of the cabin by the least damaging route. Glass funnels, rubber tubing, towels, pots, pans, canvas troughs, were all used

THE *Carnegie* RUNNING BEFORE THE WIND
On an earlier cruise.

in an attempt to save our personal effects, and to give us dry beds. In the end either they were successful, or else we had become accustomed to living under water, for we went about our work unconcerned. Captain Ault did much to keep us in high spirits by promising days of beautiful weather and moonlight nights in the tropics. Our daily radio contacts with home helped as well.

On May 27 we saw the most perfect solar halo of the cruise. There were grand arguments between members of the crew as to what it presaged. Some thought it a sign of better weather, but the gloomier predictions prevailed. On the next day we had the

worst storm of the passage. We were forced to heave to and ride it out. Several of the bronze fittings in the rigging were carried away. However, damage was not so serious that emergency repairs could not be made. The vessel was having a bad time of it. Time and time again seas swept the quarter-deck, something which had rarely occurred on previous cruises. This was probably due to the load carried aft. The new winch, generators, batteries, and so on, used for our oceanographic work, weighed many tons.

The fogs that set in on the 30th did not add to the joy of life. They interrupted the declination-observations, and kept a man busy day and night at the hand-operated foghorn. It began to look bad for our schedule. We had left Newport News nine days late, and the head-winds we were encountering gave us a run, one day, of 17 miles. In fact, we averaged only 29 miles a day during the first week in June.

But on May 31 we had splendid conditions for the oceanographic station. The wind had dropped almost to a calm. We collected the first bottom-sample of the cruise. The snapper was lowered at the end of the bottle wire, and brought up light gray ooze from almost 3000 meters. This material, which consists of the skeletons of untold billions of tiny globigerina organisms, covers the greater part of the ocean-bottom, and is often deposited in layers many feet deep.

In the following words Captain Ault describes our fight to gain entrance to the English channel:

> "And so through the storms, calms, and head-winds of the North Atlantic we approached our first port, Plymouth, England. But first we were made to feel the temper of the Old Man of the Sea. For ten days before we could enter the English Channel, we had to tack back and forth, and run the engine against a wind which seemed nailed down to the east point of the compass. When we were within a few hours of Bishop Rock Light, Scilly Islands, it began to rain; fog and mist closed in on us, and we were compelled to stand out to sea as we had repeatedly done.

The *Carnegie* Digging Her Prow into a Heavy Sea
The vessel was so buoyant that she seldom shipped water.

"After several hours, the weather cleared sufficiently for us to head in again and at midnight to pick up the light, thus giving us our landfall and departure up the Channel for Plymouth. A fair wind took us to within ten miles of Plymouth, whereupon it began to rain once more. The fog shut down, a gale began to blow from ahead, and we were on the point of heading out to sea as safety had compelled us to do again and again.

"The square-sails were taken in, the engine was started; order had been given to tack out away from shore, when, in a momentary lifting of the fog, I sighted the headland two miles west of Plymouth Harbor. We kept on, slowly forging ahead against the storm. Finally, just before dusk we slipped safely inside the breakwater where we found the pilot awaiting us. However, even here we had difficulty, for the new cable of the port anchor was so stiff and hard and wet from bad weather that it kinked and could not be let out rapidly enough to fetch the vessel up against the gale. The starboard anchor was let go just in time to avoid danger.

"For the next two days a terrific wind blew from the south. Had we not been lucky enough to weather the Channel when we did, it would have sent us hurrying back to sea for another week; for a sailing ship depends upon wind and weather for safety as well as for progress from port to port."

At no time during the remainder of the cruise was the sight of shore more welcome than on the morning of June 8. It had been tantalizing to spend a week of rain and fog almost within sight of land, with only patches of seaweed and their swarms of large crustaceans to prove that our voyage was nearly over. We skirted the coast of Cornwall all day from Lizard Head to Eddystone Light outside of Plymouth. The light on the Lizard was a familiar sight to the veterans of former cruises. They had once seen its rays reflected on the clouds at a distance of sixty-two miles.

The vivid green of the pastures, interrupted here and there by jutting promontories of rock and the dazzling white of lighthouse towers, made this short sail one of the most beautiful of the entire cruise. Steam-vessels of every nation, fishing-boats

PAUL WITHDRAWING SAMPLES OF SEA-WATER FOR CHEMICAL ANALYSIS
Such specimens were obtained down to a depth of three miles at some stations.

with colored sails, trawlers performing their mad dance in the waves, all welcomed us as they passed by. But of most interest to us was a square-rigged sailing ship with auxiliary steam-power, which passed us some two miles away. She was the Massachu-

setts Nautical training-ship, the *Nantucket*, making her annual cruise. One of the boys in training, who was aboard that day, later joined us as a seaman.

We had not been long at anchor in the harbor when we were greeted in the name of the British Navy by Captain Arnold. He offered us any possible aid while we were in English waters. We also sent ashore a cablegram to headquarters telling of our safe arrival. This was necessary beause while in port we were not permitted to transmit our own radiograms. The office in Washington kept on file a list of the addresses of our families and friends, so that our message was promptly relayed.

Early next morning we were towed into the inner harbor. This trip, ordinarily uninteresting, was thrilling on this occasion. The powerful tug whisked us through the narrow tide-gate at a terrific clip, only to find that we had gathered too great momentum to stop in the confines of the small basin. A hawser was thrown ashore to check our mad pace before we crashed into the dock at the further end. It snapped, but only after it had slowed us up considerably. A second hawser did the trick, and we found ourselves tied up to the Millbay railroad wharf.

With what joy we stepped ashore! But the ground did not feel so solid, after all. It took some hours for the sidewalks of Plymouth to settle down for us, so accustomed had we become to the gentle rise and fall of the *Carnegie's* decks. None of us will forget that first meal of lamb chops, fresh vegetables, and Devonshire cream! Plymouth was not exciting. There was more than enough to do on board during the day—computing, preparing records for mailing, answering official correspondence, and so on; but in the evening we found quiet enjoyment in poking around the historic spots of the city, or in bicycle rides over the moors of Devonshire.

Scott usually found himself the busiest man in port, because it was through him that orders for provisions, or for repairs, were issued. He also had charge of pay disbursements and account-books, to say nothing of typing the numerous letters sent to headquarters. It was always a rule on the *Carnegie* to analyze and put in form the scientific data collected on each leg of the

THE *Carnegie* AT PLYMOUTH

After a tempestuous voyage across the Atlantic—she is lying at the berth once occupied by the Danish training-ship the *Kobenhavn* which was lost with all hands while the *Carnegie* was in the Pacific.

THE STONE COMMEMORATING THE SAILING OF THE PILGRIM FATHERS

It forms part of the pavement at the boat landing of the fishing-harbor.

cruise, for the immediate use of hydrographers and oceanographic workers ashore. This feature of our routine kept the other observers occupied throughout our stay ashore.

For example, tables were drawn up showing the values of declination, horizontal intensity, and inclination, as given by the latest British, German, and American charts for the regions traversed by the ship. Against these we tabulated the measurements made on the voyage, so that errors in the charts might be corrected in future editions. Differences of as much as 1°.5 in declination were discovered on the passage from Newport News, with corresponding errors in the other elements. This serves to emphasize the importance of repeated surveys of the earth's magnetism, to determine the changes constantly taking place in the distribution of this mysterious natural force.

All of us had an opportunity for visiting the famous Marine Biological Laboratory of the United Kingdom, located in Plymouth. Dr. Allen, the director, generously put the facilities of the laboratory at our disposal, and we had many occasions for taking advantage of the invitation. Dr. Atkins, the chemist of the group, offered many useful suggestions in connection with our work. We had a chance to inspect their research vessel, the *Salpa*, and to critically compare methods. The physiological researches being made in Pylmouth impressed us as much as the magnificent collections of marine life displayed in the buildings.

We owe to Dr. Allen and Dr. Atkins two of the most delightful evenings of the cruise. Both of these gentlemen symbolized in our minds that genuine hospitality we found in almost every port we visited. Dr. Allen invited the members of our party to a dinner at the Grand Hotel, superbly situated, overlooking the beautiful harbor. After the meal he escorted us through Old Plymouth. We visited, among other places of interest, the 16th century custom-house; the old Blackfriars monastery, now used as a distillery; and the *Mayflower* stone beside the quaint fishing harbor, marking the spot from which the Pilgrim Fathers set out to the New World.

Soon afterwards Dr. Atkins invited us to his home in St. Anthony's Parish, Cornwall. Visits to private dwellings were to

The Beautiful Boat-harbor at Plymouth

Showing the characteristic fishing-boats that operate in the English Channel.

The Ferry to Cornwall

Used on visit to Dr. Atkins' home in St. Anthony's Parish—the ferry moves along two chains lying on the bottom of the river.

prove for us the most appreciated of entertainments. The charming country-place of Dr. Atkins, situated beside an ancient 9th century church in a quaint Cornish village, will forever typify in our minds the English ideal of a home. Lovely walks between the characteristic hedges radiated out from the local tavern "St. Anthony's Bells." Beside the highway on the western shore of the Tamar River grew a magnificent oak tree, whose beauty so fascinated us that we returned to photograph it the next day.

This Fifteenth-century Building, Formerly Part of the Dominican Monastery "Black friars"—now the home of the famous Plymouth Gin.

Like the giant sequoias we were to see in California, it must have had many tales to tell of the past. It had doubtless looked serenely down on the successive invasions of England a thousand years before the Pilgrim Fathers sailed out of Plymouth.

Our first Sunday was devoted to an all-day motor-trip through Devonshire. It did much to satisfy our hunger for a taste of the green landscapes for which this country is famous. We struck out inland over the rolling moors north and east of Plymouth; lunched at Exeter; and returned along the coast through Dawlish

and Torquay. At the Rougement Hotel in Exeter we had our first serious difficulties with pounds, shillings, and pence. Torreson had been chosen treasurer for the occasion. On settling the bill he nonchalantly waved aside as a tip the change from a Bank of England note, only to realize a moment later that the waiter received as much as the hotel for the hearty meal we had been served! If any of us ever return to Exeter we will know where to get prompt service!

The Cathedral at Exeter
Visited by the staff of the *Carnegie* while on their Sunday excursion into Devonshire.

The following day we installed the newly purchased Negretti and Zambra recording psychrometer in the Stevenson meterological shelter on the quarter-deck. This instrument gives us a continuous record of the changes of humidity. The air is drawn over the "wet" and "dry" bulbs by an electric fan, for the accuracy of the readings depends to a large extent on the ventilation of the bulbs.

During these days groups of technical students came aboard to inspect our equipment and to hear about our work. It was

always a pleasure to show these men about the ship, for they seemed to carry away a wider vision of the mission of science, whether or not they were personally interested in geophysics or oceanography.

Soon after our arrival in Plymouth, Parkinson was called to London on account of the illness of his father. He found Mrs. Parkinson and his son there, who had left Washington soon after we did. They were about to leave for Australia, where they were to await Mr. Parkinson's arrival in December, 1929. It had been planned that Mr. Johnston, in charge of the Watheroo Magnetic Observatory, would relieve him in Sydney.

A few days later, Captain Ault, Soule, and Jones also went to London, on business for the *Carnegie*. On the voyage across the Atlantic one of the cells of the salinity-bridge was found to have too high a resistance, and it was hoped that the National Physical Laboratory at Teddington might be able to correct the condition. Jones purchased some radio supplies not available in Plymouth. Before returning they saw a delightful musical comedy, "Clowns in Clover," containing a song which became one of the favorites on board, "Little Boy Blues."

On June 16 we were paid a visit by Sir Frank Dyson, Astronomer Royal of England, who came down from London especially to see us. He was well acquainted with the work of the vessel, and had known Mr. Parkinson, who was at one time employed at the observatory in Greenwich. Our distinguished guest stayed aboard for tea and dinner, and made a very thorough inspection of the equipment. He was apparently as delighted with the vessel and our prospects as we were to have him with us.

The second Sunday gave some of us a chance to visit the picturesque villages on the Cornish coast. Paul had gone ahead the night before on his bicycle, and expected to meet the others at Looe for a trip to the fascinating village of Polperro. But through some blunder in meeting the bus the connection was not made, and he proceeded alone, leaving the others to explore the seaside resort at Looe.

At this place there are tide-pools which are happy hunting grounds for the marine biologist. Almost the whole range of

SIR FRANK DYSON, ASTRONOMER ROYAL OF ENGLAND

Paid the *Carnegie* a visit during the stay in Plymouth—Parkinson at one time worked in the Greenwich Observatory under Sir Frank Dyson's direction.

species characteristic of English shore-life are found on these weed-covered flats: limpets and sea-anemones, blennies and sea-cucumbers, prawns and algae.

The town of Looe itself is built upon the cliffs surrounding the boat-harbor. One looks down at the tiny fishing-boats, propped up with stilts at low tide, or careened over on their beam-ends. Great racks along the waterfront display the drying nets; and over the whole scene innumerable screeching gulls whirl and dive for the morsels of fish discarded by the fishermen.

Polperro is a town of the imagination. At every turn one expects to meet a pirate, or a wrecker returning gaily from his nefarious business of dismantling a ship put aground by the falsifying of lights along the shore. Some of the quaint houses are no more than niches cut out of the precipitous walls of the gorge. Others perch on stilts on the mud-flats below. Polperro justifies its claim of being the most paintable village in Cornwall. Certainly there are no thrills left for a cyclist who has once pedalled over the crazy cliff roads surrounding the village. And anyone who has navigated a bicycle with brakes on the front wheel will appreciate how exciting a twenty per cent grade can be, when the path is but ten inches wide, and a hundred-foot cliff begins two or three feet to one side!

Before we left Plymouth, Dr. Allen of the Marine Biological Laboratory informed us that a complete set of the reports of the famous *Challenger* Expedition had arrived, and he invited us to take them with us for our work. This set, numbering about sixty large tomes, had been collected for us by the Royal Society. The task was not simple, for many of the volumes had been long out of print and for that reason were almost priceless. But to safely stow away aboard the *Carnegie* such a bulky library was out of the question. Each member of the party took only those volumes which would be most useful in his work, leaving the others ashore. The destruction of these books in the fire at Samoa must be considered one of the major losses of equipment.

By June 18 the necessary repairs had been completed, provisions had been stowed away, the scientific records were mailed to the United States, and we were ready to square the yards for the short

voyage to Hamburg. At high tide we were towed out past the breakwater, picked up a gentle westerly breeze, and headed for the narrow Straits of Dover. The channel was smooth all the way, and with fair winds and no fog we made splendid progress through the narrow waters always dangerous for a sailing ship.

Entering the Elbe River

Fog shut down a few moments later and we played hide-and-seek with the pilot-boat—an officer on a passing ship sent us this photograph when we arrived in Hamburg.

On this passage no complete oceanographic stations were occupied, but Seiwell collected many samples of surface water for phosphate-analysis.

The breeze hauled ahead as soon as it had put us safely past the Straits, and the whole North Sea passage was made by use of the engine. We passed the chalk cliffs of Dover just as they were tinted with rose by the sun rising ahead of us. Everything went well along the Dutch and German coasts, the lights being easily identified. But when we were about to pick up the light-

ship at the mouth of the Elbe River, fog and rain blotted out all landmarks. We knew that a pilot-vessel must be waiting for us somewhere in the offing, but it was hopeless to find her now. From time to time a passing steam-vessel gave us a clue to the proper course, but the strong flood-tide made us uneasy lest we should drift on to a sand-bank. For a moment the fog lifted, and we caught a glimpse of a tall mast off the bow, toward which we headed in the hope that it might be our pilot-vessel Only after a long game of hide and seek did we finally locate her. Our guess was right, and we were now sure of a safe entrance to the Elbe.

Once inside the river we picked up a tug-boat and enjoyed a beautiful fifty-mile trip up the busy river. We had a splendid view of summer resorts and yacht-clubs which lined the banks, and we exchanged greetings with giant liners passing us on their way to the four corners of the world.

At dusk we reached Hamburg. What indescribable traffic congestion! The water was alive with tugs and barges darting here and there like water-spiders, always avoiding collision by a hair's breadth. We had to elbow our way in to a berth on the Vorsetzen to get a good seat for the fascinating spectacle. Our mooring-lines were hardly made fast when Dr. Sverdrup, the well-known explorer of the Geophysical Institute at Bergen, Norway, jumped aboard to bid us welcome. He had come down to Hamburg, with his bride, to help us install the new oceanographic equipment we were to take aboard here. Dr. Sverdrup, as a Research Associate of the Carnegie Institution, had been consulted frequently during days when the expedition was being planned, for he had a rich oceanographic experience. It was always pleasant to have a familiar face to greet us in foreign ports, the more so in a country new to the *Carnegie*, such as Germany.

Early the following morning we received a most hearty welcome from the German Government and many scientific societies. Dr. Wilhelm Blaschke, Rector of the University of Hamburg; Admiral Dominik, President of the German Hydrographic Office; Dr. Kurt Burath, magnetician of the same institution; Dr. Defant, Director of the German Oceanographic Institute in Berlin—all called in turn to offer us any possible aid in the prose-

cution of our researches. Dr. Defant, as special representative of the State of Prussia, invited us to Berlin to a joint meeting of the Geographical and Oceanographic Societies, which had been called in our honor, and asked Captain Ault to deliver a lecture on the program of the *Carnegie*. Dr. Burath was designated our official host throughout our stay in Germany, and was tireless in his attention to our needs. He supplied official automobiles

WELCOMED IN GERMANY BY GOVERNMENT OFFICIALS AND LEADERS OF SCIENTIFIC SOCIETIES

Left to right: Dr. Burath and Admiral Dominik of the German Seewarte; Dr. Sverdrup of the Geophysical Institute at Bergen, Norway; Captain Ault; and Dr. Defant, Leader of the German Atlantic Expedition of the *Meteor*, and Director of the Institute of Oceanography in Berlin.

whenever we desired them, and a large launch for our magnetic work down the river; he acted as guide in our visits about the city, and called many times daily to inquire after our comfort. We were swept off our feet by this unexpected cordiality on the part of our German scientific colleagues. It was apparent on every hand that the twenty-five years of research carried on by our Department in Washington was nowhere appreciated more than here.

Later on that morning we paid our first visit to the Deutsche Seewarte, a combined hydrographic and meteorological institution, proudly situated on a hill overlooking Hamburg harbor. This organization is justly famous for its progressive and meticulous research into problems of marine and aerial navigation.

With one accord the members of the Seewarte staff shook our hands in the heartiest manner, as "fellow countrymen of Matthew Fontaine Maury"! It must be admitted that some of us were

THE CARNEGIE PARTY AT THE HAGENBECK ZOO, HAMBURG

In the front row are Dr. and Mrs. Sverdrup, the superintendent of the park, and Dr. Burath of the Seewarte.

mystified at first. As we came in we had noticed a bust prominently displayed at the entrance to the building, and this was pointed out to us as Maury's statue. It only goes to show how a prophet is without honor in his own country. Had not Maury created with his own hands the modern science of marine meteorology? Had he not made the first modern bathymetric charts? Had he not developed the electrically controlled submarine-mine as a defensive weapon in warfare?

The time was too short to see more than the magnetic and oceanographic divisions of the institution, because a tour of the

city had been arranged for us. That afternoon several resplendent Benz cars drove up to the gang-plank. The liveried chauffeurs, wearing the insignia of the Free City of Hamburg and

Dr. Burath, Official Host, Hamburg

Before the hangars of the great aviation-company, the Deutsche Lufthansa—several of our party were invited to fly over the city in the company's splendid planes.

carrying the flag of the city on their machines, took the right of way through the busy afternoon traffic. No doubt about it—we were welcome in Hamburg.

We drove through the busy waterfront streets, past the beautiful residential sections near the Alster, to the outskirts of the city, and found ourselves at the Hagenbeck Zoölogical Park. Dr. and Mrs. Sverdrup were with us, and Dr. Burath accompanied us as host. A moment later and we were on our way through the fascinating display of animal life, with the Superintendent personally acting as guide. This park is unique. Each group of animals lives in surroundings made artificially to resemble its native habitat. The collection is more complete than any other in the world. It even contains prehistoric monsters cast in cement in the most lifelike of poses. There are about thirty men constantly in the field bringing back new animals or replacing older ones.

The Hagenbecks supply animals to circuses all over the world, and the young performers are trained here in their own kindergarten. The little creatures troop out in groups and receive their instruction, just as children do: they are spanked when naughty, and get extra big helpings of dessert if they do their work well! The park is worth a long visit—even to the busiest visitor to Germany.

The following day was Sunday, so we accepted Dr. Burath's invitation to spend it in the magnificent country north and east of the city. The same official cars were on hand, and we tore through the streets, with flags flying. Traffic police gave us the right of way as before, and saluted as we whizzed by. If we ever suffered from inferiority complexes, this treatment cured us once for all.

Our drive took us over rolling farm lands, through the famous Bismarck Woods, into Schleswig-Holstein, and out upon charming lake-country roads. We were continually arguing whether to penetrate further the rich country, or to stay a little longer at some charming cross-roads inn.

The day was not over at sundown. We were to taste the night-life of Hamburg. Certainly none of us have ever lived in a city which so abounds in evening entertainments. There are operas or plays for the more serious minded; cafés which serve symphonies with the pastry; midnight revues and cabaret-dancing; and for

those who would entertain themselves an endless list of taverns and night-clubs with American jazz orchestras for dancing.

Even by Monday we had not come down out of the clouds. The famous aviation concern, the Deutsche Lufthansa, invited some of us to fly over the city in one of their cabin-planes. It was Mrs. Sverdrup's first flight, but her anxiety was soon dispelled when the giant air-liner smoothly roared its way off the ground.

The earlier part of the morning had been spent in an inspection of the various meteorological establishments in Hamburg. We called at the Seewarte for the second time to see the meteorological section at work. One of their most interesting activities is the preparation of pilot-charts for the upper air. German aviators have this wonderful organization working for them day and night. Observers are trained here, and send up pilot-balloons from the decks of German liners bound for all parts of the world. The results of these observations are published within a few hours of their receipt by radio, along with the reports of the numerous stations in Europe. It is apparent that the Germans are laying the foundations of a great over-seas air commerce. Ocean flying to South America, on a commercial scale, is uppermost in their minds.

We later drove out to the meteorological observatory at Grossborstel, where we saw the experimental wind-tunnels in operation, and a pilot-balloon ascension. We were keenly interested, for we were soon to do this work ourselves in the Pacific.

The busy morning ended with an official luncheon held in our honor in the Rose-room of the Town Hall. The elaborate affair was attended by many of our colleagues at the Seewarte and the University, most of whom spoke English fluently. Choice wines and tobaccos were provided for those who desired them, and a round of speeches of felicitation ended the ceremony. Captain Ault answered in his best style the toasts for our party.

The feeling of comradeship which was present at this gathering was very genuine. These men, who had for years followed eagerly the scientific studies of the Carnegie Institution in journals, took this opportunity for showering us personally with their gratitude. Their final act of appreciation was the presenta-

tion of a photograph of Maury's statue, which stands at the entrance to the Hydrographic Office. This picture was placed on the wall of the cabin, when we returned.

During the speeches in German which followed the dinner, some of us had difficulty in keeping our eyes on the speaker. The ceiling was decorated with full length paintings of the daughters of the successive mayors of Hamburg. Each buxom lass was posed as a rose in a thorny bush—and from this feature of the decorations the room derives its name.

On June 26, Captain Ault, Dr. and Mrs. Sverdrup, Parkinson, Torreson, and Paul, proceeded to Berlin where they were to attend the special joint meeting of the Geographical and Oceanographic Societies, and to confer with various scientists in connection with our work and new equipment. Parkinson took some of his instruments along, which he was to compare with those at the Potsdam Magnetic Observatory and elsewhere. The party was met at the station in Berlin by Dr. Defant and Dr. Wüst, who had reserved hotel rooms for them. The evening was spent in informal conferences with these distinguished scientists.

While they were in Berlin, Seiwell was visiting the famous Marine Biological Station on Heligoland; and Soule, Scott, and Jones were busy in Hamburg installing new apparatus on board, and surveying a site for a shore magnetic station to be occupied a few days hence.

The party in Berlin spent the morning of June 27 inspecting the Institute of Oceanography. They had the good fortune to meet personally the various members of the great German Atlantic Expedition of the *Meteor*, and to profit by the practical knowledge these men had acquired in their recently completed three-year cruise of the South Atlantic. The offices of this expedition were extremely busy, for they aimed to complete the publication of their scientific results within five years—a stupendous task. This visit was a very profitable investment of our time. We could get here a fine perspective of the whole field of oceanography, and could see the correlation of the physical, chemical, and biological phases of the science. The immediate results of these conferences were numerous. We modified some

of our equipment, ordered additional instruments, and accepted the loan of some of their most satisfactory devices.

While making the rounds of this institution, we were paid a visit by Mr. Richter and Mr. Wiese, renowned makers of delicate glass instruments. They had supplied us with our deep-sea reversing-thermometers, and many other highly specialized pieces of equipment. It was almost uncanny to meet these two gentlemen in the flesh; for in our minds they had heretofore been "Richter and Wiese," an impersonal, superhuman firm which did unbelievable things with glass. We placed an order for additional pressure-thermometers, and turned over to them the difficult task of reducing the resistance of the third cell of the salinity-bridge, which we had failed to repair in London. Captain Ault also commissioned them to make duplicate surface-film thermometers for the evaporation-apparatus on board, lest the one we had should be broken, and leave us handicapped.

The evening was devoted to the festivities arranged in our honor by our German colleagues. The party collected at the Geographical Society, and proceeded to the Auditorium, which was already filled with a distinguished audience. Many familiar faces greeted us; and there were physicists, magneticians, explorers, whom we had known only through print. The meeting was called to order by Dr. Krebs, the President of the Geographical Society. Dr. Sverdrup, who needed no introduction to this audience, and who was heartily applauded when he rose to speak, opened the proceedings by delivering a fifteen minute address in German. He sketched briefly the story of the *Carnegie*, and summarized, for those who did not understand English, what Captain Ault was to say about our plans for Cruise VII.

During the interval between his speech and that of Captain Ault, a figure was seen to enter quietly and take a seat in the rear of the hall. Dr. Krebs spied him, and told the audience that it was Filchner, the noted explorer, who had only that day returned from a hazardous expedition through Tibet and Central Asia The outburst of enthusiasm that greeted this announcement was immense.

When Captain Ault rose to speak, he received an even warmer

applause. He spoke briefly of the previous cruises of the *Carnegie*, and went on to describe the new program in oceanography. It was apparent that the majority of the listeners understood him, for without fail his occasional humorous touches were greeted with appreciative smiles or laughter. He closed his lecture with lantern-slides and moving-pictures, and gave a running description of each subject as it was flashed on the screen.

The final event of the meeting was the presentation to Captain Ault of a magnificent volume, just off the press, commemorating the hundredth anniversary of the Society.

After the meeting, our party was entertained by the members of the Geographical Society at a charming informal supper in a large restaurant. A spirit of good fellowship reigned. We had an opportunity for interchange of experiences with these interesting people, who were all anxious to do anything they could to further our plans and make our stay pleasant.

On the following morning we visited the observatory at Potsdam, leaving Parkinson there to complete intercomparisons of his instruments. Paul left that day for a trip to Bavaria by plane, and the others returned to Hamburg to receive the return visit of the scientists who had entertained us in Berlin. The staff of the Potsdam Observatory, the members of the Oceanographic Society, and others, made this journey to inspect the vessel and to offer suggestions based on their own experience. They were all favorably impressed with working conditions aboard, and many expressed a regret that they could not join us.

Following these suggestions, we had the winch-head turned down to hold about 10,000 meters of piano-wire for sounding and for collecting bottom-samples. This modification would make the sounding independent of the water-sample series. It would allow us to check the sonic depth-finder by wire-lengths as well as with pressure-thermometers, for it was not feasible to reach depths greater than 5500 meters with the larger bronze wire. The piano-wire was generously supplied by the *Meteor* Expedition. They also gave us a glass-lined bottom-sampling tube, which they had found useful in the South Atlantic. It is superior to the snapper-type sampler, because it gives a vertical

THE *Carnegie* DRESSED FOR THE FOURTH OF JULY
We saw many square-rigged ships in this harbor.

section of the deposit, and plunges into the sediment to a greater depth.

On Sunday the party attended the annual regatta of the Hamburg Yacht-Club. We were ushered to seats near the trans-Atlantic flyers, Koehl, Hünefeld, and Fitzmaurice, who had just arrived. These men presented the trophies to the winning shells. Hamburg is extremely fortunate in having preserved Alster Lake, and it was here that these races took place. It was one of the many features to make us realize that a busy city may also be made beautiful.

The *Carnegie* had many visitors every day. Distinguished scientists and technical students, city officials and sightseers, all were taken on the rounds. And on the evening of July 2 we gave a reception to the American Consul and his guests. Dr. and Mrs. Sverdrup left for Oslo that same afternoon. We had enjoyed their company very much during their stay with us.

The *Carnegie* was dressed up for the Fourth of July along with the other American vessels in harbor, but there was no holiday for her crew. We were towed into dry-dock across the river. There were some important repairs to make. The copper-sheathing had suffered from the rough Atlantic crossing; the winch was to be modified to hold piano-wire; the electrical psychrometer had not yet been completely installed; and there were numerous smaller details of equipment to look after. Spare coils of aluminum-bronze cable were stowed away. The Petterssen plankton-pump, which had been tested by Dr. Sverdrup in the coastal waters off Norway, was taken aboard. Standard Assmann hand-psychrometers were added to our meteorological equipment. These were furnished by the Deutsche Seewarte, and were used to calibrate the recording psychrometers on board. Plankton collected on the voyage from Newport News was shipped to Washington, and provisions for the next run of the cruise were stowed below.

During these last days in port, Soule, Torreson, and Scott had occupied a magnetic station at Finkenwärder, a small town below Hamburg. They were taken to and from their work in grand style—a splendid harbor-launch being furnished by the Seewarte.

Commenting on our experiences in Germany, Captain Ault says:

> "Our stay in Germany has been unusually profitable and inspiring. To meet so many scientists who are enthusiastic about our prospects, who indicate so strongly the importance of the data we are securing, and who are so keenly interested in the many problems to be solved, has given us a better view of the task before us, and we shall go ahead with renewed enthusiasm."

On July 7, two weeks behind schedule, we said good-bye to our German friends. We were towed down the river past Heligoland before we picked up enough breeze to fill the sails.

HAMBURG TO REYKJAVIK TO BRIDGETOWN TO PANAMA

The vessel was now well equipped for oceanographic research, and we were all eager to give the equipment its first trials. The new resistance-thermometer equipment, for measuring humidity at three levels above the sea, was recording satisfactorily. Repairs had been well done to the vessel and the machinery, and the party was in a fine frame of mind for the long voyage to the West Indies by way of Iceland.

We headed due west to get clear of the coast, then turned northward a bit to skirt the bold cliffs of the Shetlands and the Faroes. Vivid green pastures were set here and there in these forbidding rock-masses, like unmined emeralds; and occasionally a whole table-top of green rolled upwards from the precipitous coasts.

Between the Faroes and the southeast corner of Iceland we encountered some of the roughest water of the cruise. On July 14 the wind hauled ahead and for six days we fought for every mile westward by using our engine and fore-and-aft sails. It began to look like a repetition of our experience in entering the English Channel.

On July 15 we sighted the dazzling Oraefa Glacier on the southern coast of Iceland. Although it was sixty miles away, this stupendous ice-mass, seven thousand feet high and fifty

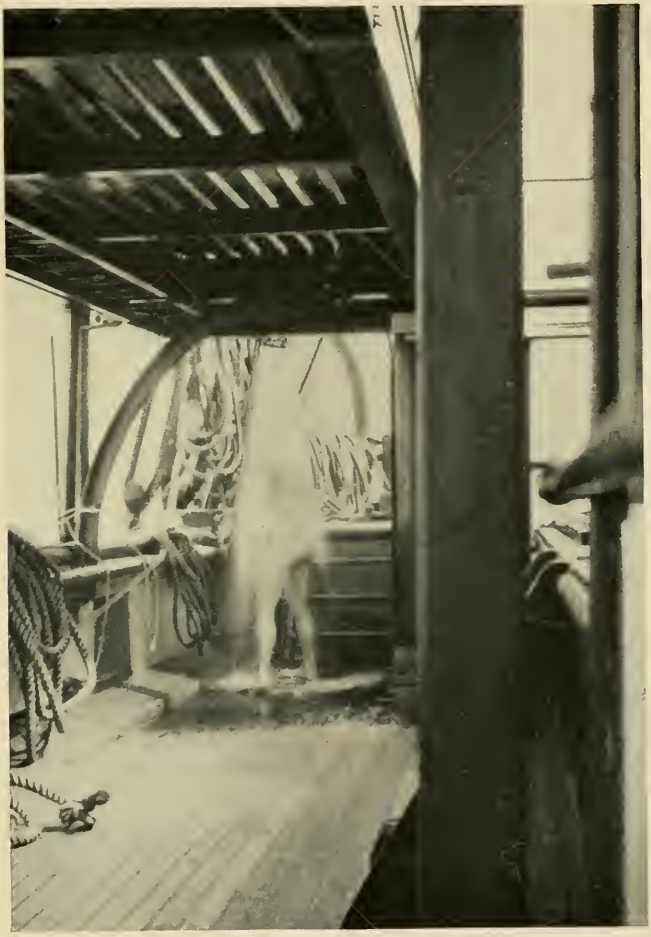
miles wide, glittered in the sun like an enormous heliograph. For some mysterious reason, the sight of it suggested a shower-bath on deck. The pump was started, and several of the party braved the cold salt-water and icy wind. The copper stove was set up in the cabin, serving to dry out our clothes and to keep the quarters more comfortable.

Once we had sighted the entrancing coast, no mere head-wind could discourage us from paying a visit. So day after day we wore ship and tacked against the westerlies. Every time we closed in on the pitiless coast, mist or rain would shut down on us, while there were also strong currents to contend with. All this made navigation hazardous. After we had averaged only sixty miles a day for five days, and not always in the desired direction, Captain Ault became disgusted. He announced his intention of heading down to St. John's, Newfoundland, on the following day if conditions did not improve. But our little engine kept bravely at its task, and the next morning found us well up in Faxe Bay, having rounded the point unawares in the gloom.

Not the least of the dangers encountered along this coast had been the erratic behavior of the compass. There are masses of subterranean magnetic materials which cause local deviations of many degrees. With the poor visibility often met with, one is almost forced to rely on his compass, so that an accurate magnetic variation-chart is nowhere more essential than on a coast like this. It was for these charts that the *Carnegie* was busy making observations. The whole southern coast is strewn with wrecks. Many of them must have come to grief through too implicit reliance on the compass-needle. So treacherous are the waters, that at every small cove or beach the government has established caches of food, clothing, and water, for shipwrecked mariners.

Our entrance to Reykjavik was uneventful except for the annoying drizzle and rain-squalls that intermittently hid our landmarks. Heavily laden trawlers passed us from time to time, wallowing miserably in the choppy seas. One wave after another would sweep their decks, while our buoyancy was such that we bobbed up and down like the sea-gulls around us. A few of the party

were still uncomfortable from the motion of the vessel; but one look at the trawlers dispelled whatever feeling of self-pity they



A Salt-water Shower
On deck in the shadow of Vatna Glacier, Iceland.

might have had. These little vessels go out every day in the year, facing the gales and the sunless days of arctic winter.

On this passage only two oceanographic stations were occupied. We were already nine days behind schedule and the time required

for tacking against head-winds made it undesirable to heave to. Besides this, the sea was so rough and winds so strong that the results would have been doubtful. The other researches were uninterrupted, however. By proper vigilance we were able to spot the sun in the mornings and evenings, long enough to get good declination measurements.

So on July 20, we came to anchor at Reykjavik, the capital city of Iceland. The first to meet us was an old friend of former cruises, Mr. Sveinston, a journalist. When the *Carnegie* had arrived here in 1914, from her long voyage to Spitzbergen, this gentleman brought the news that war had broken out in Europe. But this time he could not surprise us so readily, for we had been constantly in touch with shore through our radio schedules with amateurs scattered all over the world. Mr. Sveinston kindly offered us his services as guide, should we have time to make any excursions into the interior.

We were playing a phonograph record, "Fifty Million Frenchmen Can't Be Wrong," when we heard a strange voice in the chart-room humming the chorus. It proved to be Monsieur Simon, the French Consul! He introduced himself as an old resident of Washington where he had served in the French Consular Service. Monsieur Simon at once offered us the use of his home, and lost no time in arranging a round of social activities on shore.

Days were literally endless in Reykjavik. There was no night at all. One day merged into another with only a short period of midnight dusk to mark their passing. Perhaps this is why the party could condense so many varied activities into our week's visit. When the official day's work was over at four or five o'clock, there were still almost eight hours of daylight in which to amuse ourselves.

For those who wish to take walks there are hot springs and geysers to see, volcanic craters to explore. Green meadows and flower-gardens are inviting. There are highways to travel over by auto. The harbor is alive with interesting creatures. Giant medusae, some measuring many feet in length, float alongside the ship. Sea-parrots, eider-ducks, and cormorants, fly by on their way between the numerous islands in the bay.

THE "MEAL-SACK"

A picturesque rock which stands as an outpost to the entrance of Reykjavik harbor in Iceland.

THE GREAT ART-MUSEUM AT REYKJAVIK

We were very much impressed by the high state of culture in Iceland.

The day after our arrival was spent in examining the magnetic station on Engey Island, where observations had been made in 1914. Tents were pitched, and the hay-field cleared for the potential-gradient comparisons. That evening Monsieur Simon held a dance at his house. We were introduced to several attractive young ladies of the island. Many of them had studied in the United States, others had spent some years in England or the Scandinavian countries. All spoke English (or American!) better than we. We also met some of the officers of the Danish cruiser, *Fylla,* stationed here for part of the year to patrol the fisheries.

This event served to show us how little we knew about Iceland. Nowhere did we discard more false notions about a foreign country than we did there. The climate in Reykjavik was found comparable to that of New York. Snowfall is moderate and soon melts away. The mighty Gulf Stream, in its journey of thousands of miles, still holds enough warmth to keep the main harbors free of ice, and permits the growing of the usual household crops. Grass is abundant, and sheep and ponies are bred on a grand scale.

Life in Reykjavik is not unique, except for the very short daylight in winter, and the virtual absence of night during the summer. We were not far enough north to experience a midnight sun, but one went to bed in daylight and an early riser was many hours behind the sun.

Instead of finding a squalid fishing-village, composed of hardened toilers of the sea, fighting a cruel nature for a meagre living, we found perhaps the highest general level of culture of our whole cruise. Libraries, museums, model schools, hydroelectric power, airplane transportation, orchestras, and choral societies; a generous, intelligent population, at home in the world, reading good books and plays—truly a different picture from that we had brought with us.

We found there a successful solution to a great social problem. Once a notoriously rum-drinking community, Iceland has by a gradual process of popular education and government control closed all open saloons. By limiting the sale of liquor to wines

and beer, it has virtually eliminated distilled spirits and has not fostered the growth of a "bootlegger" class. The only source of wines and beer is a government dispensary in which there is no display or advertising. No alcoholic beverage may be obtained elsewhere except in two large restaurants, and here only with regular meals. The absence of any signs of drunkenness was notable, and as a result of this policy drinking has never become the "thing to do" among the young people.

An Icelandic Woman in Native Dress

The girls wear the latest Parisian costumes until they are married at which time they revert to the ancient dress of black cloth and ornamental skull-cap.

On Sunday, Mr. Sveinston conducted us on an all-day trip to the famous valley of Thingvalla. This magnificent plain is about forty miles by auto from Reykjavik, and is the place where, exactly one thousand years ago, the first parliament of the world was organized. Stretching to the bases of the distant volcanoes are green pastures, intersected by streams and lakes. Here and there over the landscape are great fissures in the lava-field, where water has collected, forming deep pools which display every conceivable shade of blue. A romantic spot in a romantic country!

One of the small lakes at the base of a lovely waterfall, has a name which means "Drowned Woman." In the early history of

AUTOMOBILE ROAD IN ICELAND
This one built in lava-fissures, leads to Thingvalla Plain.

Iceland all female criminals were brought here and drowned, while the men were beheaded. Even today an Icelander is assured of

THINGVALLA PLAIN

About 50 miles from Reykjavik—on this Plain was organized the first parliament of the world which has a continuous history to the present time celebrating its thousandth anniversary in 1930.

justice of the sterner sort, free from the exaggerated sentimentalism found in other civilized countries.

Another of these pools is called the Reserve Bank of Iceland, for each visitor tosses a coin from his homeland into the sapphire waters. Money from every land lies here on the bottom, glittering in the sun, and far too deep in the cold waters for a passing sneak-thief to recover.

There were several Norwegian tourists at Thingvalla that day, many of whom had come out on the handsome Iceland ponies. These little beasts carry enormous loads uncomplainingly, and can go without food for several days if necessary. We never found an opportunity for riding on them, although they are still the chief means of transport throughout the island.

We had not been long in the valley before we were wandering about in shirt-sleeves. It was uncomfortably hot in the blazing sun. The management of the little inn had been notified by telephone that they were to expect some distinguished guests. They had gone to particular pains to procure the greatest delicacies known to an Icelander. Imagine our dismay when we found spread before us canned salmon, canned sausage, canned beef, canned butter, canned fruit! Surely a mistaken way to treat eight hungry sailors, when out of the window they could see fresh mutton grazing beyond the fence of the vegetable garden!

On the return journey we visited a few of the numerous small craters which line the highway, and some of the party walked to the modern hydroelectric plant supplying the city with power. On the outskirts of the town are many hot springs which furnish the town with continuous hot water for laundering, bathing, and heating. Iceland has been called the "Land of Frost and Fire." For on every hand these great natural forces are brought into vivid contrast. The active volcanoes are hooded with glaciers. Hot springs are abundant. Our word "geyser" is no more than the Icelandic name for their most famous steam-fountain.

We were hardly back in the city when word was passed that an exhibition of Icelandic wrestling was to be held for the Norwegian tourists, and that we were invited to attend. This form of wrestling, characteristically Icelandic, resembles faintly the

WATERFALL, ICELAND

Where female criminals were drowned.

LAKE ON THINGVALLA PLAIN

The Plain contains several beautiful lakes and is intersected by many clefts in the lava.

Japanese "jiu-jitsu" and is called "glima." Each wrestler wears a harness around the body, and the object is to lift the opponent, trip him, and drop him to the floor. When any part of the body touches the boards, the referee declares the winner.

But there was still time to go to one of the two splendid moving-picture theatres. Some of the party declare to this day that they have never been in more luxurious theaters. The films are chiefly imported from America along with automobiles and many other articles in common use.

Busy days followed our spree on Sunday. Jones inspected the local broadcasting-station; the magnetic and atmospheric-electric instruments were set up on Engey Island, and the *Carnegie* was anchored out in the harbor as near to them as possible. These intercomparisons had been delayed by the strong gales of the past days. Paul and Parkinson were stationed on the island, and spent several nerve-racking hours dodging the sea-gulls which swooped down on their heads. For they were disturbing the breeding-grounds. Infant gulls scrambled helplessly around the hummocks of grass, but should we pick one up we were sure to be attacked by the screeching mother, circling constantly overhead.

It was not enough to take possession of Monsieur Simon's house for dancing in the evenings. He must arrange a full-course dinner in our honor. Charming young ladies were there in their New York or Parisian gowns; the dinner itself was a masterpiece of the chef's art, and gaiety was unrestrained. During the dinner, Monsieur Simon had us inscribe our names on a post-card, which he forwarded to our mutual friend, the late Edwin E. Slosson, Director of Science Service in Washington. Before long our numbers were swelled by the officers of the *Fylla*, who had brought from their ship some bottles of Danish beer. Since it did not grow dark, it occurred to no one that there might be such a thing as a proper time for going home!

On the following day Seiwell and Paul made a collecting trip for the Smithsonian Institution. They chartered a small launch, and, armed with an impressive special hunting permit, brought back a large number of the characteristic sea-birds of the island.

The eider-duck is sacred in Iceland. The delicate feathers which line their nests form one of the leading exports, and nothing must disturb the birds. Although we probably had a sufficient excuse for killing a few specimens, we thought it wiser to leave the eider alone.

On this same trip the diatom collecting-bucket was tried out, but the specimens were unsatisfactory because we had not located a suitable bottom-area for dredging.

On the day before leaving port several members of our party were invited to lunch in the ward-room of the cruiser. This group of Danish officers will forever typify to us the hearty, merry life led by naval officers in works of fiction. There were songs and good-natured banter, toasts and speeches—all at an ordinary noon-day meal. They presented us with a beautiful photograph of the *Fylla*, which was hanging in the cabin when the *Carnegie* was destroyed in Apia.

The time had come for us to reciprocate all these attentions, so a dance was arranged in the cabin. The best music we could furnish was from our phonograph; but with the dining-table removed we could offer an excellent dance-floor. The Danish officers joined in, of course, and a "good time was had by all." We were not ashamed to make the most of our evenings in Reykjavik. The next two months were to be spent out of sight of land, in routine that knew no Sundays and no labor laws. And none of us had imagined that we should find here as congenial companionship as we found in any port during the cruise.

At noon on July 27 we said our farewells and pushed off, using the engine until clear of the coast. Another propitious start—we picked up a favorable breeze that bowled us along toward Cape Farewell, Greenland. The wind was so strong that we had wire-angles of 50° at our first oceanographic station, July 28. There was too great danger of fouling the wires should we use the new plankton-pump, so neither this nor the bottom-sampling was attempted.

On July 30 conditions were ideal, and for the first time in the cruise we made use of our plankton-pump. Water-samples and temperatures were obtained clear to the bottom (at 3500 meters),

a specimen of bottom-deposit was secured, and the silk tow-net collected plankton at three depths. The Petterssen pump is used to count the relative *numbers* of each kind of plankton collected by the nets, so it was sent down to the same depths.

On the next day we lost our favorable breeze and were forced to operate the engine. Fog and drizzling rain added to the dis-

Iceberg Passed Off Coast of Newfoundland

As it was drifting into the steamship-lanes a radio report was forwarded to the Hydrographic Office in Washington to warn shipmasters; bergs seldom come this far south in August and are quickly melted in the Gulf Stream.

comfort. On August 1 we made less than sixty miles, and were carried south of our course. But on the 3d a fine northeast breeze picked us up and swept us past Cape Farewell. We covered 233 miles that day with a fifteen-mile current against us.

Since we were some ten days behind schedule, Captain Ault decided to omit the proposed loop into Baffin Bay, and to head directly for the Grand Banks. On the 4th, Captain Ault was

confined to bed with a severe cold. It was the first time in his life at sea that he had taken cold on shipboard. As none of the others had suffered from it in Iceland, or in the eight days after leaving, it was interesting to speculate on the source of the infection. We were to be pestered with this common complaint in many ports, but on only a few occasions while at sea.

An unexpected stir was created at sunset on the 5th, when a giant iceberg was sighted off our port bow. We changed course to determine its size and position, so that the trans-Atlantic shipping might be notified. It was very late in the season to encounter a berg, especially so far south, and the ice-patrol had already left its post. We sailed within a few hundred feet, measured its length and altitude, and sent the necessary information by radio to the Hydrographic Office in Washington. It was over a hundred feet high and four hundred feet long. Those who had never seen an iceberg were thrilled with pleasure, but to those who have navigated the Southern Ocean an iceberg is never beautiful. Once it drifts into the warm waters of the Gulf Stream it will not last long.

We crossed the Banks of Newfoundland on the 6th, and hove-to for an oceanographic station on the following morning. We were on the southern shelf, and there was a depth of only 130 meters below us. At 50 meters the water was 3° Fahrenheit below the freezing-point of pure water, while it was 23° warmer at the surface.

This station was interesting for another reason. All around us we could see whales spouting. Over in the east was a school which must have numbered over twenty. In Barbados we were to learn that whalers had pursued these same animals and had made the greatest killing of the century.

On August 8 we stepped suddenly from winter into summer. Within a few hours the water-temperature jumped 20° Fahrenheit, with the air following suit. The stove in the cabin was dismantled, woolen caps and underclothes were discarded, and we went about the deck squinting in the brilliant sunlight. We were in the Gulf Stream, and out of the cold Labrador Current.

For two weeks we logged an average of 140 miles a day, with

PAUL AT THE EVAPORIMETER

The evaporation of sea-water is enormous, thus at the equator it appears to be about seven and one-half feet per year—facts concerning evaporation are essential to an understanding of many problems in the field of meteorology.

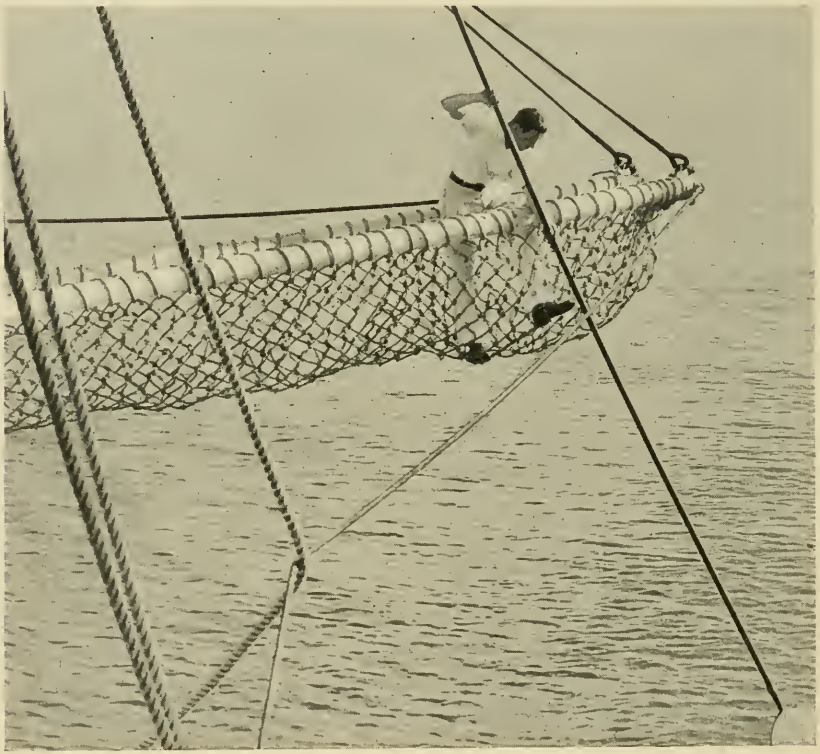
ideal weather for our work. Only one gale threatened us during this time, but it was so short a blow that the sea had no time to become rough. Little by little we expanded our program of studies. As each man developed his technique he found himself able to undertake new details. Parkinson and Torreson started weekly diurnal-variation observations in atmospheric electricity. This required continuous readings of the instruments for 24-hour runs. The fine weather simplified the navigation work, and Scott found time to take over Captain Ault's place at the collimating-compass, while Paul or Jones replaced Scott as recorder. The number of echo-soundings was increased, since Soule was now able to complete in one day the determination of the salinity of the water-samples. Paul began a series of evaporation measurements. All along the line there was a notable improvement in the scientific work.

On August 12 we took water samples and temperatures to a depth of 5600 meters, or about three and a half miles. There was a hot bearing on the winch, due to the great weight of the wire and bottles, and we were hove-to for almost five hours. It was apparent that a different type of bearing must be installed at our next dry-docking. The plankton-pump was up to its usual bag of tricks, and required encouragement from time to time. However, it seldom failed if given a second chance.

On the same day we entered the Sargasso Sea. For about a week the vessel passed through patches of the characteristic weed of the region. Paul made daily weed-counts, and collected specimens. Many of these clumps sheltered small fish, crustaceans, and egg-clusters; so the boom-walk was lowered from the side of the ship to make collection easier. Any romantic ideas of ours, about the Sargasso Sea, were dispelled. We saw very few floating logs, and not a single derelict, although we passed through the very heart of the region. The weed was at no time very thick, and was usually a few feet below the surface. Fanciful yarns are told of sailing-vessels trapped here by immense accumulations of debris.

By the 20th we had entered a region of sudden squalls and electrical storms. The sea became choppy, due to the variable winds.

Nothing can be more exhilarating than to race before one of these short wind-squalls on a small sailing-vessel like the *Carnegie*. Promptly at two o'clock in the afternoon, for several days in a row, we would feel the ship slowly heel over beneath our feet, and hear the low droning hum of the breeze in the rigging rise



THE BIOLOGIST USING A DIP-NET FROM THE "BOOM-WALK"

The boom-walk consists of two 30-foot booms with a net between and enables the observer to collect specimens beyond the disturbance caused by the ship's wash.

in a steady crescendo, higher and higher in pitch as the vessel gathered momentum, until the jibs quivered and flapped as the helmsman eased off a bit. During the next two weeks we used these squalls to best advantage, for once they passed over we would be left floundering around in a calm.

It had been growing steadily warmer, and Soule had to regulate

the salinity-apparatus to a 104° temperature, for there was no cooling device. These were glorious days for the cats on board. Flying-fish were skimming the water in every direction. At night they would be attracted to the lights and strike the ship, sometimes falling on deck. A cat was usually the first on the scene when this occurred, and so we would be deprived of the specimen. We had been asked to collect these fish for Mr. Breder of the New York Aquarium, for he was interested in the geographical distribution of the different species. Mr. Kellogg, research associate of the Carnegie Institution, had supplied us with harpoons for collecting porpoises, but we never had occasion to use them. He was making a study of the evolution (or devolution!) of the whale-family, and was anxious to complete his collection.

There were two questions that furnished lively arguments on board and were never settled: Does a flying-fish fly? Do sharks attack human beings? The discussions became so heated at times that it was well some routine duty separated us before belaying-pins began to fly. In the beautiful evenings on deck everything was close-harmony again. Torreson led the singing of the old-time moonlight favorites; and invariably began and ended with his musical signature, "Among my Souvenirs."

The last week in August was spent in glassy calms. The timbers groaned, and the sails flapped till the reef-points were in shreds. One looked over a sea like lubricating oil, reflecting all the pastel shades when the sun was on the horizon. The engine was operated almost continuously. This made evaporation-observations impossible, and increased the difficulties in other work, because of the constant vibration of the instruments. Always a squall was greeted with cheers. These calms were aggravating for another reason. We were not allowed to jump overboard for a swim, no matter how hot or cloudless the day. The rule seemed very unreasonable at times; but no doubt the Captain had good reasons. On one of the previous cruises there had been a close accident of some kind, and this time no chances were to be taken.

We were in the doldrums, there was no doubt about that.

Any attempt to get further south seemed hopeless. For ten days we had averaged less than sixty miles, and on no day had we made as much as a hundred. Accordingly, Captain Ault gave orders to head westward toward Barbados, thereby omitting the proposed loop to the mouth of the Amazon.

The scientific routine was progressing favorably. We had occasional difficulties with equipment. The piano-wire had a habit of breaking at kinks, and we lost a few snappers from this cause. It was not always certain when bottom was struck, and sometimes many meters of wire coiled up in kinks on the ocean-

THE FORECASTLE GANG
On a Sunday afternoon.

floor. We really needed a separate machine, with an automatic stop for the sounding work. Parkinson found that his electrometer-fibres were scaling and he had to radio for a new supply to be delivered in Barbados. From time to time messengers sent down to reverse the Nansen bottles were intercepted by some marine organism. But on the whole our duties were discharged more smoothly every day, and we could relax for a few hours after supper. An occasional game of cards, or a motion-picture of our own make, followed the meal. And there were those who found pleasure in stretching out on the cover of a whale-boat to watch for shooting-stars or gaze at the moon.

On Sundays the sailors would sit on deck, busy with their skrimshandy, or would collect in the chart-room to play the phonograph. Juan Oyarzo was very clever with string, and made us belts and watch-fobs in his spare time below. Others would make ship models or amuse themselves with a mouth-organ, or wash clothes. But for the "scientifics," as the sailors called us, there was no difference between Sunday and the next day. Oceanographic and magnetic stations alternated regularly. Every daylight hour was spent in the laboratories or computing-room, and even the nights brought their rounds of routine: radio schedules, echo-soundings, atmospheric-electric observations, meteorological work, star-sights.

Mr. Erickson was always ready with an excuse for our bad luck. If it was not the biologist's "plus fours," it was something else. He now accused certain members of the party for the long-continued calms because of the grotesque beards they were cultivating. Soule easily carried away the honors for his baboon decoration. He was dubbed "Admiral Benbow," for had not this intrepid seaman swept clear the Caribbean? Who knows, though, but that the jibes of the others were prompted by envy?

The oceanographic station of September 3 was exceedingly interesting. We had occupied a station within fifteen miles of this spot only five days before, but changes had occurred in that short time. The temperature at the 200-meter depth had dropped about 6° Fahrenheit, and the salinity had followed suit. The current had trebled during the same interval. We realized as never before how important it is to make repeated observations in the same spot, preferably throughout the year, if we want a complete picture of conditions in the sea.

After four days of head-winds, the long-awaited northeast trades began to blow. This was a welcome event, for we were still twelve hundred miles from Barbados, and our supplies of gasoline and water were getting low. On the same day the sailors captured some bonitos, giving us a change from the monotonous diet of tinned meat.

Unfortunately our hoped-for trade-wind disappointed us, and we were left becalmed in the afternoon, with an occasional water-

spout on the horizon. The fact that we were non-magnetic must have had some bearing on their behavior. Although we saw a good many of these "terrors of the deep," they acted as though we did not exist. They did not bear down on us as they do in books, but headed away from us as often as they approached. We did not even keep our guns loaded!

Light airs, squalls, and calms alternated for another week before we picked up a stiff breeze. This happened on September 10. It came with fury from a totally unexpected quarter, south-

An Oily Calm in the Trade-wind Belt

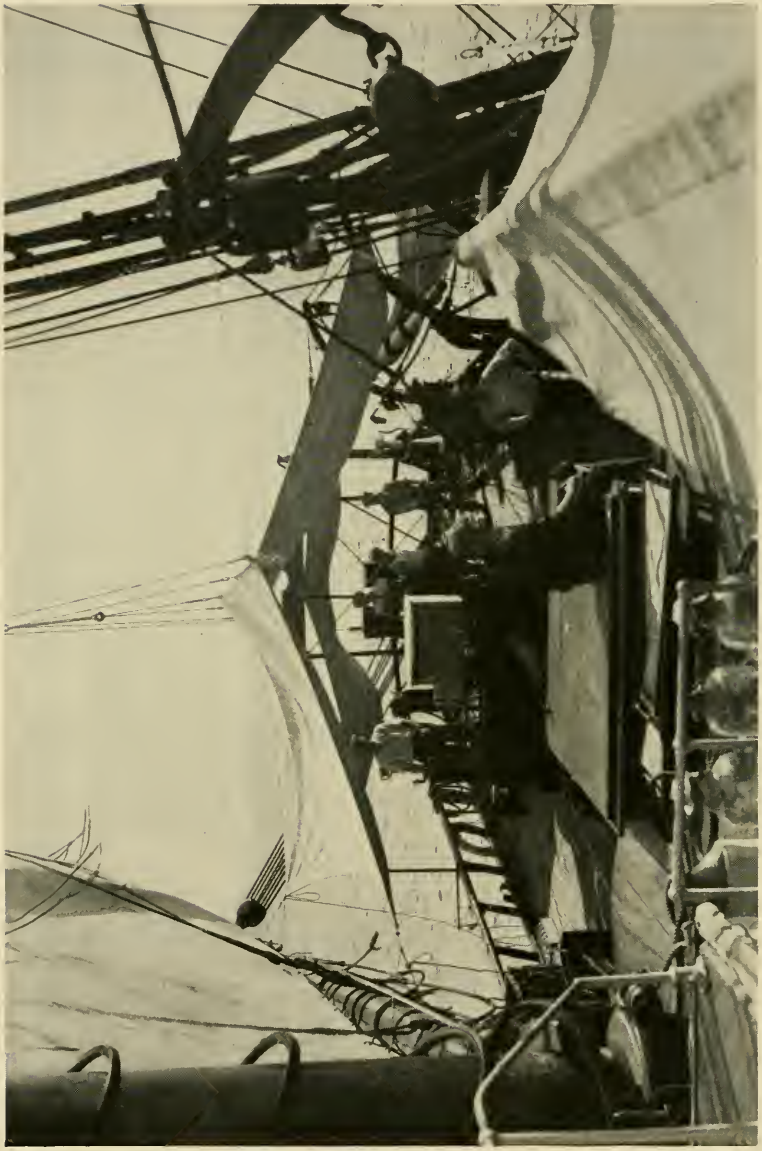
west. Rapid changes in direction and increasing force hinted that there was trouble in the neighborhood. This rather took us by surprise, although we had known from the start that we were entering the Caribbean during hurricane-season. The short disturbance was no doubt the beginning of that frightful hurricane which three days later roared through the Mona Passage, demolished many of the West Indian towns, and razed buildings in Florida. The wind did not reach violent force until it had passed over the Windward Islands, and our barograph did not show any

marked departure from the usual curve; but all the same it was a close call for us.

A night or two later a steamer passed us. This had been our first sight of human life for seven weeks, with the exception of some distant lights on a ship near the Grand Banks. We rigged up a signal-light on deck and attempted to communicate. Unfortunately, we spent so long in figuring out what language they were using that the vessel was out of sight when we wanted to say something. The best guess had it that she was a Portuguese ship bound for Brazil. This incident emphasizes the advantage of having some universal language outside of the marine code.

However, we had no reason to complain. Jones kept us in constant communication with shore through amateur radio fans. Messages were exchanged with families and friends almost daily, and if any item of real interest was picked up from news-broadcasts, it was posted on the chart-room wall. The absurdity of what is commonly regarded as front-page news in American cities is never so apparent as on a ship like ours. For a time, Jones copied out broadcasts from the most distinguished New York papers: a murder in Cicero; a divorce in Hollywood; a sharp drop in utility-stocks; a blackmail letter to scion of wealthy New Jersey family; another murder somewhere—this was the fare we were offered from shore. We laughed so heartily at the incongruity of all this and our placid existence, that Jones became discouraged and very properly ceased to take it down.

By this time our procedure at an oceanographic station had become somewhat standardized, and it might be of interest to describe just what takes place. On the morning of September 15, we are about two hundred miles from Barbados. At eight bells the new watch comes on deck and finds everything in readiness for heaving to. The winch is uncovered, the wires are threaded through blocks to the davits, outboard-platforms are in place, and running-gear is laid out on deck ready for shortening sail. With the sound of the ship's bell still in our ears, the men dash to the tackle, blocks rattle and yards creak as the squaresails are taken in. The lower topsail alone is not furled, and is set aback to check our headway. Then one after another the fore-and-aft



QUARTER-DECK OF THE *Carnegie* DURING AN OCEANOGRAPHIC STATION

When ship is hove to and instruments are lowered into the sea to collect samples of the bottom and to take temperatures and sea water for analysis.

sails come down until only the mainsail and middle staysail remain. The ship is now hove-to and comes up into the wind or falls off alternately with the helm alee.

The oceanographic team consists of four members of the scientific staff (Captain Ault, Soule, Seiwell, and Paul), the Mate (Erickson), the Engineer (Leyer), and the watch-officer with his four seamen. Practically all operations take place on the quarter-deck. Mr. Erickson immediately attaches the bottom-sampler

PAUL AND SOULE PREPARING BOTTLES FOR THE WATER-SAMPLES

These are collected in the depths of the sea to be later analyzed in the chemical laboratory.

to the piano-wire, drops it over the stern, and signals to Leyer to pay out on the winch. Meanwhile Captain Ault and Soule are attaching the Nansen bottles, with their reversing-thermometers to the aluminum-bronze wire. As these bottles are lowered one after the other in a long series, Paul reads the meter-wheel. When the desired length of wire has been paid out he signals to Leyer to apply the brake. Another bottle is attached, more wire is paid out. This goes on till some eight or ten bottles are strung on at intervals of from five to five hundred meters.

At this station we are to reach down five thousand meters, so it will be necessary to repeat the bottle-series twice. The "short-series" will consist of nine bottles lowered to 5, 25, 50, 75, 100, 200, 300, 400, 500 meters respectively, while one bottle is reversed at the surface. As the greatest difference in temperature and chemical salts occurs near the surface, the intervals are fairly short there. But in the "deep-series," which is sent down later, the bottles are spaced 500 meters apart. The strain on the wire would be far too great were we to lower twenty bottles at once.

During this time Seiwell has put out the plankton-nets. These are lowered in series, much as the bottles; but only three are used. One goes to 100 meters; another to 50 meters; and the third to the surface. Microscopic life in the sea is chiefly concentrated near the surface because sunlight does not penetrate water very far. All animals depend on plants for food, directly or indirectly, and of course it is sunlight which is utilized as a source of energy by plants such as diatoms.

Ten minutes are allowed for the lowered Nansen bottles to take up the temperature of their surroundings. Captain Ault now drops a brass "messenger" down the wire to reverse the first bottle in the series. As each bottle tips over, its own messenger is freed to proceed to the next bottle, and so on down the line. It takes from ten to forty minutes for the messenger to reach the lowest bottle. When they are inverted in this way, the valves automatically imprison a sample of water from the desired depth. Also, the mercury capillary of the thermometer separates in such a way that the temperature of that level can be read off on deck, no matter what temperatures are encountered on the way to the surface.

It is not possible to raise the bottle-series until the bottom-sampler has struck. With depths like five thousand meters this may take an hour. When the signal is given that the piano-wire is slack, Leyer ceases to pay out, Erickson reads the meter-wheel, and Captain Ault measures the vertical angle made by the wire. From these readings the depth can be calculated. Soule has meanwhile made an echo-sounding to check this value.

The winch then brings up the bottle-series and bottom-snapper together. The bottles are removed from the wire and placed in sheltered racks. Paul collects water-samples for chemical analysis, and Soule takes specimens for salinity-determinations. When this is done, the deep-sea thermometers are read and the Nansen bottles prepared for their second plunge—this time to greater depths.

While all this is going on, Seiwell or Paul has put the plankton-pump into operation. This apparatus is lowered three times, to levels corresponding to the depth of the tow-nets. A measured volume of sea-water passes through a fine silk net. The number of organisms captured, divided by the number of liters of water pumped, gives the "density of population" at each level. The plankton-nets are hauled in after an hour or so. The specimens collected are preserved and labelled for future study.

It now remains to bring up the deep-series and collect the sediment from the bottom-sampler. This done, the sails are once more set and we proceed on our way. If everything has gone well there is still an hour before lunch in which to start the chemical work. The delicate hydrogen-ion tests are made first, to avoid the possibility of changes in the samples from contamination by the air or by sunlight. The other chemical characteristics are determined after lunch, along with the salinity.

These mornings are strenuous. There are many operations going on at once. Wires lead in all directions from the winch. The sun glares on the water, making it necessary to wear dark-glasses. And only careful co-ordination saves us from utter confusion. Each man has his appointed tasks, but is always ready to lend a hand should things go wrong for the other fellow. And it was a rare day when something did not go awry. Wires might foul below the ship. Messengers might fail to reverse the bottles; or a "jellyfish" get in the way. The piano-wire might snap, or the plankton-pump fail to operate. Anything might happen, without warning, to upset the regular order.

On the afternoon of September 16 we sighted Barbados, our first land in fifty-two days. Our premonitions on leaving Iceland had not been borne out, for we had been much too busy to get

THE *Carnegie* AT ANCHOR IN CARLISLE BAY, BARBADOS

Bridgetown is a thriving port with frequent contacts with North and South America and with shipping services to all of the West Indian islands.

NATIVE COIN-DIVERS

Alongside the *Carnegie* in Carlisle Bay, Barbados.

lonesome, and time had flown. But how good a piece of beefsteak would taste! We beat up and down outside the city of Bridgetown all night, awaiting dawn and the pilot. By eight o'clock we were riding at anchor opposite the Yacht and Aquatic Clubs in Carlisle Bay, with a swarm of native coin-divers around us, and bum-boats nosing their way through the canoes to our ladder.

With the arrival of our mail hopeless indecision seized us. Would we rather stretch our legs on the coral roads for a change, or busy ourselves in the great heaps of letters that had been accumulating here for months? It took almost a day merely to sort out this mass of letters, magazines, and newspapers. The invitation could not be refused of fresh food and fruit waiting for us ashore, and most of the men scrambled into the boats to spend a few hours on land. We were at once offered guest-memberships in the numerous Bridgetown social and athletic clubs, whose privileges we enjoyed to the utmost during the following two weeks. Among these were the Bridgetown Club, Yacht-Club, Savannah Club, and Aquatic Club. They offered splendid places to dine, dance, play tennis, or swim; and all the other facilities for diversion ashore. We were given a hearty welcome wherever we turned.

Barbados offered a sharp contrast to Iceland, our last island. There we had found a population which was purely Nordic. In fact, more than ninety-nine percent were of Icelandic stock. But here we found one white man to eleven negroes! Barbados was to be our only "black" island; for the Polynesians we met in the Pacific are more similar to the white race than to the negro.

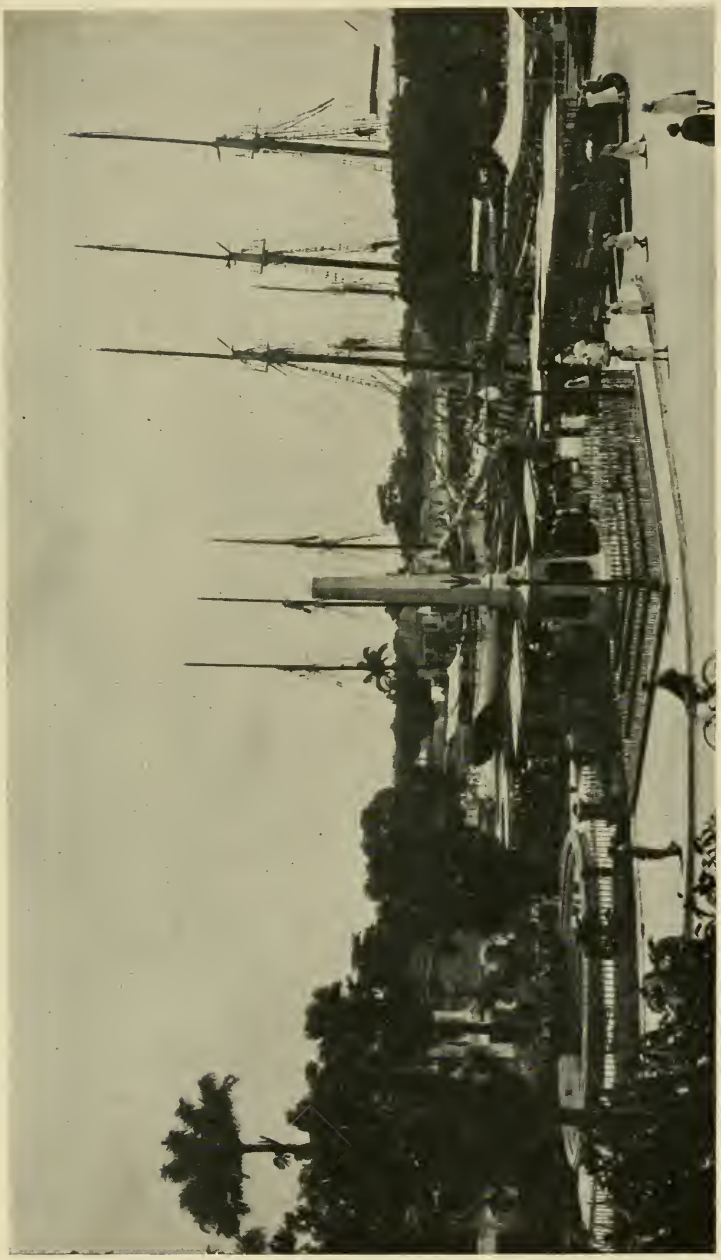
It was always interesting to wander up and down the coral-paved lanes with their pastel-tinted walls, listening to the soft voices of these light-hearted natives. Gigantic negresses, balancing their fantastic wares on their heads, mingle their musical street cries with the braying of the donkeys. One had difficulty in deciding whether it is the donkeys or the women who are the island's beasts-of-burden. Should one be thirsty, there is always a walking "soda-fountain" nearby. For some of these negresses carry great tanks on their heads, full of a native drink

called "gavy." Without lowering the heavy load from its precarious perch, they deftly fill a cup from the spigot projecting over the forehead.

A Barbadian Negress

Carries enormous loads on her head—this one is selling hot baked yams.

Others sell limes or oranges, stacked high on trays—always carried on the head, of course. Should you wander into a main thoroughfare you will see an incongruous mixture of donkey-carts and shiny automobiles, antediluvian hacks and bicycles. Oh, yes! There is traffic congestion—even in Bridgetown. But not



THE "CAREENAGE" IN BRIDGETOWN

A scene of indescribable confusion—schooners, barges, and motor-vessels are jumbled together for protection from September hurricanes.

till one reaches the careenage is one convinced that this is a bustling, industrious seaport. Into this inner harbor are crowded an unbelievable number of schooners, barges, motor-tugs, and bumboats. Arriving as we did in the hurricane-season, the congestion was at its worst; for it then takes courage to push off shore in these dinky trading-schooners.

The first few days were spent chiefly on board preparing the enormous mass of scientific records for forwarding to Washington. Captain Ault paid his official calls and made the necessary arrangements for occupying the magnetic station ashore. Then followed a flood of invitations from the local British community—tennis-matches, teas, dinners, bridge parties, dances. It was certain that our evenings would be well filled.

Scott was swamped by the official mail that required answering. He helped Captain Ault with his correspondence to headquarters, in addition to his usual business with the ship's commissary and pay disbursements. But one amusing complaint from the Chief Clerk in Washington served to add a touch of humor to the whole business. On leaving Reykjavik we had paid a large laundry bill itemized in Icelandic. There had been no time to have a translation made before sailing, so it was forwarded as it stood to headquarters. What was the dismay of the auditors when they came to check up on this incomprehensible bill!

Our work aboard was interrupted by a brisk trade in souvenirs. Natives would come alongside in their row-boats and offer shark-bone canes, bleached coral, beads, fans, and so on, in exchange for old shoes or new shillings. There were also native tailors. Prices seemed absurdly low, until we saw the long-promised suit or trousers—delivered on board by proxy the minute before sailing. And there were shoemakers (or so they styled themselves). But they were not so lucky as the tailors, who had come along at the right psychological moment. We had just arrived from a cold climate, and faced a solid year in the tropics. Everyone had postponed the purchase of hot-weather clothes, and so we fell easy game to the first outfitters that came along.

One day Governor and Lady Robertson very kindly asked us to tea at the Government House, and invited us to use their

Captain and Mrs. Phillips Visit the Ship in Barbados
Captain Phillips was Adjutant to the Governor.

The Tents Pitched for Magnetic Shore-station
Near the "Transit-of-Venus" pier at Barbados.

beautiful tennis-courts. Some games were arranged a few days later; but we were no match for the practised players of Barbados. Ample opportunity for dancing was found. The party was invited to a semi-formal affair at the Yacht-Club. There were occasional dances at the Marine Hotel in Bridgetown, and at Crane Beach. Besides this, there was a splendid floor on the Aquatic Club pier, and music was supplied every evening.

Early in our stay the party was conducted through the interesting coral caves on Dr. Manning's estate. His beautiful grounds include a superb sunken garden. A tea followed the walk, and we made the aquaintance of an old parrot, apparently very much at home in the world.

By the end of the first week we found ourselves free to leave the ship and to undertake the scientific shore work. A tent was set up for the magnetic station near the "Transit of Venus" monument; and another on the polo-field for the atmospheric-electric comparisons. The local residents responded generously to any request for assistance in connection with this work. Parkinson and Torreson carried on the electric observations, while Jones and Paul helped them out at the magnetic station on the hill. Seiwell had returned to the United States on leave of absence. He was to rejoin us at Panama, leaving Paul temporarily in charge of the biological and chemical work.

While the members of the shore-party were engaged in the magnetic observations on "Venus Hill" they usually took their meals at one of the nearby hotels. The routine was so arranged that a twenty-minute interval between two readings of the instruments would allow the observers time to rush down the hill for a bite of food. One morning, when we were seated breathless in the dining-room, the head-waiter approached one of the men and said quietly: "I'm sorry, sir. But have you not forgotten your jacket? We must not permit dining without a jacket, sir."

The answer was simply: "But I have no jacket."

The head-waiter was adamant, and our discomfited colleague left the room. As he made his way to the door, someone heard a remark from one of the hotel-guests: "Isn't that just like an American?" This turned an unpleasant incident into a grand

joke, for the victim happened to be the only non-American in our party! He, of all of us, was the most meticulous in his dress, and had absent-mindedly bolted away from the tent on the hill without his coat, and there was no time to return for it.

Another stir was created one evening in the same dining-room. A real earthquake—the first appreciable shock in the memory of the inhabitants. Pictures on the walls swung slowly from side to side like pendulums. Pillars supporting the upper stories creaked

Captain Ault Using the Diving-helmet
Trying to locate an anchor which was lost in Potomac River.

and everyone gazed at everyone else in blank amazement. It was so unexpected that the disturbance was over before there was time for panic. No damage was done to the hotel, and everyone remained seated. Human speech had been stilled for several minutes, and it was interesting to note the subdued tone of voice in which the broken threads of conversation were picked up at the tables around us.

In Barbados we found ideal conditions for trying out our diving-helmet, and we made two expeditions to the reefs. For several of the men it was an entirely new experience. Only a poet could

imagine the beauty and romance to be found under the waters of a coral reef. And certainly only a poet could describe what we saw in this fairyland of color and form. The dinghy is anchored at the selected spot, preferably in 15 to 30 feet of water, and the observer climbs over the side with a heavy copper helmet resting on his shoulders. A hose connected to a hand-pump in the boat keeps him comfortably supplied with air, and he can wander about at will on the bottom.

One is in a new universe. Everything has a soft, ethereal outline except for the fishes that come to within an inch of the observers' nose to gaze at him in wonder through the plate-glass window. They are the most brilliantly colored of living creatures. One's sense of perspective seems to have been lost. Put out your hand to brace yourself on a coral head, and you find it far out of reach. Walking itself seems ridiculous; for in the water one's buoyancy is so great that the slightest spring upwards on the toes takes one off the bottom for a slow easy flight through space. Gravity has ceased to exist. Captain Ault described what he saw in a letter from which the following words are taken:

> "... schools of marvellously colored fish... forests of submarine trees waving in the water-surges... baskets of shell... jewel-cases of coral growth... grottoes of blue and sapphire... trees of growing coral with jewel tips... bristling, black-spined sea-urchins... a basket made of cocoanut-palm leaves gathered together at the top, perhaps full of treasure left by pirates... a wonder-world not reproduced elsewhere, not even in an aquarium."

Specimens were collected by the observers. A long screw-driver and a heavy brass bucket were lowered on a rope, and on a signal from below the material was hauled up to the dinghy. Although the coral sand did not promise to be very rich in diatoms, we secured several bottles full for forwarding to Washington.

On Sundays and during the evenings we had time to make excursions into the country by train or auto. The northern end of the island is volcanic and offers quite a contrast to the region around Bridgetown. A dinky little passenger-train pulls one

Crane Beach, Barbados

Fine surf-bathing—it was our first glimpse of a "south-sea" landscape.

through the wide sugar-cane fields to this rugged coast, where there is a considerable expanse of sandy desert (not coral sand) in which several varieties of cactus flourish.

The most delightful jaunt we made was to Crane Beach, some fifteen miles from town, where some of us saw our first characteristic "South Sea" landscapes—coconut-palms, coral caves, pounding surf, and all the rest. Truly a magnificent spot to loaf and swim.

By October 1, we had completed our work aboard and ashore. The hours of relaxation in the hospitable homes of our new friends had been well spent, and we were in fine spirits for the short run to the Canal. Sailing was delayed several hours, while Captain Ault and the local police searched the town for two seamen who had failed to report. They had found Barbados rum too strong for them.

We passed the stately peaks of St. Lucia, and sailed along the beautiful coast of Martinique. Captain Ault greeted ferocious Mt. Pelée as an old friend. A severe magnetic storm had followed the terrific eruption of 1902, in which the town of St. Pierre had been buried with all its inhabitants. One of his first assignments in Washington had been the scaling of magnetic records from all parts of the world in connection with this disturbance. The long green slopes of this volcano were clearly visible during the greater part of the day, but only for a short moment did the diadem of clouds lift from the cone itself. Captain Ault insisted that it was only to allow Pelée to show her teeth! The rest of us preferred to interpret the sign as a friendly salute. For was not Martinique a picture of serene beauty—inviting the stranger to tarry awhile in its sleepy villages?

On the voyage to Panama we were favored with strong trade-winds, interrupted almost every afternoon by sudden electrical storms and heavy rain-squalls. In fact on October 3 we encountered a short blow that almost reached destructive force. Such violent thunder and lightning storms are not common at sea, and were no doubt due in this case to our proximity to the large islands northward.

On the 5th we suffered the first catastrophe of the cruise. We

Old Windmills at Barbados
They are used in extracting the juice from the sugar cane.

were hove-to for the oceanographic station. Eleven Nansen bottles, twenty-two thermometers, a bottom-sampler, and 4000 meters of wire, were suddenly snatched away from us through the parting of the aluminum-bronze wire. For a fraction of a second the attention of the observer had been distracted from the incoming bottles, and one of them jammed into the meter-wheel. There was an agonized shout from Captain Ault, then sudden silence. No one had been injured, and there was nothing to do about it, but for several seconds everyone stood in a daze. This was an appalling loss of equipment, but by using the reserve bottles twice at each station, and employing spare thermometers, we managed to carry on until replacements were made from Norway. It was well that we had taken aboard an extra spool of bronze wire in Hamburg!

Approaching Colon we passed through great wind-rows of seaweed, teeming with animal life. It was impossible to tow a silk-net, so great was the accumulation of weed. But we dipped up many curious creatures—pipe-fish, sea-snakes, porcupine-fish, and many others. These spiny porcupine-fish caused great amusement on board. Placed in a bucket of water where they are almost invisible, they swim about on the bottom like brown dominoes tapered off astern. But tease them with a pencil and they puff up into absurd white globes completely covered with spines, and float on the surface upside down in utter helplessness. One must search carefully to distinguish where the head and tail are located, so perfectly do they perform their trick.

The wind failed us just outside Colon, and we were forced to use the engine. This spot is one of the *Carnegie's* most evil memories. It was here that in 1915 she had battled a sixty-mile wind with her anchors dragging.

We were riding outside Cristobal at daybreak on October 11, having made the 1360-mile passage in less than ten days. A few of the party spent an hour or two ashore while a tug was engaged to take us through the Canal. It goes without saying that those who had never before crossed from the Atlantic to the Pacific, made the most of it. Cameras snapped from every corner of the deck, and from the rigging. Everyone was impressed by the

smoothness with which vessels are handled in the locks. The little electric mules gave us a few kicks now and then to keep us in line, but otherwise we came through in great style.

While passing the bird sanctuary in Gatun Lake, someone had the bright idea that this might be the only chance on our cruise to have a fresh-water shower-bath on deck. The response was instantaneous. What a glorious sensation to feel real lather on one's skin again! We were so preoccupied with this rare treat that we were oblivious to the gazing of passengers of passing ships. They would have forgiven this exhibition if they had realized the luxury of a real bath on a sailing ship.

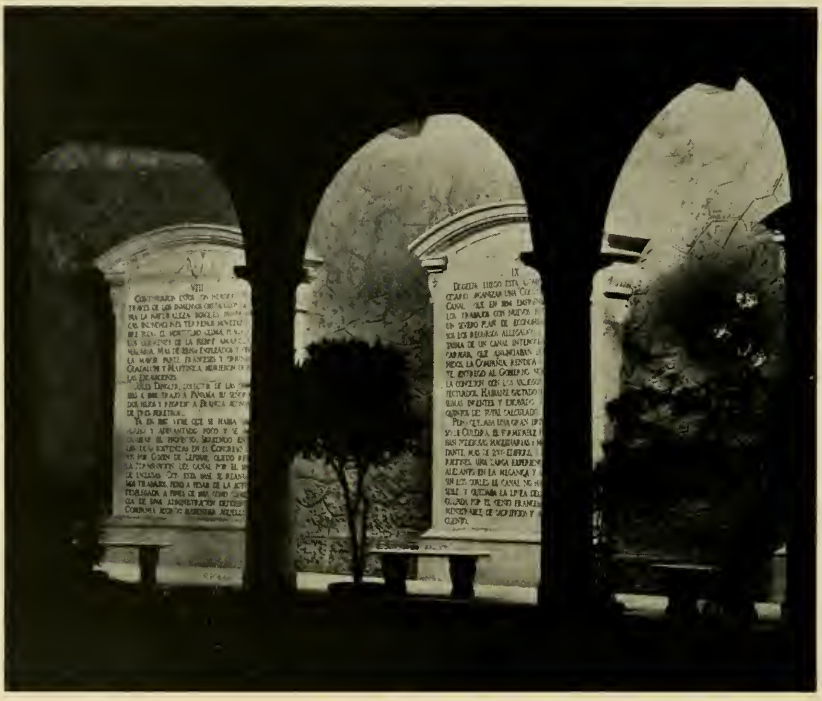
By nightfall we had nosed our way to a berth beside a submarine at the Balboa docks. We had thus concluded the North Atlantic portion of our cruise. Everyone was gratified with the progress we had been making in the scientific work. Even the members of the party themselves sometimes wondered how eight men could keep so many irons hot. Work had yielded interesting and useful results in magnetism, electricity, meteorology, physical and chemical oceanography, biology, and in a multitude of minor studies. As we stepped ashore in Balboa we were paid a flattering compliment by the Captain of the Port, who said that in his opinion the *Carnegie* has contributed more to science than all the front-page expeditions put together that have passed through the Canal.

PANAMA TO EASTER ISLAND TO CALLAO

We were at once extended every courtesy by the officials of the Canal Zone. The splendid facilities of the great commissary-stores were made available to us. We were invited to make ourselves at home in the Balboa Community House, as well as in the several social clubs in Panama City—the Union, Century, and Miramar clubs. The Gorgas Hospital staff made arrangements for operating on one of our seamen. Wherever we turned we found willing hands to aid. The *Carnegie* was no stranger here, it is true; she had already passed through the Canal four times.

The work on board was abnormally heavy in this port. Besides preparing records as usual, we had to pack and ship all the

plankton- and bottom-samples so far collected. Many instruments were replaced by new ones sent down from Washington. Others, like the electric recording-psychrometer, needed extensive repairs. Besides this we received here apparatus for the scientific studies which we were now adding to our already full program. The United States Navy had loaned us complete equipment for

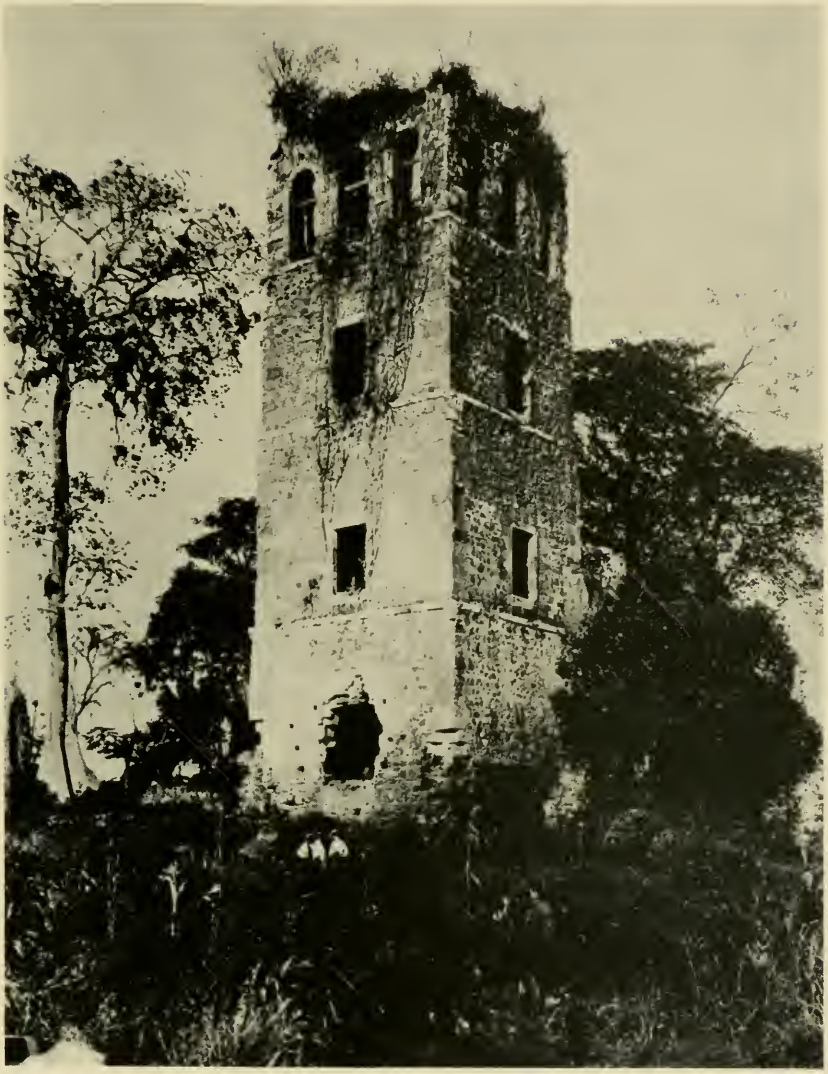


Tablets in Panama City Relating the History of the Building of the Panama Canal

They show that it was more a triumph of preventive medicine than of engineering.

making pilot-balloon observations of air-currents in the upper atmosphere. This equipment included a specially designed theodolite (for measuring horizontal and vertical angles in noting the courses of the balloons as they rise from the deck), hydrogen tanks, balloons, inflation-balance, and computing-forms.

Captain Ault and Scott were kept very busy reprovisioning the



TOWER OF OLD PANAMA

About all that remained after Henry Morgan sacked the city in the seventeeth century.

vessel for the coming six months, and supervising repairs while we were in dry-dock. Besides this several changes in the crew were made here; two seamen and the mechanic were signed off, and a third seaman deserted. To replace these four men, Sudron was engaged as mechanic; the two mess-boys were promoted to seamen; and Kidd was signed on as seaman. He had recently arrived from the training-ship *Nantucket*, which we had met in the English Channel. Two sons of a Canal Zone employee were taken on as the new mess-boys.

The "desertion" of the seaman, Nass, was somewhat mystifying. It was not Captain Ault's custom to keep any man on board against his will, and this man would, no doubt, have been signed off in the usual way had he asked to be relieved. He left behind him a tidy sum of money in accumulated wages. On our arrival in San Francisco we heard that he had shipped on a freighter to Honolulu, become a seaman on the schooner *Vigilant* bound for Gray's Harbor, and was at that time in a hospital in Aberdeen following a serious accident. He had been arrested in Panama on some trifling charge, and was on his way to the police station; the "black maria" got into a smash-up and unfortunately his leg was broken—thus an overnight stop in the local jail had turned into a long sentence to a hospital.

In Balboa we were initiated into the heat of the tropics. Merely typing a letter sent streams of perspiration down one's back. But the cloudbursts which swept down from the mountains every afternoon seemed to clear the sky for a time of its oppressiveness. The hour after dawn and the hour after sunset were delightful. Tennis and swimming were our only outdoor recreations, and at our front door there were wonderful facilities for both. The Balboa Club is famous for its "Red, White, and Blue" juvenile swimming-troupe, whose home-pool we had the privilege of using.

The heat was so intense that we were not able to live on the ship while she was in dry-dock, shut off from every trace of breeze. So the party took quarters at the Grand Central Hotel in Panama City. The change of surroundings had a fine effect on everyone, and soon we were anticipating rather than dreading the eighty-

day passage to Peru. The hotel was an admirable base from which to take short sight-seeing walks in the evenings, and it was convenient to the clubs and theatres. The berth in Balboa had been too remotely situated from Panama City.

The principal work done in dry-dock was repairing the copper sheathing, installing new bearings on the winch, changing the foremast supports, and painting all deck-houses and quarters. We had as our dock-mate the submarine *S-16*, and several of the party had a splendid opportunity for inspecting this fascinating vessel.

Our evening ambles about the city led us to many interesting places. We visited the ruins of Old Panama, the unfortunate city that was sacked by Henry Morgan's buccaneers. We also saw the famous golden altar, saved during these raids by being taken to sea. It was later cleverly disguised with whitewash, and hidden in the wall of a church. Here and there about Panama City we saw small groups of San Blas Indians squatting on the street-corners, or window-shopping like ourselves. None of the party took any extended trips from Balboa. Soule crossed the Canal Zone to Coco Solo by train and bus, in a search for new cable for the multithermograph. The "working" of the rigging, and corrosion, had broken the circuit running to the masthead. It was desirable to install an entirely new length of conductor rather than make temporary repairs. But he was not successful, and we were forced to carry on until some cable could be ordered from Washington.

Captain Ault and Paul made a Sunday excursion to Taboga Island as guests of the Yale boys on their round-the-world schooner, *Chance*. This little vessel had once been engaged under Iselin of Harvard in oceanographic work in the North Atlantic. These boys, recently graduated from college, had bought her and were making a romantic journey through the South Pacific. Bad luck pursued them from the start. They were caught by the terrible hurricane in September, and managed to crawl for safety into a harbor on Haiti. When they arrived in Panama, their "skipper" was taken ill and had already been laid up for six weeks at the time of our visit. This party preceded us through the

South Seas in the following spring, but lost one of its members through desertion in Tahiti. The charms of the island had been too great for him. As though they had not been enough at sea, Captain Ault and Paul spent the day sailing! The *Chance*, in the hands of these boys, was the picture of a carefree, careless life. What a contrast to our lot on the *Carnegie*! But there was

MALPELO ISLAND OUTSIDE THE GULF OF PANAMA

We passed this desolate rock twice in our desperate struggle against head-winds to enter the Pacific Ocean.

little envy in our minds when we said good-bye to our happy-go-lucky hosts.

Anchored a few yards from the *Chance* was the tiny schooner *Svaap* which we were to meet again in Pago Pago. The owner of this two-man sailboat was voyaging in a leisurely manner through the Pacific, collecting materials for his journalistic writ-

ing. She was literally as small as one of our whale-boats. It looked as though one of the enormous pelicans might upset her by landing suddenly on the rail.

A few days later our group accepted an invitation to inspect the Pedro Miguel locks. All the details of the working of gates, valves, and chains, of the control-room and the tunnels were explained. We stood by while liner after liner passed through—some headed for Europe, some for Australasia. That evening Captain Ault gave a lecture on our work before the Sojourners' Club of Balboa.

By the 25th, all was in readiness for our departure. Scott had replenished the "slop-chest" with cigarettes and singlets, the steward was supplied with a bulging storeroom, the tanks were overflowing with fresh water, Seiwell had rejoined the party, and all repairs were completed. Before we could cast off our lines we must mail our Christmas cards, although it was only October 25! We could expect no mail for almost three months ourselves, and would find no Post Office for the same length of time.

We picked up a fine sailing beeze and ran 152 miles the first day. This carried us clear of the dangerous coast. But for the next ten days we waged our bitterest struggle against head-winds. The Gulf of Panama is a notorious trap for a westward bound sailing-ship. Captain Ault describes our fight to get out into the Pacific:

> "For the next two weeks it rained every day and every night and often in between. The wind blew steadily from the southwest as if to deny us entrance into the Pacific, so we made a long tack to the south, gaining a little westing as the wind changed back and forth, but not enough to clear the coast of Ecuador. We ran the engine a few times when the breeze went light, in order to keep closer to the wind. Then we made a long tack to the north, hoping we could slip through, but the breeze again proved stubborn. This tack carried us close to Malpelo Island, an isolated barren rock, one mile long and 846 feet high."

Captain Ault gave orders to tack southward once more with only fore-and-aft sails set, and the engine running continuously.

We kept on in this way

> "until we could no longer spare our gasoline, in an effort to crowd the southwest wind so hard that we could slip by without bumping into the coast of Ecuador. We did not make much westing for three days, and almost ran over Malpelo Island again."

While the mechanic was on watch in the engine-room a connecting rod bearing was allowed to burn out. For two days we nosed our way southward by sail, until a new bearing was cast and polished by the Engineer.

> "We resumed the struggle. Every hour or so the Old Man (of the Sea) turned the wind on a little stronger. Just to tease us he would pull the wind a little more to the westward at night making believe he had given up.
>
> "Finally, on November 8, after seven days continuous battle, when we were too close to the coast of Ecuador for comfort, and when our gasoline supply was low, considering the three months ahead before we could replenish it, the wind shifted to the south enabling us to proceed westward."

This long attack of bad luck gave the sailors a grand opportunity for expressing their various superstitions. Erickson's explanation for the delay was finally adopted as probably the correct one—someone had left port without paying his bills. And when the men in the forecastle had been exonerated on this charge, the "scientifics" were accused.

These two weeks were by no means wasted. Rarely had we been in a more interesting region, from the standpoint of the oceanographer. Stations had been occupied every other day. The area was characterized by a low sea-surface salinity. This was doubtless the result of the torrential rains and the large supply of fresh water dumped by the rivers into the Gulf of Panama.

At our first station we found the temperature at the surface 81° Fahrenheit, while it was only 61° at the 60-meter depth, and 36° at 3000 meters. The surface-life was rich, just as on the other side of the canal.

There were two reasons for celebrating October 29. It was Captain Ault's birthday, and we had gained 15 miles against the west wind in the past twenty-four hours! Oscar cooked one of those elaborate birthday cakes for which he was famous ashore.

By-the-wind in the South Pacific

No creation of a New York pastry-chef could excel his masterpieces of decorative icing.

Our second oceanographic station was a dismal failure because we could not reduce the wire-angles to less than 66°. The combination of strong winds and strong currents kept the bottle-wire so far from the vertical that the messengers failed to slide down with sufficient force to reverse the bottles. Nevertheless

the plankton-collections were made as usual. Conditions were never so bad that something interesting could not be learned. And the magnetic observations continued without interruption in spite of the wretched weather.

During these gloomy days of rain and contrary winds we were kept constantly in touch with home through the radio. The "New York Times" had sent us their news broadcast schedules with the Byrd expedition, and invited us to listen in. Besides this daily messages were exchanged with our headquarters in Washington.

On November 3 we had a second look at the forbidding cliffs of Malpelo Island. This gigantic rock rises sheer upwards from the bottom of the sea. Soundings of 3,000 meters are obtained only a few miles offshore. It looks exactly like a great iceberg—but glistening black—with similar prism-like walls. Landing is almost impossible. There are no inhabitants, of course, for nothing grows on the bare rock.

Malpelo was the first Pacific island to be discovered which was situated out of sight of the coasts of the New World. It is shown on a map of Peru published by command of the Emperor, Charles V, in 1530. On this chart it is called "ye mallabry," from the Spanish "malabrigo" meaning shelterless. Only one landing has been recorded. In 1790, a ship in distress collected some dirty water from the rock pools on the top of the island.

November 3 brought very bad luck indeed, for the sonic depth-finder failed us. The coils in the oscillator in the keel had apparently become short-circuited. We would be unable to make repairs until reaching Callao in January. This break-down deprived us of our best means for charting the ocean-floor, and seriously handicapped us in the oceanographic work. It was our custom to measure the depth with the oscillator at the beginning of an oceanographic station. With the depth thus determined we would know how many bottles to attach and how far to lower them. It now was necessary to send down the bottom-sampler on the piano-wire before the other operations could commence. The depth charts in this region gave far too little information for our use.

Our experience on November 8 was a striking example of this. We were hove-to about 100 miles from the coast of Ecuador. The chart indicated a depth of 3,300 meters. We had no intention of obtaining the usual bottom-sample, but wished to get temperatures and water-samples down to 3,000 meters. When only half of this length of wire had been paid out, the wire slacked and we suspected that we had struck bottom. When the bottles were brought up we found the wire tangled near the lowest one, confirming our suspicions. To establish definitely this unexpected discovery, the piano-wire was sent down and globigerina ooze collected at 1,454 meters! We named this new ridge, discovered quite by accident, "Carnegie Ridge." It rises about 6,000 feet above the general level of the bottom in this neighborhood.

It was obvious that we must devise some method for securing sonic depths. Soundings with the wire would take too much valuable time. The hydrophone-outfit was found still in good shape, and we needed only a suitable "noise-maker." The first suggestion was to manufacture some bombs, out of the gunpowder we carried to fire the cannon of the breeches-buoy equipment. But there was only a small stock of this powder. Paul suggested a chemical bomb, but there were insufficient materials for this. Then Captain Ault thought it might be possible to use the shot-gun shells furnished by Dr. Wetmore of the Smithsonian Institution. These had been carried for hunting land birds from the inaccessible ports we should visit.

The problem of making a submarine shot-gun was turned over to Leyer, the Engineer. Within a few days he constructed a suitable device for firing the shells under water. A twenty-foot length of brass pipe was fitted with a shell-holder, which screwed into one end. This end was submerged and a firing-pin dropped down the tube. Soule measured with a stop-watch the time-interval between explosion and arrival of the echo from the bottom. We compared depths so determined with soundings by wire and pressure-thermometers, and found that the accuracy was sufficient to justify soundings two or three times a day until we reached Callao.

The noise made by this outfit was terrific at times. The tube was held over the side of the vessel amidships, and when the shell exploded it sounded from the cabin as though we had suddenly struck a reef. Occasionally the ship would roll to one side just as the firing-pin was descending the tube, and the explosion would occur just at the surface.

The failure of the oscillator became a trifling worry when the ominous news was spread on board that Oscar the cook was in

One of the Islands of the Galapagos Group

Because of our delay in leaving the Gulf of Panama we were unable to stop at these fascinating islands.

bed with a steadily rising fever, and with indications that he had contracted typhoid in Panama. Everyone was inoculated who had not been previously. This happened two days before the wind had changed in our favor, and Captain Ault seriously considered turning back to Panama to repair the oscillator and to leave the cook in the hospital. Another possibility was to run in to Guayaquil or to leave the sick man at Galapagos, where he might have to wait six months or a year for transportation to the mainland. But it was not Captain Ault's habit to give up a fight. We kept on pushing our way out of the Gulf until a diagnosis of typhoid could be definitely established.

Fortunately, after four days, the cook's temperature dropped toward normal. By November 11 he was back on duty, and things did not look so black for us. Courtney Whalen, the former mess-boy, had acted as cook while Oscar was confined to bed. It would have been utterly impossible to have on board for weeks a bedridden patient who required constant nursing, without crippling our scientific work. Every man's day was so completely filled with routine duties that with one man laid up and another acting as nurse, everything would be dislocated.

On November 9 we at last entered the trade-wind belt and made better progress toward the Galapagos Islands, lying on the Equator. As we approached, the air and water became increasingly cold. We used woolen blankets at night, and Soule regulated the salinity-bridge to a lower temperature.

Schools of large blackfish performed their antics beside the ship, as though to tell us we were entering the cold Humboldt Current. With a long running start these heavy fish would fling themselves out of the sea to land with a great splash on the surface. Several good pictures were taken, but the negatives were destroyed at Apia, along with all our other personal photographs.

This Humboldt Current, like the Gulf Stream, has a profound effect on the climate of the coasts it bathes. A few years ago it seemed to "disappear," while Beebe was cruising in this very region. At least he did not find it where he expected. This phenomenon changed the climate of the coast of Peru in a remarkable way. Regions that had been without rain for centuries received such deluges that markings on ancient "adobe" buildings were obliterated. It was not our luck to stumble upon such an upset in the circulation of the Pacific. It is a great pity that such an interesting discovery as the *Arcturus* made was not followed up by careful oceanographic studies; for another opportunity may never be offered.

In these waters we saw many salps, transparent, jelly-like organisms showing clearly the transverse markings which identify them as the "ancestors" of the vertebrates. It was very easy to dip them up at night when the depth-light was lowered into the water. One of the most disappointing compromises between

demands of the magnetic survey and oceanographic investigations was the omission of night stations for collecting plankton. The minute creatures show pronounced diurnal vertical migrations, and only by towing silk-nets repeatedly during the twenty-four hours can we get an undistorted picture of their distribution. But our time and our personnel were so limited that all idea of heaving-to at night was given up. The important studies in the marine biology of the future will be physiological. There is little to be gained by identifying new species when we are so poorly acquainted with those already named.

On November 11 we first sighted the Galapagos Group. It was cruel to pass these intriguing islands without stopping off, but the delay in getting clear of the Gulf made that out of the question. We sailed close to the barren shores on the next day, but saw no signs of life except the sea-birds. From the view obtained from a passing ship one would never dream that the islands are a paradise for the biologist. As we rushed by, a fresh trade-wind filling the sails, we dragged up our belongings to dry in the warm sun. Mildew had begun to do its work on our clothes and books, after their long exposure to the wet weather of the Gulf.

On the unlucky 13th, the heavy currents and strong winds encountered in this vicinity almost took their toll. To start things wrong the bottom-snapper failed to close. Then followed a grand mix-up of our wires. The plankton-pump lowered on the starboard side fouled the bottle-series. So great was the strain on the bottle-wire that it parted when we tried to reel it in. When the accident happened there were still four bottles with eight thermometers out, and we faced a serious loss. There had not been time, of course, for replacements to arrive after our Caribbean disaster.

With heavy hearts we brought up the plankton-pump. Then, lo and behold, our bottles were seen coming up entangled with it. The men on deck scarcely breathed as they leaned over the side for a firm grip on the broken bottle-wire before the precious instruments should make another attempt to get out of our grasp. By cautious work everything was recovered. Captain Ault says:

> "We never know what will happen next at an ocean-station. The piano wire with the bottom-snapper is used on the davit aft; the smaller aluminum-bronze wire is operated on the port davit; the plankton-pump is lowered on the starboard davit; and the silk two-nets are operated from the forecastle head forward. So we have a four-ring circus going on all the time."

It was even worse when we had towed the three silk-nets from the quarter-deck; by placing them forward the difficulties from fouling were greatly reduced.

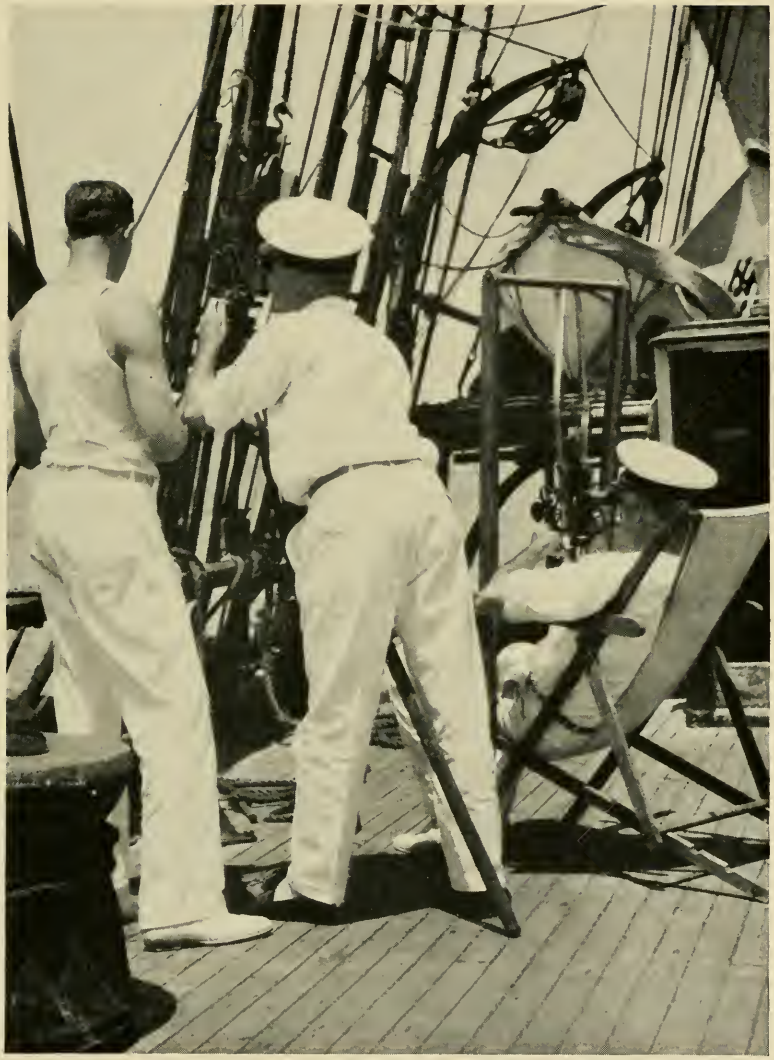
Once in the trades, the weather was perfect for pilot-balloon flights. The new equipment, supplied by the United States Navy, worked well and observations were made daily. With strong winds we were able to follow the balloon for only fifteen to twenty minutes, but sometimes it would be visible for an hour. By tying two together we could often follow them long after a single one would have been lost to view. In this way we traced the direction and force of the wind in the atmosphere up to heights of from two to six miles.

Three men take part in a balloon flight—usually Captain Ault, Torreson, and Scott. A pure-rubber balloon is inflated until it is about three feet in diameter with hydrogen from a tank. By "weighing" it we are able to calculate its rate of ascension. The scales operate upside down, of course, for the balloon pulls the pan upwards. At a signal from Scott, the recorder, the glistening globe is released. At one-minute intervals Torreson reads the azimuth, or horizontal position of the balloon with respect to the ship's heading; and Captain Ault checks the altitude by using an ordinary sextant. It was of course possible for Torreson to read off both altitude and azimuth from his theodolite; but the rolling of the ship often caused him to lose track of the object, while it was still clearly visible to the sextant-observer. By reading the altitude from the sextant, it was possible for Torreson to sweep the sky at that level until he had again picked up the elusive sphere.

As a result of a multitude of observations on wind and weather conditions at sea, we have today fairly accurate "pilot-charts"

Captain Ault Releasing a Pilot-balloon

These globes ascend at the rate of about 600 feet a minute and are wafted here and there by the winds they encounter in the upper air.



Captain Ault, Torreson, and Scott Following the Pilot-balloon
From these observations pilot-charts for aviators will some day be prepared.

of the ocean, for the use of mariners. Now that trans-oceanic flying is coming to be a serious enterprise and not merely a stunt, it is highly important that aviators have "pilot-charts" as well. They must know the direction and velocity of the wind at many levels, if they are to make succesful flights over the great expanse of the ocean. This work which we were doing, added to the observations made by other marine observers, will some day be the basis for such charts. As we noted in Hamburg, the Germans are very active in this regard.

On November 14 the wind died down for a time. Captain Ault gave orders to lower the dinghy, to allow Parkinson and Soule to photograph the ship under full sail. They succeeded in taking many striking views of the beautiful vessel, some of which are reproduced in this book.

A few days later there was excitement on deck. Just before dawn an intensely brilliant meteor appeared in the northeast, swept over the sky, stopped ahead of the ship at about 35° altitude, and faded away. The display lit the decks more brightly than the full moon had ever done.

The days of fair winds and clear skies were glorious, and we began to appreciate the beauty of Pacific sunsets. It was of times like these that a previous observer on the *Carnegie* was writing when he said:

> "The exhilaration experienced when making an ocean-passage in a small sailing-vessel like this is beyond description. With but a few feet between you and the sea, gracefully, rhythmically responding to every motion of the water, you feel as though you were part of the sea yourself. Of the many passages in ocean-liners some of us have made we had never been so comfortable, have never gotton so much pleasure as aboard the *Carnegie*."

If the days were beautiful the nights were even more so. The 27th was one of those extremely rare days when there was no cloud in the sky. What a night for stars followed! Magellanic Clouds glowed in the south, and the Southern Cross itself fairly blazed. Star-charts were brought out to aid in identifying the Southern Hemisphere's constellations, for some of us had never before crossed the line. We were now more than 30° south.

Everything was running smoothly. The trades were strong. The scientific program was in full swing. And there was no reason why we, as well as our friends on shore, should not celebrate a Thanksgiving dinner. An elaborate affair was arranged for the night of the 29th. Everyone dressed up in his stiffest collar and sleekest black. There were even full blown dinner-suits. A most impressive menu was printed for the occasion, and is here reproduced. Readers will recognize some of the allusions, but there are others which must forever remain a dark secret to the uninitiated.

Thanksgiving Day, November 29, 1928
Dinner
Cocktail Fylla
Radishes au Mirage Celery Imaginaire
Crême de Plankton
Lapin Rôti à la Alpendorf
Papas Marinas de Barbados Sin Chaquetas
Petit (Avoir du) Pois au Cigoin
Pâté de Fruits à la Marie Glenn
Gateau Chinois au Medico
Pâtisserie Shortwave à la Hartford
Bonbons de Slopchest
Thé à la Russe Café Noir
Cigarettes

Radio conditions became very poor during the last week of November and almost all our contacts were lost. WIMK of Hartford, our old stand-by, was the last to go. For several days they sent us messages "blind," for their signals were received with the usual strength while ours were inaudible in the United States. Jones was able to pick up their broadcasts, one of them being a cheery Thanksgiving message from the folks at home.

We were only 4,500 miles from Hartford, and should have had no difficulty in sending messages that short distance. It was thought that our antenna might be at fault, but as time went on it became clear that we had entered an area of disturbed radio conditions. The trouble was apparently not due to defects in our transmitting apparatus. Schedules were arranged during night hours, but there was no improvement.

On December 1 we made a record for balloon flights, 64 minutes.

This corresponds to an altitude of about seven miles. It is not a remarkable record for land-stations; but seems quite a feat when one realizes that we were on a small vessel in choppy seas. Anyone who has used a sextant will appreciate the terrific nervous and physical strain involved in following an object for such a long time.

THE *Carnegie* HOVE-TO FOR AN OCEANOGRAPHIC STATION IN THE PACIFIC
Only enough sail is carried to keep the ship headed into the wind.

We were now nearing the famous "riddle of the Pacific"—Easter Island. No mail awaited us, no clubs or theatres to offer relaxation from the two months of scientific routine; but everyone looked forward impatiently to a sight of land. We made a great loop to the southeast of the island to clear the strong trade-winds, and then headed northward and sighted Rano Kao Volcano on December 6. After skirting the Bird Rocks of legendary fame we anchored in the foul ground of Cook's Bay, opposite the village of Hangaroa.

The island looked very uninviting from the open roadstead. It was no more than a rocky waste. Yet it proved one of our most interesting visits. This tiny, isolated speck in the ocean presents a great challenge to the archaeologist. It lies two thousand miles from the nearest mainland, and more than a thousand from its nearest island neighbor. Yet there is undeniable evidence that thousands of people once lived on these treeless, almost sterile lava-plains. Today only about three hundred apathetic natives with their domestic animals manage to scratch for a living between the boulders, in soil that will not even grow the coconut. Furthermore, water is scarce, for the coarse volcanic soil is so porous that the forty-inch rainfall is lost at once. They water their flocks and wash their cloths only from brackish springs along the beach at low-tide, and from the crater-lakes high up in the volcanoes.

To make the picture even blacker, the sea is almost devoid of life in this region, and because the island is not surrounded by shallow waters, the villagers cannot expect to subsist on shellfish or slugs. How is it possible that this inhospitable tiny island once produced the surplus leisure and labor necessary to build some of the most stupendous memorial architecture in the world's history?

Easter Island, or Rapa Nui ("Big Dancing Paddle") is situated in the South Pacific Ocean at 27° south and 109° west. It is about midway between Coquimbo, in Chile, and Tahiti. The nearest island is the uninhabited Ducie (over a thousand miles away), except for the rocks of Sala y Gomez, which lie to the east. The area of Easter Island is forty square miles. It is roughly triangular in shape, and consists of mountains and plains—gentle, rolling contours except where the volcanoes are situated on the coast. Here, there are bold cliffs. There are no true valleys, formed by erosion; and there are no running streams. The climate is about ideal, with trade-winds blowing continuously from October to April.

But our attention was soon distracted from the island itself to the swarm of native boats which had come out to greet us. Some of them recognized us at once, since the *Carnegie* had called

here before. But the real reason for the excitement among them was that they had not seen a ship for six months, so far is the island out of commercial traffic-lanes. While Torreson and Scott were still recording the bearings of the ship, the government agent and two political exiles from Chile climbed aboard to bid us welcome.

A party from the *Carnegie* at once took the dinghy ashore for a visit to our old friend, Mr. Edmunds, the only permanent white resident. He is an agent of Williamson, Balfour and Co., who lease the whole island from Chile for stock-raising. The landing is precarious even on a quiet day, and highly exciting when a moderate surf rolls in from the open sea to the west. A narrow channel in the rocks leads to a few feet of sandy beach. One must idle a moment outside the channel waiting for a swell large enough to carry the boat through; for even an eight horse-power outboard motor cannot make headway against the outrush of a receding wave.

On shore we found the whole village collected. Over the rocky plains little puffs of dust converged toward the landing, raised by native cowboys galloping at their characteristically reckless pace. Mr. Edmunds was soon persuaded to accompany us back to the ship for a renewal of acquaintance.

Upon our return a sight greeted us which was to become more and more familiar as we voyaged through the Pacific islands. The *Carnegie* swarmed with brown faces. On the forecastle-head a seaman was bartering an old sailor-hat for a wooden idol. On the quarter-deck the steward was haggling for a hatful of eggs. Oscar the cook was offering a handful of empty bottles for a scraggly chicken; but to his dismay was told that only the transfer of his trousers would close the deal. Members of the staff found shirts the magic medium of trade. Strangely enough, new shirts taken from the lockers were not so much in demand as old ones on your back. The natives were in no great hurry to come to a bargain, and would often amble away as soon as you came to their terms.

As days passed the whole population acquired the necessary shirts or trousers, and playing-cards, neckties, and cigarettes

were then demanded in exchange for souvenirs. The people were inordinately fond of cigarettes, especially the women. What a contrast from the time of the ancient explorer, Gonzalez, when the smoking indulged in by his crew precipitated a panic of fright among the inhabitants! They raised great lamentations whenever they saw smoke rising from the mouths of the sailors, and insisted that smoking be stopped. Gonzalez was not able to determine the cause for this superstitious fear, but could only conclude from

IMAGES LINING THE SLOPES OF RANO RORAKU, EASTER ISLAND

Where the sculptors did their work—this slope has been called the "show window" for the busts stand as though awaiting buyers who would erect them on the burial platforms along the coast.

the sign-language they employed that they objected because "smoke goes upwards!"

Among the trinkets we picked up were stone fish-hooks, obsidian spear-heads, wooden house-gods, "reimiros," hieroglyphic tablets, and small stone-images which were made to resemble the gigantic statues for which the island is famous. The basalt fish-hooks were of enormous size, and none of us could imagine a fish being caught by them. But there were smaller ones made of human bone which were actually used at the time of our visit.

The wooden images we obtained were, no doubt, modern imitations. It was learned that expeditions value these objects, and so they are made for trading with the infrequent ships that come this way. They were originally made of "toromiro," a native hard-wood brush now almost extinct from the depredations of the sheep and cattle. Surgeon Cooke of the *Mohican* Expedition describes these wooden house-gods as "rudely carved out of the solid wood, hideous imitations of the nude human form, male or female; two to three feet in length, with preposterous development of the chest and preternatural collapse of the abdomen, as though famine had brooded over the land and the patient had perished of inanition; with attenuated forms, long, slender arms and legs, narrow faces, a goatee, and long prominent ears. In the eyes of these idols the iris is usually represented by a circular button of bone, generally cut from a human skull; while a fragment of obsidian, fixed in a round hole in the center of the bone, and which glistens in the light, makes a fair imitation of the pupil, both being deftly fitted in the wood of the eyeball."

Paul succeeded in acquiring two "reimiros," one of which was a beautiful specimen of ornamental wood-carving. These curious objects were hung by strings over the chest as a decoration in the days when "war-dances" were performed. They are shaped like a crescent moon, from one to two feet from horn to horn. The hard wood from which they are made is intricately carved with the characteristic hieroglyphics of the ancient race.

After our first bout of bartering with the natives aboard, several of the staff went ashore for lunch with Mr. Edmunds. How good his fresh vegetables tasted after our two months of tinned food! There were cucumbers, lettuce, fresh mutton, and bananas. Others stayed aboard and became acquainted with the two Chilean exiles: one a military attaché in Paris who was sent here for being involved in a revolutionary plot; the other a senator who had made some political blunder. Neither spoke English, but our fragmentary knowledge of French, German, and Spanish gave us the necessary vocabulary for small talk with these two charming gentlemen. Who knows but that the authorities in Chile have forgotten their political crimes—forgotten their very existence?

Paul went ashore to secure volunteers for his studies of racial metabolism, never suspecting that half the stay in the island would be spent in finding an Easter Islander! So hopelessly mixed are the races here that only one old woman about eighty years old had any reasonable proof that she was of pure native stock. This old woman made a beautiful "kete" basket for Paul from the rushes which grow in the crater-lake of Rano Kao. She was the only one who remembered the ancient art of weaving these rushes.

Speaking of his visit to the home of this old lady Captain Ault writes:

> "In one small hut, consisting of one room with a dirt floor, lived a family of four women. There was a pile of sticks in one corner, a small pile of corn in another, a raised platform with some bedding in a third corner, and in the fourth corner a more elaborately-equipped single bed, about five feet above the floor. A few magazine illustrations were tacked to the wall, some straw was scattered about the floor, otherwise there was no furniture and the walls and ceiling were full of cracks through which the rain doubtless entered freely. This white-covered bed, elevated above the dirt, gave the startling effect of a shrine amidst squalor, of a white rose amidst a patch of cockle-burrs, of a best room or parlor in the middle of the kitchen.
>
> "And here lived the old grandmother, one of the few surviving natives of the old days, a real *Paquensa*, who spoke only a few words of Spanish, and was proud to speak them all at once as we entered the hut where she was squatting in front of a small fire of corn-cobs in the middle of the floor, with a battered old kettle resting on an oddment of bricks, boiling a few grains of corn for the family dinner.
>
> "Her daughter is the mother of two girls, one very dark, about 18 years old, with a native father, and the other a very fair girl about 16 years old, who could easily pass as a white girl. Her father was a white man, a seafaring man, here today and gone tomorrow. And this fine bed is for this girl, the jewel and treasure of the family, the rose born to bloom unseen."

Hardly a crew touches here without leaving some trace in the population, for every family seems anxious to boast a white child. Voyagers of the eighteenth century, whalers of the nineteenth, shipwrecked sailors, traders, expeditioners, and Peruvian blackbirders, all contributed their quota.

The first afternoon was spent ashore poking about the village. We mounted the tough little horses which were offered everywhere for our use in exchange for a smoke. Young girls lined the fences along the road, making fun of us, and flying precipitately behind the house when we rode too close. Good horsewomen themselves, they laughed uproariously when we lost control of our mounts in trying to pursue them.

Toward evening we saw a revolting meat-market scene. An old woman had slaughtered a sheep near the center of the village, and a crowd began to gather, along with the flies. They brought sweet potatoes, bananas, and taro with which to barter for meat. The carcass lay in the dirt, positively black with flies. As many as could reach it proceeded to pinch the meat, jabbering away with the old woman who was going around in her turn rolling over the vegetables. From time to time, someone having found what he considered a tender cut, would yell for a knife and hack off a piece, only to have it knocked out of his hands by the old lady, as too large for his offering of yams. While it rolled in the dirt and the flies were having their turn, they argued to a bargain.

But all was not squalor among them. Some of the houses had flourishing flower-gardens. On the day after our arrival the villagers appeared dressed in dazzling white, thanks to our contributions of soap and linens. They love to look clean themselves. We had taken ashore a formidable accumulation of dirty linen to be laundered by the native women; and paid for the work by presenting the laundresses with twice the amount of soap necessary to do the washing. Nothing is so much appreciated as this present. On a previous visit Captain Ault had taken great pains to teach the women how to make soap out of grease and potash, but it was characteristic of these folk that they would rather go without than take the trouble to make it.

No one on the ship was allowed ashore after sundown because of

the precarious situation of the vessel. The usual sea-routine of watch-and-watch was kept aboard so that we might put out to deep water in an emergency. We shall see how fortunate this provision proved to be.

The houses of the village are fairly substantial structures of wood. They rely on wrecked vessels for their lumber. The shore near the boat-landing is covered with spikes, bolts, anchors, and chains from these unfortunate ships. Windows are a rare luxury. The floors are usually of dirt. Furniture is scanty and most of the natives sleep on the floor or on low bunks set against walls. As a rule several families occupy each house. We saw a few cooking-utensils, but for cooking the Samoan style of the hot-stone oven is relied on.

The schoolhouse was built in 1914 and the "governor's" wife is the teacher. Instruction is given in the Rapa Nui language, which was put into writing by former missionaries. The schoolmistress does not take her duties very seriously, and the building is used as much for community dancing and feasts as for anything else.

There is no ordained priest for the village church, but a missionary comes out each year on the boat from Chile to baptise the infants, preach a sermon, and hold a service for the dead. He returns with the vessel, and the church-affairs are supervised by a native patriarch.

One of the recent visitors to Easter Island reports a scandalous funeral ceremony which he witnessed. A distinguished personage of the island had died. Just as the body was lowered into the ground the natives lined up and burst into a perfectly drilled "Hip, Hip, Hooray!" No doubt, they had picked up this cheer from a passing English ship, but had not been told that it was hardly appropriate as part of the funeral-rites!

December 7 was to prove our only full day of liberty ashore. An assortment of horses and saddles awaited us on the beach in the early morning. It was first come first served. There were various combinations to choose from: good horses with makeshift saddles, feeble nags with shiny trappings, and some with only a "sheepskin over a ridgepole back." Even stirrups were a luxury,

and we had before us a thirty-mile "ride" over the roughest terrain imaginable, headed for the famous sculptors' workshop at Rano Raraku.

What a cavalcade! Our Captain rode proudly in advance on Mr. Edmund's handsome steed, with genuine saddle and stirrups. Behind him stumbled a motley array of bedraggled followers. A Coxey's Army on horseback. Many of the men had apparently forgotten how to shift gears. Some would lurch forward into full gallop, others stall at the first step. In one minute the party had deployed all over the landscape, but not in obedience to the Captain's command.

First one horse, then another, was a runaway. The bold volunteer who hastened to aid a colleague found himself out of control in a moment, and before long the dignified explorers were weaving wild circles over the cruel lava-fields, to the amusement of the native guides. Captain Ault laughed uproariously at the exhibition. He had been born and raised on a Kansas farm, and had an unfair advantage over the rest, some of whom had never mounted a nag before.

These horses deserve the study of a psychologist. Should there be a few feet of sod beside a rock-pile, they invariably chose to clatter over the rough, and would shy away from the grass as though it were poison ivy. And, after all, we went where the horse chose to go. With the help of the guides we steered an easterly course, but with much tacking and wearing.

Clambering out of the village over a low ridge between two volcanoes, we proceeded toward the southeast coast, where we found mile after mile of megalithic burial platforms, with their grotesque statues tumbled over in ruins. The ground was very uneven, and strewn with lava-boulders. What grass there was occurred in hard tufts; so that one was more comfortable on board the horses than on foot. Scattered over the plains are small stone enclosures in which yams or sugar-cane or taro are growing. Besides making a clearing for cultivation, these stone circles keep the sheep and cattle from destroying the crops.

The first stop was made at Vaihu, a cattle-watering hole on the beach. There was formerly a considerable settlement here

with a village church. There is now nothing but a windmill and a shed—no inhabitants. While the guides were watering the horses, we amused ourselves by turning over the loose rocks at the base of the images, in hope of discovering some ancient relic overlooked by previous expeditions. Nor were we disappointed. Paul found a collection of skeletons with bones intact, and a pile of old skulls. Climbing under the rocks he passed the skulls out to the others. One of them had the chiselled markings supposed to be the sign of a chief.

While we were digging around in this way we saw a solitary native bathing at the base of the platform. Each time before he dived into the water he vigorously made the sign of the cross three times, as he stood at attention facing the sea. Apparently he had some superstitious fear of the sea.

A short ride brought us to the cabin of two Scotch shepherds who had been brought to the island for one year to set up fences for the cattle. These men said that our disturbing the bones of the dead was responsible for the heavy rains that fell throughout our excursion. We were much surprised to find a turkey walking around in their grounds. They explained that it was left here by the Routledges of the *Mana* Expedition.

After tea we proceeded to the volcano, Rano Roroku, on whose slopes the hundreds of giant images were quarried. The nearer we approached, the harder it rained. Only the tremendous spectacle, which had been visible for many miles, kept us from turning back. The long rows of overturned images and an occasional fig-tree offered shelter during the heavier showers, although we could not have been more thoroughly soaked.

Half buried in the débris from the quarries above, dozens of huge busts stand up menacingly. They are single blocks of lava, twenty to seventy feet from waist to head. There are no two alike; but all have a prominent aquiline nose, wide nostrils, thin, closed lips, and bold chin. None of these now standing carry the absurd three ton hats which we had seen on our halt at the beach. Their features, haughty and arrogant, suggest a scorn of life. Captain Ault remarks: "The unseeing eyes, sombre, austere expressions, and unsmiling lips give no hint of the secret which they have been guarding for centuries."

The grotesque heads are quite flat behind, as though a knife had sliced off vertically the whole after half behind the ears. This represents an ideal of beauty not confined to this island, since many Polynesian peoples shaped infants' heads in this pattern in stone molds or wooden forms.

Everywhere one sees evidence of a sudden interruption of the work of the sculptors. Some statues are still undetached from their rocky beds high up on the hillside, some have fallen to pieces in the process of lowering them down, some are only roughly blocked out, while others were apparently being moved to the platforms around the coast when all work ceased. It has been suggested that these were busts of great chiefs. No one knows. The magnificent architectural plan for a complete double line of images facing each other around the thirty-odd miles of coast, with a paved ceremonial floor between, can be easily made out even now. The shaping of these twenty- to sixty-ton images with no tools but stone, sand, and water, is no more remarkable than the tooling of the much harder material of the platforms and foundations which ring the island. Some of us were to see the famous Inca work in the Titicaca region in Peru, but in places this masonry was equally impressive.

What this great outburst of the memorial arts means is still a mystery. Was Easter Island to be the burial ground for other Polynesian islands? How could it have been, when the nearest is over a thousand miles away, and only open canoes were known to the ancients. The only instruments of navigation we heard of were crude gourds drilled with holes for measuring altitudes, while no chronometers were known. And how were these enormous finished statues transported for ten or fifteen miles across the rough lava-fields without breakage? There has never been found a trace of forest on the island to furnish wood for levers or sledges. The engineering of the pyramids presented no greater problems.

To account for the former great population, McMillan Brown has developed a theory which he discusses in his book, "The Riddle of the Pacific." He presupposes a nearby archipelago which was submerged in historical times. He bases his assumptions on the following evidence: Easter Island legends say that the first settlers

came in canoes from the northwest; the navigator, Davis, sighted land to the east in 1686, now disappeared; Juan Fernandez reported land to the south, with great rivers flowing down to the sea; the ancient name of the island is said to mean "navel," as though Easter Island were the center of the group of islands; and there have been recent probable submergences of land in the Pacific. This theory shows what a wild assumption must be used to explain the presence of so many people of the island in

COLOSSAL STATUES, EASTER ISLAND

Why or even who made them no one knows—were they meant to be busts of notable personages? (Courtesy of the Library of Congress.)

ancient times—the submergence of a whole archipelago. Our soundings in approaching and leaving the island gave no hint of such a submergence, although a ridge as high as the Andes was discovered in the sea near the coast of Chile.

The fig-tree umbrellas beneath which we had halted on the way out had furnished more fruit than cover, but we were still ravenously hungry, and wet. The only shelter we could find on Image Mountain was in an artificial cave left by the sculptors when the lava was cut away around one of the gigantic images. We spread

our lunch on the chest of the completed image, which still lay there undetached from its rocky bed beneath. This statue was an excellent proof that the work was suddenly interrupted. All about us we could see through the rain images in every stage of completion—some of them halted on their way to the burial platforms along the coast.

What catastrophe caused this cessation of labor? There is no evidence of volcanic activity in historical times. It is not prob-

GROUP OF STATUES, EASTER ISLAND

There are over 500 of these gigantic statues on Easter Island, some measuring 70 feet in length and all are cut from single blocks of lava—there is evidence that the work of the sculptors was suddenly interrupted for the images are found in every stage of completion as shown in this view reproduced by courtesy of the Library of Congress.

able that the island was attacked by hostile neighbors—the nearest inhabitable land being over a thousand miles to the westward. Were the people wiped out by an epidemic of disease? Or did they devour each other during a famine? This is another of the Island's many mysteries.

But heated arguments on this subject did not warm us up enough. It was cold and we had to move along to keep from shivering in our wet clothes. So we proceeded to climb up the hill to see the

crater-lake above us. A short muddy scramble up the Rano Roraku and one stands at the edge of a lake spotted with island-like masses of dank rushes. Cattle were browsing here and there on the margins, although the grass seemed very sparse. Hoping to bring home some new species of plankton from this isolated crater-lake, we had brought some small silk-nets. After several attempts to throw the net into the open water beyond the rushes, Paul waded in over this barrier and cast it, standing in water

Quarry for Statues, Easter Island

The statues were quarried from this hill and transported to the platform along the coast—how images weighing ten to sixty tons could be moved over the rough ground without breakage is another mystery, the more so as there has never been a forest to supply levers or wheels.

up to his waist. Lining this crater on the inside are more statues, but somewhat smaller.

On our way back to the plains Seiwell and Paul circled the rim in hopes of shooting two hawks which were soaring over the quarries. We did not then know that these two were the only land birds left on the Island. Many attempts have been made to introduce game, but have invariably failed. The native guides encouraged us to kill these hawks, since they had lost many a chicken by their depredations.

The hunt was really sportsmanlike. We were armed with a tiny ".22" gun, and they with powerful claws. They would spiral upward high over our heads, poise a moment, and then, if we faced away, manoeuver behind us, and swoop straight down at our heads, with blood-curdling cries. The odds were all on their side, and we did not even wait to exhaust our supply of shot.

Before turning back along the southeast coast toward Hangaroa, we rode about a mile to the famous platform of Tongariki. Here we saw the best examples of masonry. A great pavement, made

Crater-lake of Rano Roraku, Easter Island

The image-mountain and lake, the latter where Paul and Seiwell towed silk-nets hoping to obtain interesting fresh-water plankton.

by fitting together gigantic stone-blocks, acts as a pedestal for several of the largest images we had seen. They had fallen, and were now lying face downwards, with their red tufa hats rolled many yards inland. One of these hats was a solid piece of rock twenty-seven feet in circumference, and nine feet high. Under this platform one comes across caves in which are human bones and skulls.

During all this time it had been raining. Of the large amount of film exposed here, only a few negatives were worth printing. This was a pity, for this platform offers the best "shots" of all. Should any of the readers happen to stop off at Easter Island, they might bear this in mind!

It was a great disappointment that we could not return to the ship by way of the north coast. The sea breaks furiously on these great basalt-cliffs, wearing them down into fantastic arches, towers, and pinnacles. The *Mohican* Expedition has written some vivid descriptions of this romantic shore-line. They found in the caves of these cliffs many deposits of human bones—presumably the remains of chieftains which were hidden here to prevent desecration of their bodies by their cannibal enemies.

THE PLATFORM AT TONGARIKI, EASTER ISLAND

Near Image Mountain, constructed of enormous tooled stones fitted together in the manner of the Incas of Peru—at the left can be seen a red tufa hat weighing several tons which has toppled off the head of one of the images when they were overturned.

It is painful to write of the ride home. In the case of some of us it might be described as a walk! Rain, cold, thirst, rough country, wet saddles, broken stirrups and bridles, mud, barbed-wire fences, unwilling horses—all make it a nightmare in memory. Certainly more than one of us would have preferred to stand up for the evening meal on board!

The next three days were busy ones indeed. The tent for the magnetic and atmospheric-electric station was pitched ashore, and the intercomparisons of atmospheric electricity and the magnetic elements were carried out day and night. The tent

was surrounded by a circle of native boys and girls who sang their folk-songs. Captain Ault identified some of these songs as being Tahitian and even Samoan.

But the flies and mosquitoes did not keep a respectful distance, as the singers did. The old navigator Schouten named Rairoa "Vliegen Island," for the hordes of flies he encountered. He should have called here first! However, the worst pest of all was a little beetle that had the nasty habit of crawling into one's ears. Frank Moline, one of our seamen, suffered the tortures of the damned from this cause.

During the afternoon Paul had clinics ashore, for the villages have no physician among them. It was naturally impossible for him to hand out any but the simplest remedies to these ignorant people. There was no evidence that the people used native drugs at the time of our visit. Several cases of serious disease like leprosy, tuberculosis, and syphilis were found, but no treatment for these could be considered in the few days of our visit. Almost the whole town had the "seven-year itch;" so great bowls of sulphur ointment were distributed with directions for proper use—directions which were certainly not followed, since it involved the treatment of the whole village simultaneously, and a complete change to fresh linen. The infants suffer terribly from eye-infections carried from one to another by the hordes of flies. The few lepers among the people have had a fine house built for them some half-mile from Hangarao. They live there during the week; but on Sundays entertain all their relatives from town in their quarters.

On his rounds through the village, Paul would single out two or three natives as subjects for basal metabolism measurements. They were brought aboard for supper, and would be put to bed in the chart-room—a necessary preliminary to the experiments made next morning. Basal metabolism is a measure of the rate at which oxygen is consumed by the body when lying at rest. Recent researches have hinted that one race may use oxygen at a faster rate than another—live at a higher speed, physiologically. Accordingly, the doctor had been supplied with a portable apparatus for use on this cruise when opportunity offered. The in-

strument was loaned by Dr. Benedict of the Nutrition Laboratory of the Carnegie Institution. Unfortunately, conditions here were very unfavorable for these studies, since we could not work on shore. The vessel rolled so miserably in the open roadstead that the patients were never at complete rest during the readings.

One afternoon the Chilean exiles gave a tea in their tiny bamboo-grove in the church-yard. They have put up a partition across the nave of the village church, and live on one side. A very jerky conversation was carried on in French, German, and Spanish—all mixed at once into a single sentence at times.

We picked up from these men and from Mr. Edmunds some good yarns about white visitors to Easter Island. It seems an aged priest was once sent out here from Chile to spend his last days ministering to the natives. He was presented with a luxurious gold-plated casket and a very large stock of wine on his departure from the coast. Everything went well for several months after his arrival: the casket was installed in the church as an ornament, and the wine stowed in a cellar below. Since the villagers have no taste for intoxicating beverages the old priest thought his wine safe. However, he soon had reason to suspect thievery. The barrels were installed in the altar upstairs, in hope that the culprit would not dare to commit a sacrilege. Still it leaked, and on investigation it was found that the village "policeman" had developed the taste. The real tragedy in his story came some time later when the wine was exhausted and the old priest had not yet died. There was nothing to do but wait for the annual boat and depart with his golden casket. He refused to part with this although a very good offer had been made to him. He could not sell it since it was a gift from his bishop at home. In his stay on the Island he had been able to persuade at least one couple to be married. The woman involved had been told by her Tahitian father that it was a necessary rite.

Some years ago the government of Chile had the sense of humor to send out a "registrar of births, marriages, and deaths." Needless to say the man left in the next boat, for fear his arduous duties should undermine his health!

There have been several shipwrecks on Easter Island; and it

is from these that the natives get their building materials. A few years ago they had used up the last of the timber from a wreck, and were in need of more, when a schooner carrying Oregon pine was destroyed in a storm. Unfortunately for the inhabitants, the only thing they saw from this disaster was the crew of the vessel. These men had navigated a whale-boat hundreds of miles to the Island. Mr. Edmunds describes what mental distress it was to realize that the valuable cargo of lumber was floating around somewhere in the Pacific, when they needed it so badly themselves.

The description given by Mr. Edmunds of the agony these men suffered in reaching Hangaroa village was extremely vivid. It made the literary attempts to portray such an experience look pale by comparison. The fellows had to remain here almost a year before a ship from Chile called, to take them off. One of the crew found the boredom too great and shot himself.

There are some exciting yarns about the war-period. On one occasion the German Asiatic fleet used Easter Island as a rendezvous and carried off beef and mutton. Another time, the S. M. S. *Prinz Eitel Friedrich* came into Cook's Bay with a French bark in tow, which carried a cargo of coal. After the coal was transferred into her own bunkers, she sank the captured vessel in the roadstead. The local populace at first did not know that a war had been declared, and were rather mystified by these events. But through the boasting of some of the junior officers, the information leaked out. The Routledge Expedition was here at the time, and anxious about the safety of their British ship, the *Mana*. On their return they informed the Chilean and British authorities that the neutrality of Easter Island had been violated. But by that time Von Spee's squadron was operating off the Falkland Islands.

A few days later, the staff together with the two exiles made an excursion to Rano Kao. This old volcano rises immediately to the south of the village to about thirteen hundred feet, and contains a fine crater-lake. Its surface, half a mile in diameter, is covered with a dense mat of vegetation—so thick that the cattle walk with safety on its surface, and small trees grow on

it. The descriptions in Prescott's "Mexico" of the floating islands in the ancient capital came at once to mind. These Aztec gardens could be moved at will like rafts, whereas in Rano Kao the lake is literally choked. This great garden rises and falls with the level of the lake, which is about half way from the rim to sea-level. Toward the sea the rim has been greatly worn away,

Ancient Rock-carvings

On the rim of Rano Kao Crater—the present inhabitants can give no account of the race which made these decorations.

and in some distant period, Easter Island will boast a crater-harbor like Pago Pago.

The party divided on the skyline near some carved rocks. Soule, Seiwell, and Paul decided to approach the prehistoric cave-dwellings on the seaward rim of the crater, by descending to the lake-level and up the rocky slope inside. The others went on around the top. Passing showers made the mud and boulders slippery, and the going was tedious. At the lake-level we found here and there a cluster of banana or fig-trees, and from the shore

of the lake practically no water was visible because of the vegetation floating upon it. With great hesitation we crept out upon these curious gardens, floating no one knows how far from the bottom. One might be more bold with a pair of snowshoes. Every Saturday the women of the village make an excursion to this lake to do the family wash.

It was not till we started the mad scramble up the other steep slope of lava-boulders that we began to realize what a task we

An Entrance to the Burrows on the Rim of Rano Kao Crater

These caves are extensive enough to accommodate thousands of people but no one knows why they were built.

had undertaken. Every few minutes a loud clattering of rocks echoing across the crater told us that someone had too hastily trusted his footing. In time the rim was reached and we found the rest of the party exploring the seemingly endless underground burrows made by some ancient race. Soule and Parkinson were photographing the carvings on the rocks near the numerous low entrances. Having crawled inside one of these curious doorways one could proceed through a maze of tunnels by stooping slightly. In places the roof was caved in so that one had to retreat to try a second shaft in a different direction. The painted stone-slabs

which decorated these caves have all been removed by previous expeditions, although we saw a few fragments here and there.

Someone has estimated that thousands of human beings might be accommodated in these tunnels, but it is not clear what purpose they served. Some advance the notion that they were used in times of tribal war; some say that the young girls were secreted here until they were marriageable; but a more reasonable ex-

"Bird Rocks" Lying below the Caves on Rano Kao Crater

Legend says that the man who swam to these rocks and brought back the first eggs of the sooty tern was made king for the ensuing year.

planation seems to be that they were temporary living-quarters for the population during certain religious festivals and while waiting for the return of the sooty tern to the "Bird Rocks," which lie off the base of the cliffs some thousand feet below.

To prevent the extermination of the sea-birds and spawning fish, one of the more recent kings made it a capital offense to eat birds' eggs or fish for the two months preceding the return of the sooty tern from the north (usually in September). He reinforced this taboo by appealing to the vanity of the natives in the follow-

ing way. He who first swam out to the rocks, climbed the precipitous cliffs, and brought the egg of this tern to land was appointed "king" or chief bird-man for the year. Accordingly the whole population took up their abode in their caves on this overhanging cliff for a period of several weeks in July and August, while they awaited the arrival of the first terns. During this time, festivals of dancing and feasts were arranged. This restraint allowed time for the native birds to hatch their young, and for the spawning of fish.

On the way down the slope toward Hangaroa, someone sighted a steamer on the horizon. This caused the greatest excitement among the natives. At once they concluded that it must be the Chilean vessel, now long overdue, which was to call here for sheep and wool. Seeing this ship was one of the most remarkable coincidences we had observed, for Easter Island lies far away from any possible commercial route. It might have been a tramp-steamer making a trip to Australasia from the West Coast of South America.

We had found on our arrival that many sheep had been driven into corrals near the landing to await the vessel promised for November. Mr. Edmunds was getting apprehensive when it was a month overdue, so through our short-wave radio equipment on board, and amateur stations in the United States, we were able to forward an inquiry to Williamson, Balfour and Company offices in Valparaiso for him. Easter Island has no cable or radio equipment, of course.

This brings to mind certain headlines that appeared in San Francisco newspapers on our arrival in July: "*Carnegie* scientists prove Easter Island has not disappeared," or words to that effect. All of us but Captain Ault were bewildered by the statement, until he explained that some enterprising newspaper reporter broadcast a radio to Easter Island after the great earthquake in Chile some years ago, and, not receiving a reply, published the report that the island had gone down. We were to encounter even more bizarre reporting during the cruise.

The evening of December 12, a time set aside for a grand village-dance and feast in our honor, found us far out to sea. Late in the morning it was found that the ship was drifting from

her anchorage and was headed toward the rocks to the south of Hangaroa—our bronze anchor was gone in sixteen fathoms. Fortunately for us the engine responded promptly in the emergency, and, with the help of a light breeze, we were clear of danger. It was a very close call. We were not to leave this inhospitable anchorage without paying our forfeit. So fouled with coral heads is the ground of the bay that almost every ship loses an anchor.

This incident shows some of the difficulties of operating a sailing-vessel with non-magnetic features like manila hawsers instead of iron chains. The hemp had been worn through by the constant chafing on the sharp coral. When the second anchor failed to hold, there was nothing to do but put to sea at once, thus cutting short what was promising to be the most interesting call of the voyage. Only by the exercise of constant vigilance was the Island deprived of one more shipwreck.

While the *Carnegie* stood off and on under fore-and-aft sails and engine-power, the doctor was sent in the dinghy with a radio message for Mr. Edmunds, assuring him that a steam-vessel, the *Anartico*, was due to leave Valparaiso about December 20th. The reply had been delayed several days by the wretched radio conditions in the neighborhood. Scott went ashore to arrange for the immediate slaughtering of some animals for our larders. And Soule went to mail some letters. Believe it or not!

There were a few postage-stamp enthusiasts on board. Letters are so rarely mailed here that the members of the staff usually send home some mail in the hopes that the envelopes will carry the surcharge "Rapa Nui." None of the letters mailed on Cruise IV reached the United States, so there was less enthusiasm this time. However, Soule delivered some mail to Mr. Edmunds for forwarding by the next boat. He succeeded in getting it through to the States, but found no special stamp or surcharge. The envelope had been inscribed by the hand of a postmaster "Isla de Pascua," and carried the usual Chilean stamp.

By mid-afternoon the dinghy was piled high with beef, mutton, chickens, and bananas; and we waved good-bye. We will never forget the kindness of Mr. Edmunds, and of the new friends we made on this lonely island.

During our few hours of liberty ashore we could not hope to add anything of importance to the knowledge of Easter Island. Anyone who is interested in learning more about this fascinating place may look up the books referred to at the end of the chapter. It was well that we had completed our scientific shore-work during the first few days of our visit, and had brought all the equipment aboard. The sudden departure only deprived us personally of a chance to relax for a few more days in prowling around the coasts.

We were able to learn a great deal about these people in our short stay. There were always from ten to twenty of them on board during the day, and the whole village stood by as we did our scientific work ashore. The population is now about three hundred. Mr. Salmon, who lived during the latter part of the last century, estimates that there were about 20,000 people on the island in 1850. Slave-raids, small-pox, cannibalism, and emigration to the islands of the South Pacific can easily account for the decrease. For example, at one period about 5,000 natives were carried off to work the guano-deposits on the Chinchas Islands off the coast of Peru. Of them only two returned—and these brought back the small-pox! The last of cannibalism seems to have been in 1864, at which time there were 1,500 people and a Jesuit mission established on the island. At present the population is slowly increasing, and emigration has ceased.

As we have said before, there is a great mixture of races here, but the average villagers may be described in the following words. They are medium in stature—a great contrast to the ancient inhabitants as described in Rogewein's narrative at the end of this chapter. They are a lithe, wiry folk with brown eyes; black, straight hair; prominent cheek-bones; straight noses; and thin lips. There is no resemblance to the negro. Their skin is a light brown and their bodies are kept clean. They have a gentle, emotional, light-hearted disposition, and display no interest in the history of their past. These amiable islanders see no reason to work unless they are hungry at the moment. Mr. Edmunds engages most of the men as sheep-shearers for a few days each year, and employs some ten boys as shepherds. The others

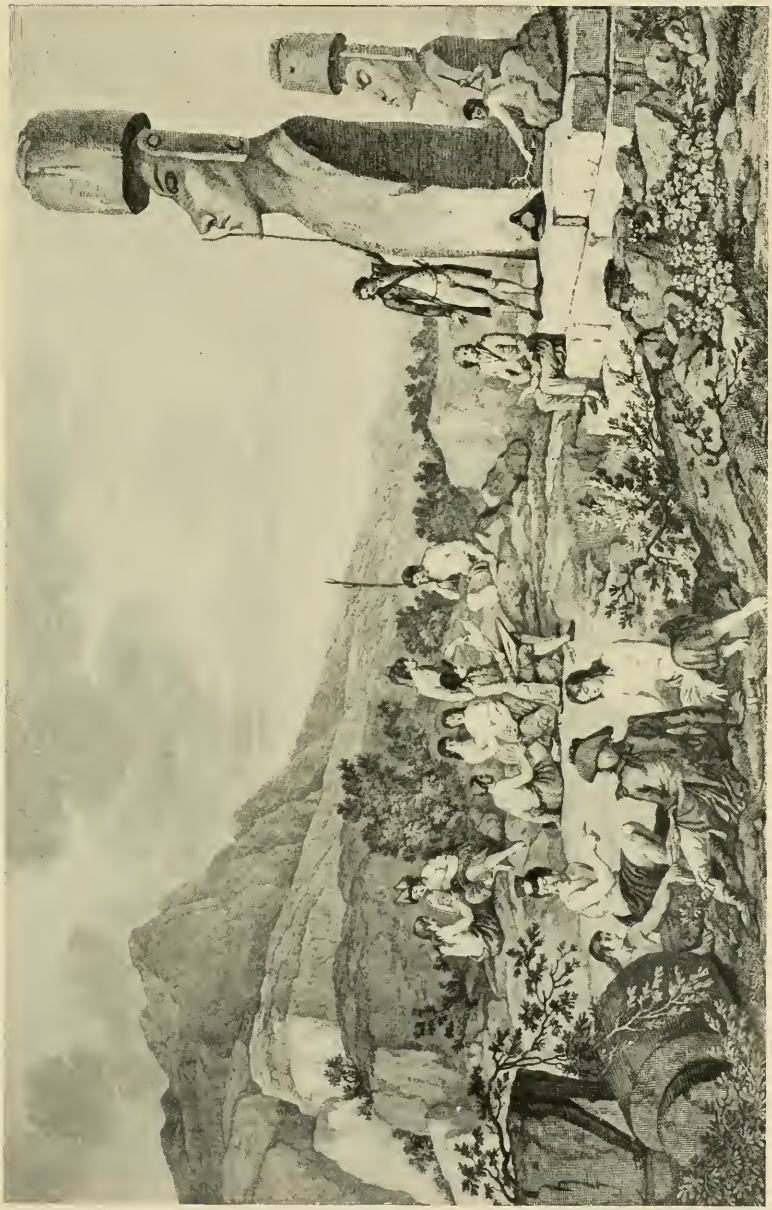


PLATE SHOWING NATIVES AND MONUMENTS, EASTER ISLAND, FROM THE "VOYAGES OF LA PÉROUSE"

Shows the images with their red tufa hats in place—note the evidences of petty thievery in the picture and the interest in the mirror which the natives are seeing for the first time. (Courtesy of the Library of Congress.)

putter around in the garden for a few minutes occasionally, and spend their days galloping through the village on their ponies and and in talking. How they love to talk! They show no desire to accumulate possessions and live in a little communistic society where everyone is considered a member of the same big family.

Once in a while they go out fishing. Our hope for witnessing a night crayfish-hunt with torches was not fulfilled, since we left so unexpectedly. Surgeon Cooke of the *Mohican* party gives a vivid account of this "strange, weird, savage and interesting sight."

There is no native or imported intoxicating drink on the island —not even the "kava" of the South Seas. Their morals seem adequate to their little society. Marriage in the exclusive, permanent sense is not the rule; but polygamy is not found, since mates may be changed without much ado.

Petty stealing seems to be the commonest crime. Perhaps this is because there is a no strict respect for personal ownerships. From the earliest voyages of Rogewein, Cook, and La Pérouse, the natives have been addicted to thievery. The picture of the ancient images made by La Pérouse's artist and reproduced here shows examples of this propensity. One boy is reaching for a hat with a stick, another is stealing a scarf, and a girl is removing a book from the artists' pocket.

Stealing is now punished by one day's hard labor in the garden. This is a frightful penalty for an Easter Islander. A former governor constructed a tight sentry-box and placed the culprit inside for a day. It was so small that the victim could not shoo away the flies—a genuine torture-chamber.

The natives wear old-fashioned European dress, and have lost the art of making bark-cloth from the paper mulberry tree which grows in the crater of Rano Kao. Even their hats are acquired from the ships that call here once or twice a year, and weaving of rushes has been forgotten. There is no pottery, gourds being used as water-vessels where the family has not acquired tin-ware from trading.

The language used is the old Rapa Nui speech modified by the use of some Spanish, English, and German nouns. It is a dialect

of the Polynesian used throughout the South Seas. Their music seems to be similar to that in Tahiti or Samoa. We saw no native instruments. Their singing is simple three part harmony—bass, alto, and soprano.

There is little use for money on the Island. Goods are exchanged by barter. The ancient medium of trade is reported to have been rats! If that were true today it would be a good place to make a fortune, for these rodents thrive. On leaving the United States we were asked to collect as many of these animals as possible for museum use, in the hopes that a few specimens of the old native rat might still be found. The only ones we saw were the common rats carried aboard ships. Nevertheless, a cake of soap was offered for each rat captured. The news spread through the village like wildfire, and in a few hours a fine collection of *cats* was brought to the landing. The villagers could not comprehend why we wanted *rats* and assumed that we had used the wrong word. Two of these little kittens were taken aboard, and our early departure left no time for rat-hunting.

These two Easter Island kittens were the treasures of the ship. They were named Lena and Cleo. Tom, from Washington, had become quite grown up since leaving home, and we hoped that he might be the proud father of some Easter Island offspring. Cleo fell overboard some months later; but little Lena eventually had a litter of some eight or nine kittens.

In comparing the conditions of life here at the time of our visit and during the previous visit of the *Carnegie*, Captain Ault has this to say:

> "In general there was a decided improvement in the dress of the people and in their manner of living. Many are growing yams, sweet potatoes, corn, and raising sheep and cattle. They have learned that a little labor will add much to their comfort and to their supply of food.
>
> "The Island is much improved in appearance. Fences have been built dividing the entire pasturage into several paddocks for grazing and breeding purposes, and the ranching is being done with modern methods, with trained shepherds. Eucalyptus trees are being planted each year and are doing well."

The following narrative of Rogewein's discovery of Easter Island, though not exactly in place here, is altogether too delightful to miss. It is copied from Henry's "Voyage Round the World," published in London in 1774. The book is so inaccessible that a few extracts are given for the benefit of those who are interested.

> "Upon the 6th day of April, being in latitude 27°S. and longitude 268°E., we discovered an island, hitherto unknown to any European; for which reason, according to the usual custom on the first discovery of any unknown land, we christened it by the name of EASTER ISLAND, it being the anniversary of our Savior's Resurrection on that very day that we arrived there. As soon as the anchors were ready to drop, we observed at a distance a neat boat, of a very remarkable construction, the whole patched together out of pieces of wood, which could hardly make up the largeness of half a foot. This boat was managed by a single man, a giant twelve feet high, who exerted all his strength to escape us, but in vain, because he was surrounded and taken.
>
> "His body was painted with a dark-brown colour. We tried with such signs and words as are used here and there among the islands of the South Seas, to get some intelligence from him, but could not perceive that he understood anything, wherefore we permitted him to go into his boat again and depart. Two days afterwards the whole sea was covered with the savage inhabitants of this island, who came swimming round the ship in such multitudes, that we neither could, nor did we think it advisable to land. They clambered like cats up the ship's side with the utmost assurance, and came aboard, where they did not appear to be in the least afraid of us, but they seemed very much surprised at the largeness and extent of our ships and rigging, and could not conceive the meaning of all that they saw; but their curiosity was chiefly engaged by the great guns, which they could not enough admire, and which they frequently struck their hands upon, to try if they could not lift them up, and carry them off; but when they saw that such logs by such an attempt were too heavy for them, and could not be moved, these overgrown fellows stood abashed, and were, in appearance, very much out of humor.
>
> "They no sooner came aboard, than we immediately

found that they were naturally as thievish and nimble-fingered as the inhabitants of those islands to which voyagers have affixed the name of the Islands of Thieves [Marianas or Ladrone Islands], from the great propensity of the people to rob and steal, if they were not beaten from it. Rusty nails, old iron, and whatever they could catch hold on, was equal to them, with which they jumped overboard immediately. They attempted with their nails to scratch the bolts out of the ship, but these nails were too fast for them.

"These huge fellows came at last aboard in such numbers, that we were hardly capable to keep them in order, or keep a watchful eye upon their motions, and the quickness of their hands; so that fearing they could become too many for us, we used our best endeavours to get rid of them in a friendly way; but they not seeming inclinable to leave us, we were obliged to use harsher methods, and drive these savages out of the ship by force.

"On the 10th of April we made for the Island in our boats, well armed, in order to land, and take a view of this country, where an innumerable company of savages stood on the sea-side to guard the shore, and obstruct our landing; they threatened us mightily by their gestures, and showed an inclination to await us, and turn us out of their country; but as soon as we, through necessity, gave them a discharge of our muskets, and here and there brought one of them to the ground, they lost their courage. They made the most surprising motions and gestures in the world, and viewed their fallen companions with the utmost astonishment, wondering at the wounds which the bullets had made in their bodies; whereupon they hastily fled with a dreadful howling, dragging the dead bodies along with them; so the shore was cleared and we landed in safety.

"These people do not go naked, as many other savages do; every person is clothed in different colours of cotton and worsted, curiously woven, or stitched, but nothing misbecomes them more than their ears, which are abominably long, and in most of them hang upon the shoulders; so that, though they themselves look upon this as the greatest ornament, they appeared very uncouth to us, who were not accustomed to such; the more so, as there were in them such extravagantly large holes and openings, that we could easily put our hands through them.

"Thus far my narrative will gain credit, because it contains nothing uncommon, yet I must declare, that all these savages are of a more than gigantic size, for the men are twice as tall and thick as the largest of our people; they measured, one with another, the height of twelve feet, so that we could easily (who will not wonder at it!) without stooping, have passed betwixt the legs of these sons of Goliah. According to their height, so is their thickness, and are all, one with another, very well proportioned, so that each could have passed for a Hercules; but none of their wives came up to the height of the men, being commonly not above ten or eleven feet. The men had their bodies painted brown, and the women with a scarlet colour.

"I doubt not but most people who read this voyage will give no credit to what I now relate, and that this account of the height of these giants will probably pass with them for a mere fable or fiction; but this I declare, I have put down nothing but the real truth, and with this people, upon the nicest inspection, were in fact of such a surpassing height as I have here described.

"After the inhabitants of Easter Island had made trial of the strength of our weapons, as we have before related, they began to use us in a more civil manner, and brought us from their huts all kinds of vegetables, sugar canes, with yams, plantains, and a great quantity of fowls, which came very a-propos, and tended to refresh us greatly.

"What I have seen of the worship and idols of these savages is very wonderful. Two stones, of a largeness almost beyond belief, served them for gods; the one was broad beyond measure, and lay upon the ground; upon this stood the other stone, which was of such extent and height that seven of our people with outstretched arms would hardly have been able to encircle it; so that it appeared to me, and all others, impossible that this stone could have been lifted up and placed upon the other by the inhabitants of these islands, how large and strong soever they might be; for, besides the thickness, it was fully as high as three men. About the top of this stone there was cut or carved the shape of a man's head, adorned with a garland, which was set together in the manner of inlaid work, made of small stones, in a manner not very improper. The name of the largest idol was

called Taurico, and the other Dago; at least these were the words they called to them by, and wherewith they worship them.

"These savages had great respect for the two idols, Taurico and Dago, and approached them with great reverence, namely, with dancing, shouting, jumping, and clapping of heads, in the same manner as we read in holy writ, that the children of Israel worshipped the golden-calf which Aaron set up; and when the cannon (of which they seemed to be in great terror) were discharged, and the heavy shot sounded in their ears, they made surprising and wonderful gestures and leaps, and pointed with their finger, first to our people and then to their gods, whom they appeared to supplicate for help against us, and to call upon with a frightful shout, and howling of Dago! Dago!

"While we lay before this Easter Island, a heavy tempest surprized us, which pressed so much on the ships, that I had no thought but that they would drive from their anchors, and we with them to a miserable end on this coast, which God prevented, the storm being at last appeased, without having done any damage to the ships."

Anyone who wishes to learn more about this unique island would do well to read "The Mystery of Easter Island" by Mrs. Routledge, or "The Riddle of the Pacific" by J. MacMillan Brown. An extensive bibliography on Easter Island may be found in a publication of the Foreign Office, Great Britain, Historical Section, Numbers 141 and 142, entitled "Malpelo, Cocos, and Easter Islands," London, H. M. Stationery Office, 1920. (Obtainable in the United States through the British Library of Information, French Building, New York, N. Y.)

After clearing the dangerous waters of Easter Island by the aid of our engine and a slight breeze, we struck out for the long loop to Callao. For two weeks we waged a constant battle with head-winds. It was necessary for us to go about 800 miles southward before we struck the westerlies which were to carry us eastward toward the coast of South America. This detour took us 300 miles out of our course. We were only three days out when a short gale pounced upon us and pushed us back to the west. The sea was very choppy for a time, and our balloon theod-

olite had a close call. Although it is mounted solidly on a tripod, one roll knocked it off its balance and it pitched over the rail. The observer managed to grab one of the tripod-legs just in time to save the instrument. After this experience we never failed to tie the apparatus down to the desk with some rope-yarn.

At our first oceanographic station out of Easter Island, we gave the glass-tube bottom sampler its first trials. This outfit was loaned to us by the German Atlantic Expedition of the *Meteor*. It is a superior instrument because it collects a vertical *section* of the bottom deposit down to a depth of some two or three feet. The snapper-type we had been using merely samples the upper few inches of the bottom and gives very little information as to the successive layers in which the sediment was deposited. Unfortunately, the German apparatus was very heavy and offered a large surface-resistance to the water. Our power was so limited that it was not possible to use it as a routine procedure.

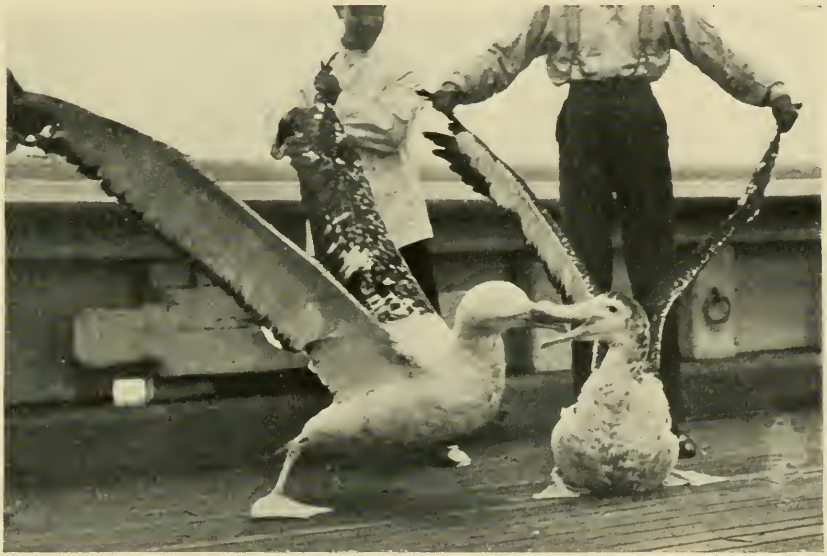
Radio conditions continued to be very bad and schedules were uncertain. We occasionally intercepted messages to the Byrd Expedition and communicated with them, but we seemed to have difficulty in pushing our signals through to the United States. On Christmas Eve conditions improved and Jones was able to handle some twenty-eight messages that had piled up during the past days. As these were mostly personal Christmas greetings, they were particularly appreciated. As Captain Ault remarked: "The modern Santa Claus apparently saw the frolicsome reflecting layers and radio waves as he passed along on Christmas Eve and set things right for our benefit."

During these days we met unusual meteorogloical conditions. We had drenching dews at night, and on December 22 we encounted a real fog—an extraordinary experience in this area.

As we proceeded southward the plankton-tows became heavier and heavier; and surface-life increased as well. Great fleets of Portuguese men-of-war sailed by us from time to time. With this change we also came into regions of heavy surface-currents which were a great handicap in the oceanographic work. At one station we had to lower the Nansen bottle-series four times to a depth of 3,000 meters before the messengers finally released the bottles.

The wire-angle was so far from the vertical that the bottles would not upset when the weight struck them after sliding down the wire. At these angles, any small marine organism which caught in the wire would arrest the messenger on its way downward.

By Christmas our supply of fresh food was getting very low, and we decided to have one grand feast out of what was left rather than to spread it out over another week. Accordingly, all of the chickens we had brought aboard were killed for Christmas dinner.



THE ALBATROSS OF THE SOUTH PACIFIC
Easily caught with a fishing-line and bait.

The last of the fresh beef had been consumed for lunch that day. The members of the scientific staff dressed up in their best Sunday clothes and had a merry time celebrating our first real holiday at sea. Captain Ault had given orders that no scientific work was to be done. Ordinarily, Sundays and holidays found us making the usual oceanograpnic or magnetic station, as the case might be. We played "500" till late that evening and finished up by taking a ghastly flash-light picture of the staff.

A few days later we saw our first wandering albatross. It

circled about the ship for several hours as we lay becalmed in the neighborhood of what is marked on the charts as "Podesta Island —Existence Doubtful." On December 26 we had been able to head up for Peru, having reached 40° south at noon. We had been driven 10° out of our intended course and we were not far from the iceberg-region. Enormous quantities of salps were seen in the water, and many specimens were dipped up at night with the depth-light hanging from the quarter-deck.

A Small "Bottle-nose" Whale of the South Pacific
Coming up for air near the *Carnegie*.

Captain Ault determined to search for the mysterious Podesta Island before we left this area. We passed within two miles of its charted position, but we did not see any signs of land. The visibility was excellent, and the soundings gave no hint of shoaling in the neighborhood. It is very difficult to get a "doubtful island" off a chart, once it has been entered there. We could only send our report to the Hydrographic office to be added to the numerous others that have come in from unsuccessful searching parties.

Our New Year's dinner was less of a gastronomic treat than the one on Christmas, for the bay-leaves and "kitchen bouquet" could not disguise the fact that the chicken came from a tin can. Nevertheless, we made up for this by making a deafening racket to welcome in the new year. The noisiest record was played on

LARGE DEEP-SEA ORGANISM

Resembling a pink stocking captured with a silk net at a depth of 1,000 meters—these jelly-like animals often arrested the "messengers" sent down the wires to reverse the Nansen sampling-bottles.

the Victrola, pots and pans were requisitioned from the galley, the fog-horn was brought out, and before we were through, Seiwell went on deck to discharge the bird-gun. Those of us who stayed below did not even hear him, such a din was being raised in the close quarters of the cabin!

The first week of 1929 was featured by calms and light airs.

For five days we logged only 44 miles a day. The gasoline supply was getting so low that it was not possible to use the auxiliary engine. Two weeks of head-winds leaving Panama, and two months' operation of the electric generators had left us little for pushing our way through calms. Of course, it was not possible to buy gasoline in Easter Island! On these long voyages we found that the power-requirements for oceanographic work, radio, and lighting used almost as much fuel as the main engine.

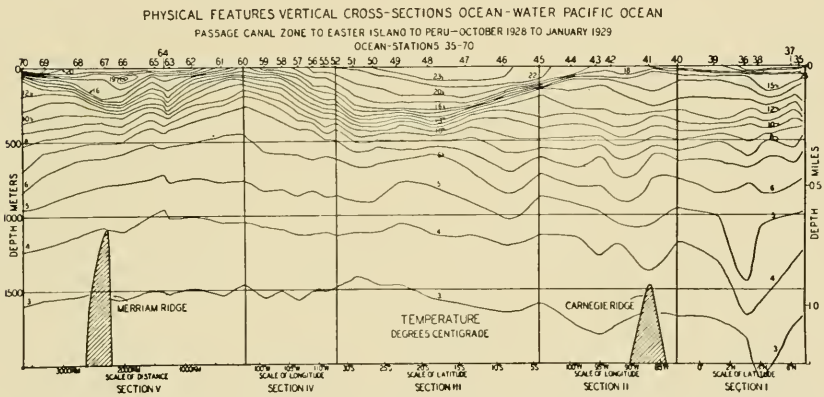
At our ocean-station on January 3 we varied our plankton-work by lowering a large silk-net to 1000 meters. The surface-water was so rich with life that the net was almost burst with the haul. There were salps, medusae, and ctenophores, but the most interesting part of the catch was an enormous stocking-like colony which we have not yet identified. It was a beautiful object when we separated it from the rest of the catch. It filled a small bucket by itself and looked as though it were made of pink-colored tapioca pressed out into a long hollow tube.

On the next day we experienced the most remarkable coincidence of the cruise. At sunset someone reported smoke on the horizon. In our nine weeks in the Pacific we had seen only one ship, so that it was an event to see even smoke on the horizon. There was a premonition in everyone's mind that this ship was the *Antartico*, bound for Easter Island. However, that would be absurd. We were three hundred miles out of our course. She was to have left Valparaiso on December 20. And in any case, her course would not bring her into this region. Nevertheless, at dusk, our suspicions were verified and the *Antartico* came alongside for a friendly visit.

The Captain had never before been to Easter Island and was surprised beyond belief to hear that we had just cleared from that place. He had not been informed that it was we who had sent the radio to the company's office in Valparaiso. A torrent of anxious questions was shouted across the water to Captain Ault. Was there a good anchorage? Could he get water? Was there a supply of coal? The answers were not reassuring. We told him that we had had to leave precipitatedly because we had lost our anchor and that he would find no supplies there.

On leaving Cook's Bay we had sent Mr. Edmunds a note requesting him to fish up our bronze anchor, if possible, and to forward it by the *Antartico* to Valparaiso. A sketch was made showing the bearings of the ship when we lowered the anchor, hoping that this might enable his men to locate it. The anchor-buoy had disappeared below the surface for some unaccountable reason, so that the usual mark for lost ground-tackle could not be used.

A few months later we had a radio from headquarters in Washington saying that our anchor was in Valparaiso and that it was being shipped to Japan for us. Mr. Edmunds had written a



Typical Vertical Section Showing Temperatures at Various Depths for Voyage from Panama to Easter Island to Peru

letter telling us how it had been recovered. The water was too deep for the natives to dive for it, so they hauled up on the buoy-rope, hoping that it would hold the heavy weight—and it did.

Fishing for lost ground-tackle was by no means a new task for Easter Islanders. The usual method is to lower a man to the bottom on a small kedge-anchor, have him attach a heavy rope, and bring him with the anchor to the surface. A few years ago one of these natives divers was badly mangled when he was fouled in the lines.

Radio contacts continued to be very erratic. "Skip-distance" effects played havoc with the schedules. For the two weeks

preceding our arrival in Peru we were unable to communicate with headquarters.

On January 8 we made one of the salient discoveries of the cruise. A sounding of 13,000 feet had been made during the night, but the usual eight o'clock sounding was omitted because the "shot-gun" was out of order. When the depth was determined at ten o'clock it was found to be only 4,700 feet! By noon it had shoaled to 3,900 feet and Captain Ault gave orders to heave to for a wire-sounding. But the wire-length and pressure-thermometers checked the sonic depth very nicely. A sample of globigerina ooze was taken at the same time. We thus confirmed the finding of a great submarine mountain ridge, rising to 10,000 feet above the general level of the surrounding ocean-floor—almost as high as the Andes. Thirty miles beyond, the soundings again gave 13,000 feet.

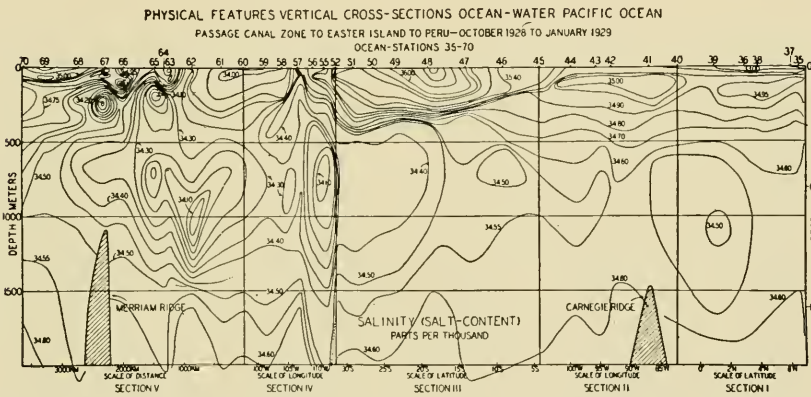
This new ridge was named in honor of Dr. J. C. Merriam, President of the Carnegie Institution. Captain Ault believed that it was a northern extension of the peaks which break through the ocean surface at San Felix and San Ambrosio, 140 miles away. It was a great disappointment to us that our time was too limited to explore this interesting region more thoroughly.

Shortly after meeting the *Antartico* we had picked up the southeast trades. These steady winds drove us along in fine style toward Callao. However, the sky became overcast as we neared the coast, interrupting our declination-observations and the balloon-flights. It was even difficult to get good time-sights for determining our geographical position. Frequently we were able to use the stars for this purpose when the sun had been obscured all day.

If the heavily clouded sky interfered with the magnetic and astronomical observations, it offered ideal conditions for comparing the electrical resistance-thermometers of the multithermograph. The steady wind and absence of direct sunlight on the instruments made the readings reliable. To make these standardizations, Paul would climb up to the cross-trees or have himself hoisted to the main truck in a bo'son's chair. At thirty-second intervals, timed to coincide with the recorder in the control-room,

he would read off the wet- and dry-bulb temperatures from the Assmann psychrometer he held in his hand. It was sometimes a very thrilling experience, especially in rough seas; for he must manage to hold a watch, a recorder's pad, a pencil, a bottle of water, and the psychrometer in one hand while he clung to the mast with the other.

Our last two oceanographic stations before reaching Peru brought bad luck. On January 10 the piano-wire broke, causing the loss of the bottom-snapper, a Nansen bottle, and two thermometers. However, the trouble encountered on January 12 was so unusual that we rather enjoyed it. The bottom-sampler was



Typical Vertical Section Showing Salt-content of Sea-water at Various Depths for Voyage from Panama to Easter Island to Peru

being sent down as usual and 500 feet were paid out when the wire suddenly went slack. This was certainly bewildering for there was a great depth of water below the ship. The windlass brought back the sampler and sure enough, it had closed. What had we struck? Was it a whale? This was the only explanation which seemed plausible. The sounding was then repeated, and a good sample was received from several thousand feet.

Soule had a set-back in his work in the laboratory about this time. One morning he found that the wax which holds the cells in the salinity-bridge had melted and had dropped into the water-bath below. An indescribable mess resulted. It required two days of hard work to clean things up.

We entered the Humboldt Current again about 75 miles from Callao. The temperature of the surface dropped suddenly, for we had entered water which flows from the Antarctic along the coast. The wind died out and left us to work our way to port with the remaining gallons of gasoline.

The sea was literally choked with small fish. A single dip of the hand net would half fill a bucket. And they were good fish. In a few moments the steward and cook had enough for both messes. Enormous flocks of sea-birds were diving all about us. These were all signs that our 81-day voyage from Panama was nearly over.

THE WATERS OFF THE COAST OF PERU ABOUND WITH FISH, BUT THE BIRDS ARE THE FISHERMEN

The guano deposits on the islands of Peru and Chile are one of the chief national resources.

The overcast sky on January 13 had made good time-sights impossible. However, early on the following morning, by standing by for a break in the clouds, the observers obtained a good "shot" on Rigel and Arcturus. Captain Ault then set his course so as to bring us just north of San Lorenzo Island. The fifty-mile stretch was sailed without changing our heading and we found ourselves only one mile from the desired landfall. By three o'clock we were anchored in Callao Bay, ten days behind schedule.

A tense feeling of apprehension on the part of our friends in Peru had been created before we arrived. We were two weeks later than had been expected; furthermore, our short-wave wireless communication had failed about that time. Paul's mother, who had come down from Washington laden with letters and Christmas gifts for the personnel, and Forbush, one of the observers at the Huancayo Observatory, had become so alarmed that they had requested the vessels of the Peruvian Navy to broadcast daily calls for us. It seems difficult in these days of steam to realize that a sailing-ship like the *Carnegie* may be delayed so long, and may all the time be enjoying fine weather.

All hands were glad of the change in routine which port-life was to offer. However, there was to be little relaxation for most of the men, since there were extensive repairs to supervise; new equipment to install; magnetic observations to make ashore; and an endless series of reports to prepare covering the long cruise just completed. Nevertheless, several members of the staff had an opportunity to leave the vessel and to make a trip into the Andes.

The first few days were spent on board the ship, completing computations and in making repairs to the scientific equipment. Shortly after our arrival we had been moved to a wharf, which greatly facilitated the reprovisioning of the vessel. Parkinson at once developed the moving-picture film which had been taken during the last three months. Soule and Paul overhauled the meteorological instruments. And Captain Ault went ashore to make his official calls.

By January 19, the program of work in port had been well laid out, and Captain Ault, together with Soule, found it possible to make a visit to the Huancayo Magnetic Observatory. Paul had applied for a week's leave of absence and had already left, with his mother, for Huancayo.

To reach this city, one takes the Central Railroad of Peru, which is the highest standard-gage railroad in the world. The train follows the Rimac River for several hours, passing through many towns noted for their beautiful orchards and flower gardens. The grades then become so steep that the train must zigzag back and forth on a series of switch-backs. One passes through

SWITCHBACK AT CHICLA, PERU
On the highest standard-gage railroad in the world.

seventy tunnels and crosses innumerable bridges before reaching the divide at an altitude of almost 16,000 feet.

Long before this, the passengers have begun to show signs of mountain sickness. Some are complaining of splitting headaches; others find themselves out of breath when they merely walk across the station-platform; and the train-physician is busy going from car to car with an oxygen tank to relieve those most seriously

THE PRIMITIVE WOODEN PLOW

Still used by the Indians of the Peruvian sierra—note the buildings of the Huancayo Magnetic Observatory in the distance.

affected. The railway company keeps special trains in readiness to send anyone back to Lima who shows signs of heart-failure.

After passing the tunnel through the topmost peak, the train descends gradually to Oroya. In this city are located the great smelters of the Cerro de Pasco Copper Company. The poisonous fumes from these plants kill all the vegetation for miles around. On the way up the mountain many trains of flat cars are passed which carry the unrefined metal to the coast.

There is still a long journey down the Mantaro River before

one reaches Huancayo. Only rarely does one see a patch of snow on the mountains. The most striking sight is the superb example of the effect of compression on the rocks of these barren peaks. Even at this elevation, travelers have picked up fossil remains of marine shells, which indicate that at one time these mountains were lying below sea-level.

At nightfall, the party was met by the staff of the Huancayo Magnetic Observatory, which is located some nine miles from the

A Herd of Llamas

Passing the Huancayo Magnetic Observatory, loaded with grain which is being carried from some distant hacienda to the coast.

city. For several days Captain Ault and Soule were busy inspecting the equipment and conferring with the observers.

Huancayo is one of the largest cities in Peru which still retains the flavor of the old native life. Its Sunday market is noted throughout the whole country. "Cholos" from the mountain villages bring their wool and grain; Indians from the Amazon valley bring fruits and vegetables; traders come from the coast with dyes, soap, and other manufactured articles which are in

A Typical Village Church in the Andes of Peru
At San Geronimo, near the Huancayo Magnetic Observatory.

Gulls Near Huancayo
They seem quite at home in a farmyard in these high altitudes.

demand by primitive folk. During the night thousands of people arrive in the city. By dawn the streets are covered with little piles of merchandise and the bartering has commenced.

When their work at the Observatory was completed, Captain Ault and Soule returned to the ship. When they arrived in Callao they told a hair-raising tale of a ride down the sixteen thousand feet on an open hand-car. They plunged through jet-black

FLOWERING CACTUS

Thrives in the high valleys of the Andes—these are growing near the Magnetic Observatory at Huancayo.

tunnels only to shoot out, with abandon, on to dizzy trestles and around breath-taking curves with the sky below. The Peruvian guard, with whom they rode, went in advance of the train to "feel out" the track for any break or loose stones on the right of way. For once, they realized how cold can bite! The whole flying descent was made by gravity, and there was only a small hand-brake to ease them over the most appalling stretches.

Meanwhile, Parkinson and Jones had departed for Huancayo to compare the magnetic instruments at the Observatory with those on board and to recondition the radio equipment. Paul and his mother had already returned to the coast.

While in Callao we were invited to make some meteorological observations with air-planes furnished by the local aviation company. Parkinson, Scott, Torreson, and Jones made flights, with the necessary instruments, over Lima and its vicinity. They also

WINNOWING BARLEY

After the barley has been trodden out by horses on the earthen threshing-floor—near Huancayo Magnetic Observatory.

demonstrated, by using pilot-balloons, what useful information could be obtained about the currents in the upper atmosphere. We were all much impressed by the progress of aviation in Peru. Lima is served by several regular air-lines from north, east, and south; and journeys formerly taking a week may now be made comfortably in a few hours. Paul's trip to Arequipa took only five hours by air, whereas two days were required for the return journey by rail and mail-boat.

BUILDINGS OF THE HUANCAYO MAGNETIC OBSERVATORY

Several members of the *Carnegie's* scientific staff had been stationed here before they joined the expedition.

On January 25 the vessel entered the floating dry-dock at San Lorenzo Island. It was necessary to repair the copper sheathing and to overhaul the oscillator, which had been out of commission for more than two months. While this was being done we narrowly excaped a serious accident. Ordinarily, when assembling the instrument for use, a pressure of forty pounds per square inch of carbon dioxide was run into this apparatus. Accordingly, a gauge was ordered to check accurately this pressure before

THE SUNDAY MARKET AT HUANCAYO

Famous throughout Peru—the people from the country for miles around come to town to trade their grain, vegetables, fruit, hides, pottery, coca, and other products of the sierra and the montaña for shoes, saddles, furniture, and other manufactured goods.

the vessel was refloated. Soule and several workmen were filling the oscillator from a tank of compressed gas; and, when the gauge read "sixteen" the packing was violently blown out. Fortunately, no physical injury was caused to the men. It was then discovered that the gauge furnished was made to read in "atmospheres" and not "pounds" pressure, thus registering in units about fifteen times greater than the one they had ordered.

The journey from Callao to the floating-dock, a distance of

HUANCAYO VALLEY

The adobe walls on the left protect the gardens from pack-trains of llamas or burros.

about five miles, may be classed as one of the most dangerous in our experiences. The region is frequented by very dense fogs, which pour down continuously from the slope of San Lorenzo Island to the harbor. One must navigate the small ferries by compass. The launch was hopelessly lost for an hour during the first trip. Its captain had lost his bearings, and furthermore his compass was mounted directly over the Diesel engine! The second trip was made in shorter time, by Soule's reading the com-

A Native Inn at Huancayo

The sign over the door proclaims that "consolation of the afflicted" is on sale by the glass, bottle, or keg—chanchamayo is a liquor and chicha a native beer; the musical instrument in the painting is the Peruvian harp.

pass, held well away from the machinery, and by Captain Ault himself giving orders to the man at the wheel. So well, in fact, was the stretch navigated that they almost ran down the dry-dock before they sighted it in the fog.

While the vessel was in dry-dock the staff moved to the Hotel Bolivar—a very welcome escape from the cramped quarters of the cabin, and from the diet of the ship. For even the finest quality of goods, and the ingenuity of a ship's cook, fail to make tinned fare appetizing after a few months at sea.

Sundays and evenings in port were spent going to the movies, window-shopping, attending bull-fights, and in making trips to places of historic interest. Of these excursions, one of the most interesting was that taken by Parkinson and Torreson to the ancient Inca ruins at Pachacamac. They were accompanied by Dr. and Mrs. Tovar, whom they had met while they were stationed in Huancayo as observers, before the cruise commenced.

NATIVE DANCERS PAY A VISIT TO THE HUANCAYO MAGNETIC OBSERVATORY
They are dressed for one of the numerous festivals.

No opportunities were missed for seeing characteristic Peruvian life. The native markets, national lotteries, and coca-chewing, were new experiences. It was also new to live in a country where almost every essential commodity of daily life is controlled by a monopoly. Matches, tobacco, and sugar, for example, are all on this list. There is a twenty-five dollar fine for carrying a cigarette-lighter, or any matches except those of Peruvian manufacture. Someone in the United States had the sense of humor to send one of our men a lighter for Christmas! We were usually

GLACIERS IN THE CHUSPIOCHA (FLY-LAKE) VALLEY, PERU

About a day's ride by horse from the Huancayo Magnetic Observatory—the peak in the distance is at the summit of the central cordillera of the Andes and is over 16,500 feet high.

THE EARTHEN OVEN USED BY THE INDIANS IN THE ANDES

The kerosene tin at the left is put to a multitude of uses, just as it is everywhere else in the far corners of the world.

THE INDIAN WOMEN OF THE ANDES SPIN WOOL-YARN AS THEY WALK OR GOSSIP

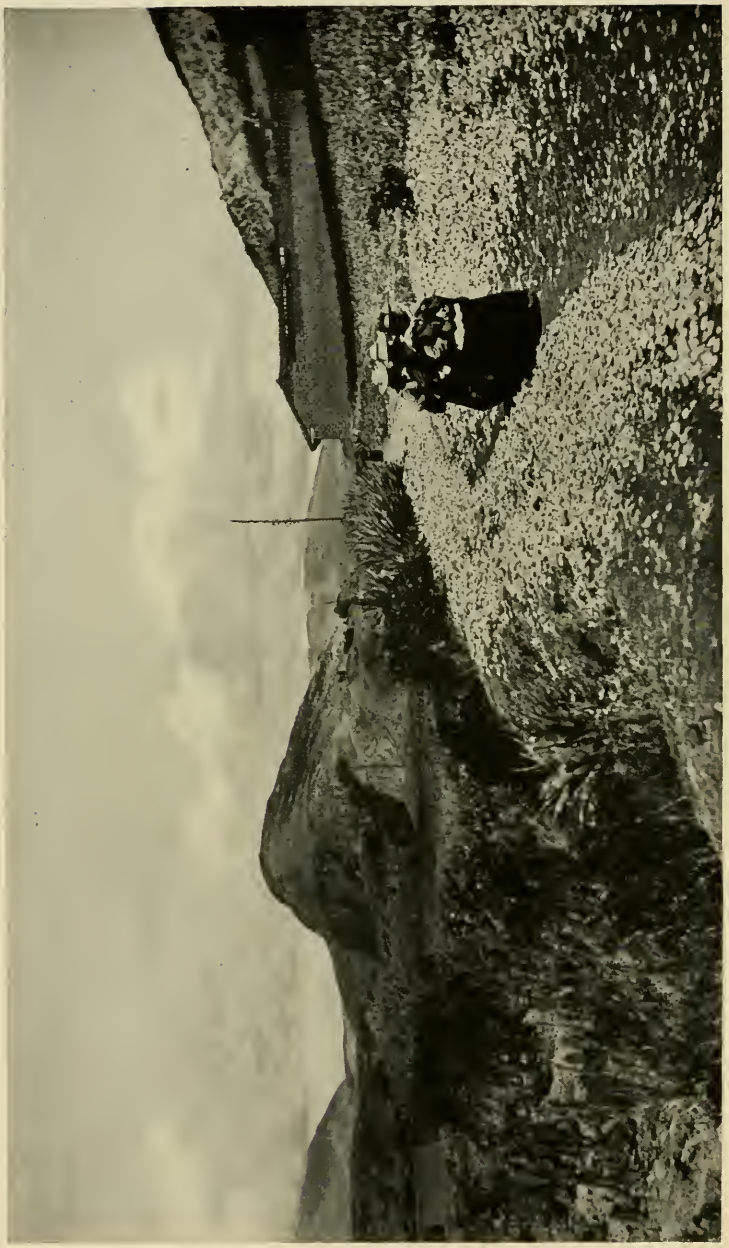
Exquisite rugs and shawls are woven on their hand-looms.

Burial Place in Lima

In Lima one rents a tomb just as one does an apartment—when the rent is not paid the space is let to someone else, and your bones are disposed of in short order.

Burro Burden-bearer

Shares with the llama the distinction of being the best burden-bearers at great altitudes.



INDIAN WOMEN ON THEIR WAY TO MARKET

They carry their loads in heavy woolen "mantas," slung over their shoulders.

searched for foreign matches as we came ashore. On one occasion Paul was landing for a trip to Oroya, high in the Andes. He had put a few aspirin tablets into a Swedish match-box for protection against the usual headache which develops as the first symptom of "soroche," or mountain sickness. The customs agent, with a gleam in his eye, fished the offending article from his suitcase; opening it, he found matches of a new shape indeed! Not to be

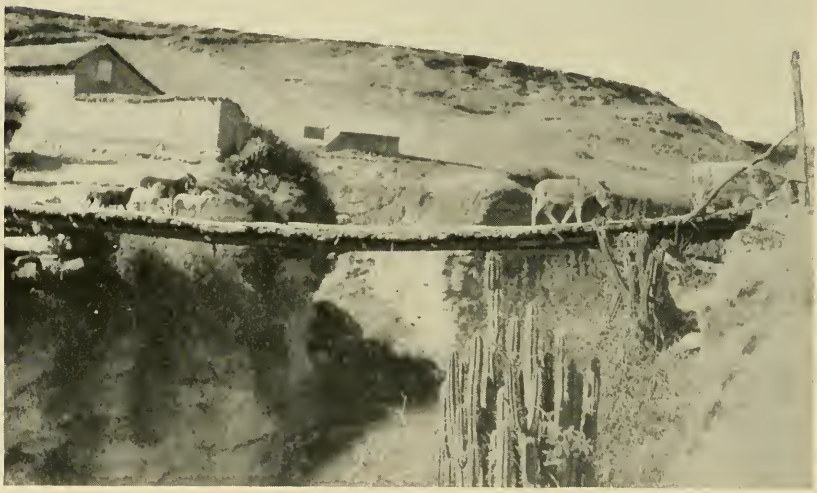
FACADE OF THE ANCIENT JESUIT CHURCH, AREQUIPA

The church was constructed in 1698 (the date shown on the tablet at the right of the entrance) of the soft volcanic rock which abounds in the country around Arequipa—the building is in good condition and is still in use as a church.

fooled by this Yankee trickery, he solemnly removed one of the white pellets and struck it on the side of the box!

While up in the mountains we heard several good stories of life in the "montaña" region on the lower eastern slopes of the Andes. Many of these had to do with the primitive Indian tribes which still resent the intrusion of outsiders into their forest domain. Not long ago a certain British naturalist had been sent to negoti-

ate with one of these wild Indian tribes. He was unable to allay the antagonism of the natives and planned to live among them until they became friendly. So he built himself a shack out of galvanized iron roofing which he had brought in from the coast. One night his shanty was surrounded by a circle of hostile warriors armed with bows and arrows. When he appeared at the door he was greeted by a volley of arrows. He retreated inside and



THE ORIGINAL "BRIDGE OF SAN LUIS REY," NEAR CHUPACA, PERU

for several hours lay there listening to the din made by the arrows as they struck the iron sheeting.

On the following day he emerged to find the woods apparently deserted. The Indians had been greatly surprised to find the house impervious to arrows and had retreated for a council-of-war. Their plan was to burn the house while the Britisher was away. That evening he returned to find great piles of ashes around the shack and a group of Indians making signs that they wished a peaceful interview with him. They had been even more

impressed by the fact that the house would not burn than that it would turn back arrows, and promised the Britisher no further molestation if he would only tell them what tree it was that produced the marvellous bark of which his house was built! They would like to grow such trees themselves.

On January 22 the shore-station was set up at Las Palmas aviation-field; and for several days, determinations of the mag-

A Wayside Shrine in the Andes of Peru

Religion plays a very large rôle in the life of the natives—in fact, there is probably no country in the world in which the church is so powerful.

netic elements were made to find out what changes had taken place since our last visit to Peru.

Callao offered a remarkable contrast to our other ports of call in that very few visitors came to inspect the ship. Captain Davy of the United States Navy and his group of Peruvian naval-school cadets were about the only ones to show any interest in the scientific aspects of our work. The Peruvian naval and aviation services employ American officers to train their men, and

we made many friends among these instructors. One afternoon, Commander Wyatt and Lieutenant Johnston paid us a call in their little yellow sea-plane. Captain Ault had known Commander Wyatt since 1923 when they had met in San Diego. At that time Captain Ault was a member of the solar eclipse expedition sent to California from our headquarters in Washington. After these visitors had seen the ship, they invited Captain Ault to take a flight over San Lorenzo Island and Callao.

Soon after his return from Huancayo, Paul made a trip by airplane to Arequipa and Lake Titicaca. This short trip is one of the most magnificent in the world. One travels southward along the barren coast to Mollendo; crosses the coastal range; then a wide desert; and finally spirals down into a green valley in which Arequipa is situated. This ancient city, once the capital of Peru, has remained almost unchanged since the days of Pizzaro.

When flying over the deserts along the coast of Peru one sees to best advantage those curious traveling sand-dunes which are characteristic of the region. They are shaped like a horse's hoof and measure from ten to one hundred feet across. Each of these dunes is composed of sand-particles of a single color, so that there will be white ones and black ones moving side by side over the plain. The direction of the prevailing wind can be told by noting the orientation of these dunes.

When the various members of the staff of the *Carnegie* had come together again from their excursions into the mountains, Dr. and Mrs. Tovar invited us all to a dinner. Among the other delicacies they served were oysters sent down from New York on ice. No memory of Peru is more delightful than the evening spent in their home.

Our last days in port were spent in the company of some of the observers from the Huancayo Magnetic Observatory who had come down to Callao to return our visit. These people only rarely have an opportunity for leaving their isolated post and seemed to envy us our wandering existence.

Several changes in the crew had been made in Peru. There were two new cabin-boys: one, a young lad from Ecuador; the other, a fine Bohemian who had been a member of one of the nu-

merous colonies sent from Europe to open up the eastern slopes of the Andes. This young man, a favorite of us all, was killed in the explosion at Samoa which also took the life of Captain Ault. Two vacancies in the sailing crew were filled by Frank Moline, an old-fashioned, deep-water sailor, and Arthur Ericksen; while Bagelman was promoted from seaman to mechanic.

Before sailing, we took aboard the ship a new bronze anchor which had arrived from New York to replace the one lost at Easter Island. On February 5 we put out to sea for what was to prove the finest passage of the cruise—next stop Tahiti. The breezes were steady and fair, skies clear, sea moderate, and conditions for observing ideal.

CALLAO TO APIA TO PORT APRA TO YOKOHAMA

The month of February was a notable one for us in that we made several important changes in our instruments and methods. Ever since our departure from Washington, an attempt had been made to use the marine earth-inductor for determining the strength of the earth's magnetic field in addition to the angle of inclination. All the trials up to the present time had failed to give results as reliable as those obtained with the standard "deflector." By changing the method slightly we were now getting comparable readings.

The *Carnegie* has ever been on the alert for new and simpler methods for making physical measurements at sea. In fact, her contributions in this respect may be considered among the greatest of her achievements for science, because little advance can be expected until reliable and practical instruments are available.

In collecting samples of the ocean-bottom we had been using a "snapper" type of collector, in which a large lead weight surrounding the shaft was made to close the jaws when bottom was struck. It often happened, however, that the apparatus hit at an acute angle and not head-on; in which case it would fail to close. By countersinking the weight so as to bring it down over the spring, the center of gravity was lowered. Thereafter, only one failure was recorded from that cause. When it is realized

that it took from two to three hours to make a sounding, and used a considerable amount of our supply of gasoline, it will be apparent how greatly this simple change helped us.

Bottom-snapper with Countersunk Lead Weight

By countersinking the lead weight on the bottom-snapper the center of gravity was lowered to insure striking the bottom head on.

Another advance in methods was the modification of a Sigsbee reversing-frame to contain two thermometers instead of one. This frame was attached to the sounding-wire near the bottom-snapper, and the original single thermometer gave us only the temperature of the bottom-water. This information itself is of great interest to oceanographers. However, we needed a check

on the depth from which the deposit was collected—a check which would be more reliable than that offered by the length of wire paid out and the angle. Due to the drift of the vessel and cross-currents in the deeps, the wire almost never dropped in a straight line to the bottom. We were able to calculate depths accurately from the difference between the readings of two reversing-thermometers sent down together. One of them was protected against the enormous pressures at great depths to give the true temperature; the other, being unprotected, gave a reading which represented the temperature plus the mechanical "squeezing" of the mercury bulb due to the weight of the water-column above it.

A Propeller-device for Reversing Deep-sea Thermometers

This is attached to the bottom-sampling wire, and when the sampler is hauled in the propeller turns and releases the pin which holds the thermometers upright as they plunge to the bottom—temperatures of the ocean-bottom have rarely been measured, although they are of great interest to oceanographers.

Our echo-sounding device gave us a third check on bottom-depths, of course. In scientific work such as we were doing, there are never too many checks. Even the simplest procedure is subject to error at times; and our aim was to attain the highest degree of accuracy possible in every measurement made on board.

During heavy weather we often found our silk tow-nets torn by a sudden surge of the vessel. These nets were very expensive, and had to be made to order in Washington. So we made every effort to save them. On February 18, we tried attaching the nets to the ship by a long rubber rope commonly used in the landing gear of air-craft. Afterwards, we seldom lost a net. In addition, after February 6, the plankton-tows were made from the forecastle head, thus reducing the danger of fouling the other wires which were lowered from the quarter-deck.

The work with the pilot-balloons was made very successful by the beautiful blue skies we enjoyed after clearing the dense clouds of the Peruvian coast. These flights often lasted thirty to sixty minutes, so one can imagine the severe strain on the muscles holding a heavy sextant for that length of time. It was necessary to devise some method for supporting the instrument. One of the deck-chairs was fitted with arms and uprights to support an over-head bar. The instrument was suspended from this by a long, thin coil-spring. In this way the entire weight was removed from the observer's arms; while still allowing freedom of motion. The whole outfit could easily be moved to whatever part of the deck was most favorable for observing the balloon. Captain Ault dubbed the device the "Joshua Chair," in honor of the old-testament hero who commanded the sun to stand still. He had also suggested that it might better have been named in honor of Moses who at one cricitical moment in history had to call in the assistance of two men to support his arms.

Captain Ault says: "With this device we have perhaps carried the matter to an extreme, and caused the balloon to stand still. On at least three occasions, the balloon has suddenly appeared to be fixed in the sky, moving only very slowly in altitude and azimuth. On the first occasion, Torreson, the observer at the theodolite, was observing the balloon for fifteen minutes without getting much change. Finally, Paul, who had been watching the flight, accused Captain Ault, the sextant man, of looking in the wrong direction and of reading altitudes that were far too low. It turned out that the theodolite had gotten side-tracked to Venus, and the difference between its altitudes of 76° and the altitudes by sextant of 45°, could no longer be ignored. On the second occasion, both observers got side-tracked to Venus."

It is remarkable how closely a white balloon floating at a great height resembles the planet in the sunshine of the late morning or early afternoon. For most of us it was a great surprise to know that Venus could be seen at all in the middle of the day. Captain Ault told us that he had occasionally used this planet for determining geographical position at sea. This trick appears to have been known to mariners of former times, but has fallen out of use.

On February 8, Soule and Leyer moved the sonic depth-finder from the radio laboratory to the control-room on the quarter-deck. This was done to enable us to take additional night soundings without disturbing Jones who slept in the radio room. Paul had learned the technique of using the apparatus and now took a sounding after he had completed his Greenwich Mean Noon meteorological observations. Jones had by this time resumed a large number of schedules with amateur radio stations and had to get his sleep whenever he could, for he had regular magnetic observations and computations to do in the daytime.

For the first ten days out of port we had noticed an unusual display of "sunspots." These solar disturbances seem to have an effect on radio and magnetic conditions. When our scientific results are analyzed, it will be interesting to see how closely sunspot-numbers are correlated with magnetic and radio conditions as measured on board.

On February 12, with a slight sea running and bright sunlight shining on the sails, Parkinson and Paul were dropped over the side in the dinghy to secure pictures of the vessel under way. Splashing and diving through the waves like a porpoise, the little boat made several circles about the ship while she was held "by the wind." They stayed out long enough to take a few shots after the sails were shortened for the oceanographic station which followed.

It was not our habit to play practical jokes on each other, but Soule was made the victim of one about this time. Smith, our Chief Clerk in Washington, had sent the staff a ten-pound cake of milk chocolate for Christmas. Captain Ault had cut it into eight pieces and had put one of these in each observer's cabin. Soule came down to his room soon afterwards and found the strange brown bar on his desk. Not being able to decide what it was, he asked his next door neighbor. He was told promptly that it was salt-water soap. The jest worked perfectly; for at his next shower-bath he used it to work up a lather!

While sailing in latitude 15° south, and longitude 98° west, the sea deepened suddenly from 2,700 meters to 5,380 meters, and soon after shoaled again to 3,400 meters. The new deep

thus revealed was named after Dr. Bauer, the Director of our Department in Washington. Throughout the voyage from Peru to Tahiti, the bottom was found to be very irregular. Echoes from as many as six surfaces on the bottom would be returned from a single signal of the oscillator.

Although the depth-finder had been giving good service since the repairs had been made in Peru, certain parts were beginning to show signs of wear. So Soule gave it a complete overhauling and replaced several parts, including a new set of brushes.

The bottom-sampling was never more successful than on this leg of the cruise. A specimen was collected from virtually every oceanographic station. The samples represented almost every type of mud, sand, and ooze, with an occasional piece of lava. The colors were also various; there being white, grey, brown, bluish-green, chocolate, and black among them. The only failure to recover a specimen was due to the sample being washed out of the snapper while it was being brought back to the surface. The jaws were closed as usual and showed signs of having been on the bottom. Captain Ault considered fitting the sampler with a rubber apron; but the infrequency with which this particular difficulty was met with made him decide against further complicating the apparatus.

The full moon and glorious weather made the evenings delightful. Our sporadic efforts to produce vocal harmony on the quarter-deck were revived. Someone had discovered that Aage Henricksen, one of the seamen, had a note-book filled with sea-songs. Many of the old sea-chanteys were there, but were buried in a mass of unsingable ditties picked up on the water-fronts of the world.

On these nights it was usual to hear strange buzzing noises emanating from Parkinson's electric laboratory. He expected to leave the vessel in Australia to return to the Watheroo Magnetic Observatory. A short-wave radio set had been installed there and he was learning to operate such a set in his few spare moments on board. He had ordered a small apparatus from the United States which gave one practice in reading Morse code. The outfit was received in Peru and he was now learning to read fast

enough to take down news-broadcasts sent through short-wave stations.

The trade-winds had been more southerly than expected. We anticipated difficulty in clearing the Tuamotu Group of islands, and decided to head directly through them. This was of advantage in many respects for our scientific work. It would also enable us to make up for the two weeks we had lost in reaching Peru. So, early on the morning of March 7, we skirted the reefs

THE BOAT-HARBOR OF AMANU ISLAND

These tiny vessels collect the copra from the various parts of the atoll to sell to the occasional trading-schooner that calls their way.

of Tatakoto Island. From a note on our chart we had not expected to find it inhabited; but soon we saw a few brown bodies scampering through the trees, headed toward a flag-pole set in a break of vegetation. Another moment, and the red, white, and blue of France was proudly displayed—whether as a warning or as an invitation, we did not stop to discover.

For many of us this was the first view of a south-sea island. At daybreak it was no more than a long, thin line of dark-green

on the horizon. The Island is one mile wide, nine miles long, only fifteen feet high, and is covered with rich groves of coconut trees. All through the night while we were approaching, and throughout the morning as we sailed away, the sonic depth-finder was kept at work mapping out a bottom-profile. The slope was very steep for there was a depth of 900 meters under us when we were only two miles off shore. These soundings were made to determine the shape of the rocky pedestal on which these islands rest.

Captain Ault announced that he planned to allow a few hours for a visit to one of these islands. So we picked out from the chart what we thought would be a fair sample of these unspoiled coral atolls; and on the next day hove-to off Amanu. There was an exciting struggle to gain an entrance to the lagoon against the ebbing tide which poured through the narrow channel. The outboard motor of the dinghy would gain a few yards against the current only to lose it all when the little boat entered an eddy. However anxious we were to make a landing, we were all fascinated by the magnificent coral bottom beneath the dinghy. One must see with his own eyes the beauty of form and color displayed by these coral reefs to appreciate what we saw.

We found no white man on Amanu; but about three hundred happy, healthy natives. They were living on the products of their little garden-patches and from the sale of dried copra to the occasional trading-schooner that passed their way. To many of us this visit will remain a vivid memory; we found ourselves for the first time among the light-hearted, generous Polynesian people, so famed in song and story.

Scott went off in a dugout to the lagoon to try his hand at pearl-fishing. The rest of the staff ambled about the village taking moving-pictures or exchanging gifts and smiles. Paul had the good fortune to receive an exquisite shell "lei," an ornamental hat-band made of thousands of tiny shells, arranged in a beautiful color pattern. These, we found later, are rarely picked up by voyagers—they are ordinarily given to a young man by a maiden as a symbol of betrothal. While we were wandering about we saw several of the great green turtles which the natives prize so highly for food.

Captain Ault Pays His Respects to the Native Chief of Amanu
Our first "south sea" island.

The cemetery of Amanu was a village in itself. The graves are thoughtfully enclosed in small coral huts, or are covered by iron roofing, as though to protect the dead from the scorching sun and tropical showers.

Before we returned to our ship, we were assembled in the village school, a fine white-plastered building decorated with mural paintings of poilus and with mottoes, such as "Vive la France." A great heap of coconuts was stacked on the floor which had been collected for us to take back to the ship. At this convocation we observed the love of oratory found among the islanders throughout the Pacific. Captain Ault had discovered a native who spoke English, and with him as an interpreter, he returned the courteous remarks of the old native chief.

We were gaily escorted back to the ship by a motley assortment of canoes, row-boats, and barges, laden deep with our good natured friends-of-a-moment. On the quarter-deck we put on a dance with the help of our victrola. At four o'clock orders were given to get under way and our guests departed. The old chief was the last to leave, in a dugout manned by two strong boys.

Since entering the Tuamotu Group we had encountered a steady succession of calms, light breezes, and violent rain-squalls. Our little engine was having its innings. We passed many islands during the week following our call at Amanu. Hao, the largest of the lot, was sighted from the rigging; while Tekokota, Marokau, Hikueru, and Mehetia were visible from the deck. The moonless nights prevented a view of Reitoru and Anaa, although we passed quite close.

With calm water and with the engine running it was possible to use the boom-walk frequently. With dip-nets we scooped up many interesting forms of surface-life. The most difficult creature to capture was the little marine insect, holobates, which darted here and there over the surface. It is the only insect that lives its life at sea.

On the afternoon of March 12, we found it very hard to stay below deck. Everyone was anxious to get the first sight of Tahiti. However, the clouds concealed the peaks of the Island all day. While running in toward land that night, we experienced

Our First Drink of Coconut-water

The natives of Amanu enjoyed our visit almost as much as we did for there are no white men on the atoll.

Boatload of Native Guests Leaving the Harbor of Amanu for a Visit to the *Carnegie*

one of those cloudbursts characteristic of the tropics. There was no moon, and the darkness was so intense that it suggested liquid tar. Then, little by little, two rounded black masses became visible off our port bow. Surely they were clouds. Soundings showed that we must have drifted southward of our intended course, so we steered more to the north. About midnight it became apparent that the black masses we had seen were in reality parts of the island we were seeking. The flickering lights of the fishing-villages soon confirmed this.

Shortly afterwards, we opened up the lighthouse on Venus Point, and hove to to await dawn. By ten o'clock the vessel was moored at Papeete, her bow toward the sea, and her stern almost within the front yard of the American Consulate.

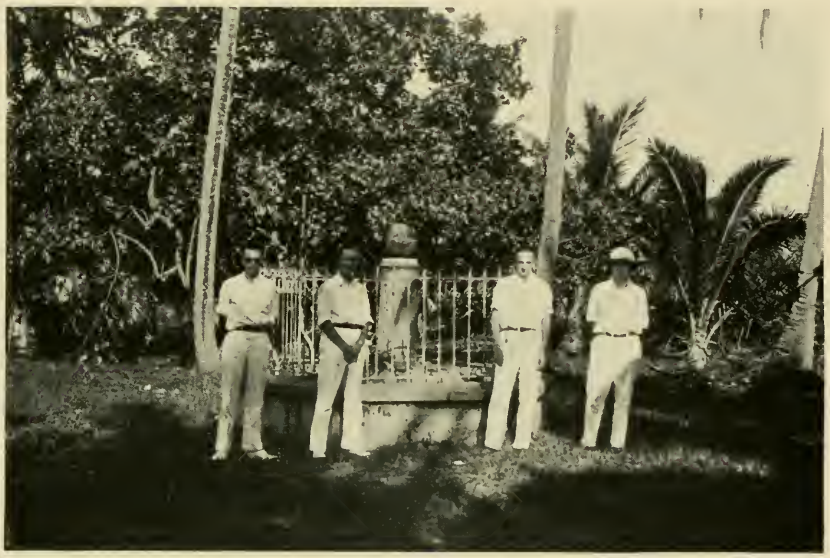
With the flurry blown over which was caused by the arrival of letters from home, we were all eager for a taste of the famous cordiality offered by Tahiti. Here we found a town where social distinctions are vague, race or religious prejudices absent, and formalities happily dispensed with. It was well for us that this was so, for we had but a few days in which to pack a host of new impressions.

Automobiles were at our disposal, so it did not take long for our party to disperse over the Island: some went to look up old acquaintances; others to tramp in the jungle-clad mountains or along the winding beach-roads; some were content simply to loll about the town, or found their pleasure in picture-taking and visiting the homes of the numerous foreign writers or artists who have fled here to live life as they dreamed it.

The atmosphere of the Island is one of amused tolerance for genius and dullness alike. We found little evidence of a legalized morality. Temperance is achieved not by ordinance, but by an unconscious realization that any appetite run wild soon cloys. Life here holds no terrors for the half-caste or for the child of divorce, as it does elsewhere. The heavy work of the community is done by Chinese, who mingle freely with the populace without being stifled by a sense of inferiority, and who are encouraged to retain their own customs.

Native life does not much resemble that of the time of James

Cook or La Pérouse, although true Polynesian hospitality has survived. As in other islands, we found that the women, not the men, are the chief smokers. The girls are as much at home fishing for octopus under the waters of the reef, as they are on a dance-floor. The ukulele (literally, "jumping-flea") is part of the household equipment. This little instrument now found the world over is said to have been invented by a Harvard student, and first introduced in Hawaii. If so, it may be classed as one



SOULE, JONES, SCOTT, AND TORRESON VISIT THE "TRANSIT-OF-VENUS MONUMENT" NEAR PAPEETE

The famous navigator, James Cook, was commissioned to observe the transit of Venus at Tahiti in 1769.

of the most important contributions of the white man to the Polynesian peoples.

The days in Papeete were by no means lazy ones for us. Captain Ault used the diving-helmet to inspect the hull of the vessel and to repair the torn sheathing. Paul was engaged in arranging hospital treatment and transportation for Henricksen, a seaman whose health had been failing for several weeks. Others of the staff took a hand in the stowing of provisions which had been

sent down from San Francisco. A new Coast Survey type of sounding-apparatus had to be installed, customs-formalities required attention, and the apparatus aboard must be cleaned and repaired for the voyage to Samoa. Seiwell made a short trip inland to collect fresh-water plankton from the lakes. Soule availed himself of the break in oceanographic routine by making some changes in the electrical salinity-outfit.

Among the many excursions made by members of our party were a visit to Cook's monument at Venus Point, and a circular tour of the Island by automobile. Readers will recall that James Cook was commissioned by the British Crown to observe the transit of Venus at Tahiti in his first voyage in the *Endeavour* (1768-1771). These observations were successfully made on a high point of land not far from Papeete, and a bronze tablet now commemorates the event. The automobile route along the coasts of Tahiti must be classed as one of the most magnificent in the world. Jagged peaks, tinted coral beaches, palm-groves, picturesque waterfalls, and bold lava-cliffs, are passed in panorama, with the resounding surf of the fringing reefs and the outlines of the neighboring islands in the distance.

During the drive several halts were made at the homes of various members of the local community. The visits at Dr. Williams' and at Major Hawkins' were among the most delightful. Dr. Williams has long been a resident here and is now the British Consul. Major Hawkins, who proved to be a hearty host, lives in a house previously occupied by Gouverneur Morris, the author. These men have lived unique lives and have each developed his own philosophy from a life of travel.

Among those who entertained us in Papeete were Governor and Madame Bouge; Sir and Lady Skipwith; and Mr. Dobson from the United States. We attempted to return the courtesies of all these people by giving a party on board. The Victrola did its best to furnish music for dancing. There were about one-hundred guests so that the quarter-deck was more than filled to capacity.

While in port we had many occasions to call on Oscar Nordman to furnish us with automobiles and to arrange for our deck-party. He was at one time cabin-boy on the *Galilee* and was now operating a hotel and garage in Papeete.

In the midst of all these festivities we received the sad news that Parkinson's father had died. He had been ill ever since our visit to England at which time Parkinson had gone to his bedside.

Just before leaving Papeete, an elaborate beach party was arranged in our honor by the members of the local "Society for Polynesian Studies," of which Father Rougier was president. A dinner in the ancient Tahitian manner included such delicacies as broiled "centipedes" and "castor-oil fish." No wine was

Fisherman's Hut on the Island of Tahiti

Very little is seen today of the old Tahitian ways of life, the island having become cosmopolitan.

served at the table of honor, in deference to the feelings of the American Consul, who never missed an opportunity of telling these people what they should drink. When it came time for the toasts one of the speakers at this table inadvertently began by saying: "I lift my glass—." Captain Ault, with a twinkle in his eye nudged him and suggested he begin again with: "I lift my coconut—."

Moving-pictures were next on the program. These showed scenes on Christmas Island, which is owned by Father Rougier.

These were followed by the pièce-de-resistance of the evening: a theatrical performance arranged by a professional dramatist, featuring some hilarious scenes of life in Papeete. Native songs and dances were interspersed throughout the festival; and an orchestra tuned up for the dance which closed the entertainment.

On the afternoon of March 20 we reluctantly set sail from the charming port of Papeete, all hands reporting for duty. Not many vessels leave this seductive spot without desertions on the part of the crew. We had, however, signed on a Tahitian sailor, Benjamin Tehau, to replace Henricksen.

We sailed past the magnificent island of Moorea, behind which we had seen the sun set in splendor throughout our stay in port. But the wind hauled ahead, and we were obliged to pass Huahine and Raiatea to the north. Then followed a week of calms and light airs, during which we fitfully made our way westward towards Samoa. We were alternately pushed ahead by our little engine, and bowled over the smooth sea by bracing the yards to catch the short wind-squalls that swept down on us from every direction. The easterly trades were picked up for only four days during this passage.

The usual routine of magnetic, electric, and oceanographic work was carried on, with the exception of the bottom-sampling. Repeated attempts to use the new Coast and Geodetic Survey sounding-apparatus resulted only in the loss of many samplers and thermometers. We found that the machine was not suitable for use on a small vessel which rolled so noticeably when sails were shortened for sounding. The floating-drum, mounted athwartships, had to be continuously manipulated between clutch and brake to control the speed of paying out. These sudden changes of tension would part the piano-wire, not made to withstand such severe strains. It had been hoped that this apparatus would save power and time by making the bottom-sampling independent of the main winch. Later on experiments with the new machine were resumed, but with little success.

The almost constant use of the main engine resulted in a burned-out bearing on March 24. But by now the trades were blowing, and as we sailed past Mopihaa Island, the engine-room gang were

busily engaged in casting and polishing. On March 26 we were startled by a loud explosion in the engine-room. One of the air-tanks had blown up. The end had smashed its way through the bulkhead into the gasoline tank-room, while the tank itself jumped aft, out of its cradle, and landed against the air-compressor. Fortunately the mechanic on duty was uninjured, and no equipment was too seriously damaged for immediate temporary repairs. The accident was apparently due to weakness in the tank, as the safety-valve was in good working order.

TAHITI HAS A MAGNIFICENT COAST-LINE
An automobile road encircles the island—the peaks of Moorea are seen to the right.

During the night of March 28, a sudden squall carried away the starboard royal-sheet, and through the din of the heavy rain on the deck, we could hear the sailors aloft making fast the damaged rigging. The next day we succeeded in following a pilot-balloon for over seventy minutes. This represents an altitude of almost eight miles, certainly a good record for a small vessel like the *Carnegie*.

On March 31 we passed the uninhabited Rose Island, the eastern outpost of the Samoan Islands. This tiny speck in the archipelago

is remarkable because it is the only coral atoll in the group. Every year the Navy tug from Pago Pago calls here to replenish the supplies of food and water kept here for emergency use by shipwrecked sailors. By dawn the following day the peak of Tau was made out on the starboard bow. It was a great disappointment to us all that there would be no opportunity for visiting this sacred island-home of the old Samoan kings. From here migrated whole fleets of sea-going canoes, to populate other so-called Poly-

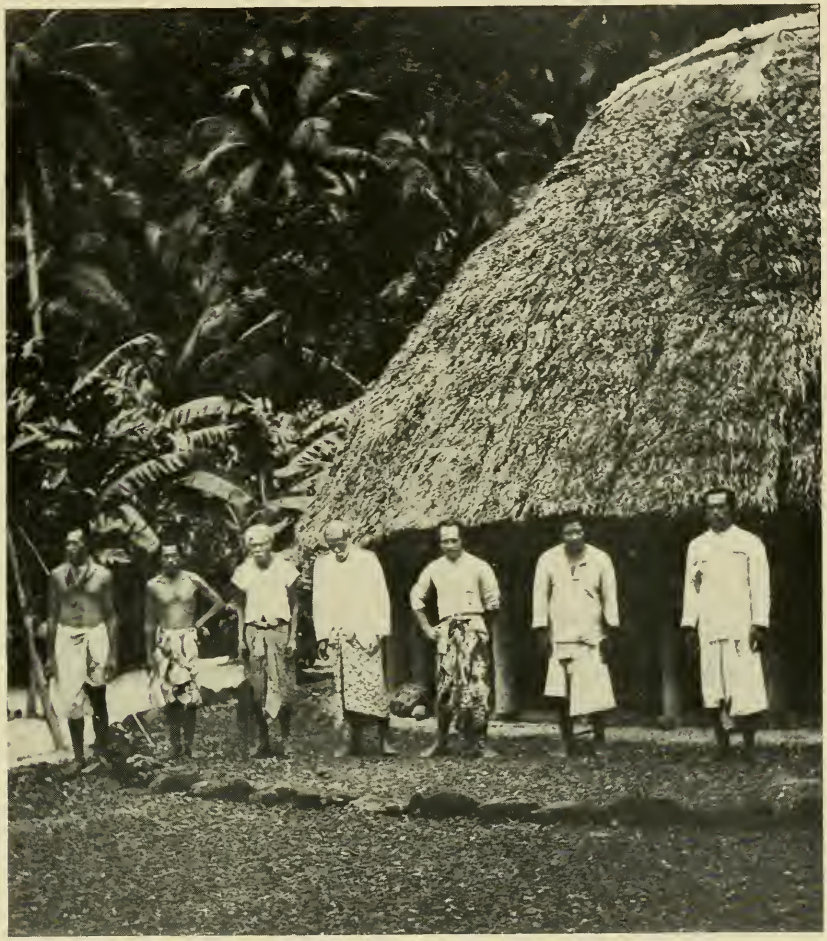
Inlet near Taravao, Island of Tahiti

The great quantities of rain falling on the mountains in the interior supply innumerable waterfalls.

nesian islands so far away as Hawaii. It was because of these remarkable feats of seamanship that the Samoan Group was once called "Navigators' Islands." One marvels that a small open canoe ever reached its destination, in the absence of some apparatus for determining position at sea.

By nightfall we were pushing our bow into the dense shadows of Tutuila, whose harbor, Pago Pago, is known as the finest in the South Pacific. Hardly had we picked up the two range-lights, which a ship must keep in line to safely enter the channel, when

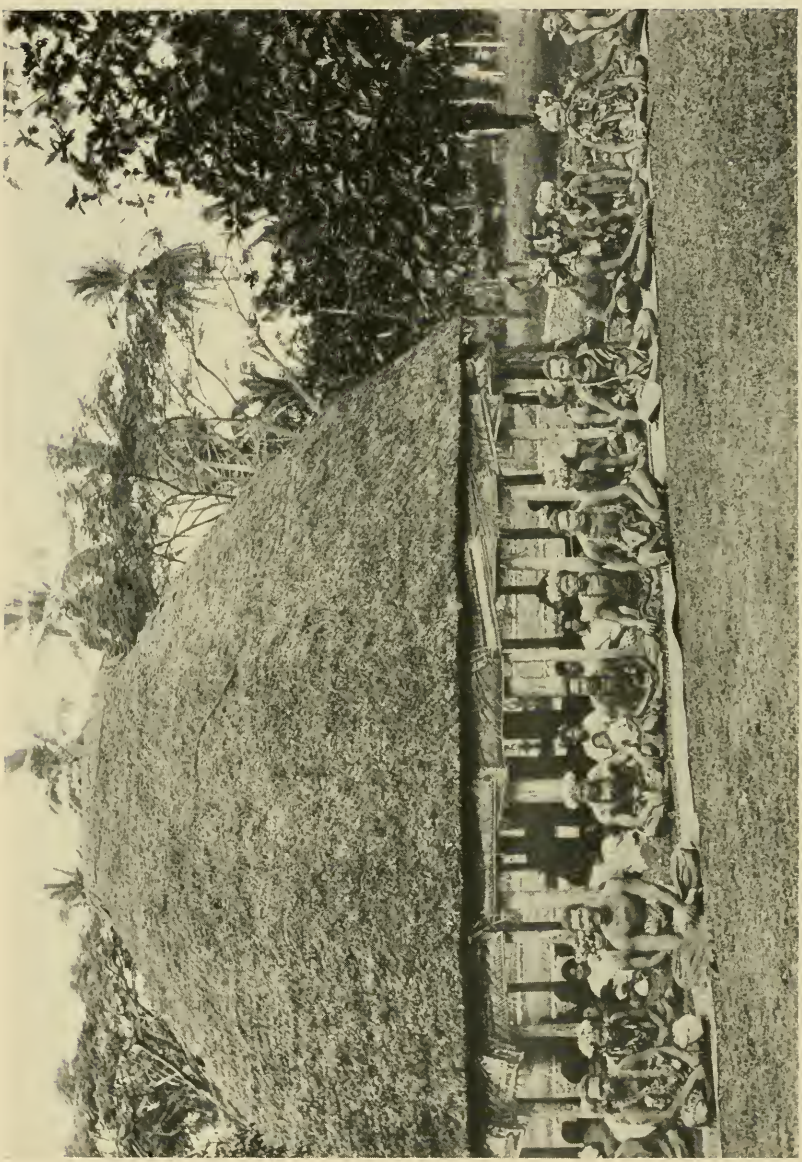
a scene of utmost confusion was spread before us. The night was so black that we could barely make out the outlines of the towering crater-rim which forms the harbor. To further baffle us,



A Group of Samoan Chieftains

The houses and grounds are always immaculate—there is no furniture inside the "fale," for one sits, sleeps, and eats on mats spread over the pebble-floor.

the water was covered with a steamy mist that made our search-light more than useless in trying to pick up the mooring-buoys. But worst of all, the whole harbor was covered with short strings



SAMOAN MEN RESTING IN FRONT OF THE "FALE" AFTER A *siva-siva* DANCE, APIA

Ventilation is perfect in the beautiful "fale" or Samoan house and the thatched roof is a splendid insulator against the sun's rays.

of evenly spaced lights. These gave the effect of lighted piers running in absurd fashion out into the bay at all angles, and in places crossing the main channel itself. We found later that these were fishing-canoes tied bow to stern, each carrying a lantern or torch.

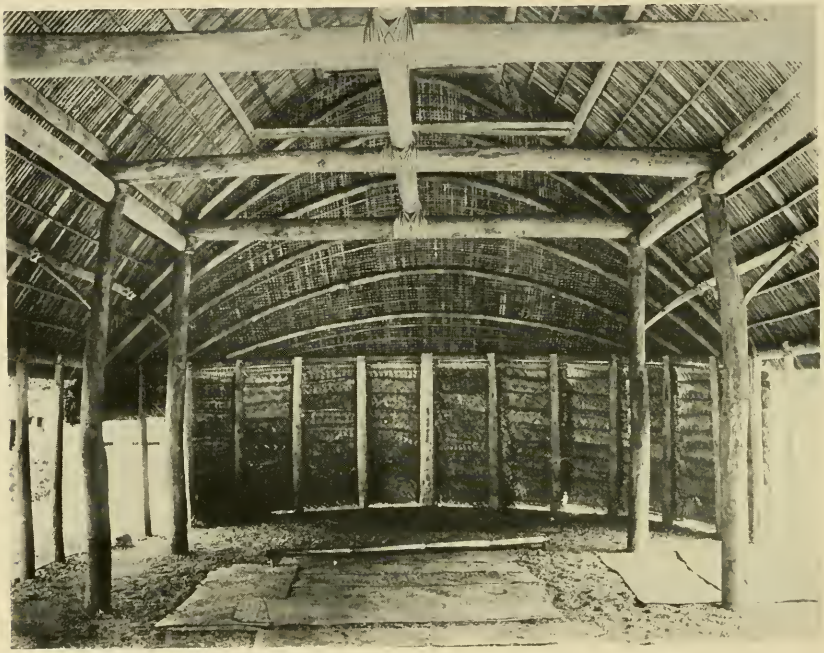
In an attempt to clear these unexpected obstructions, we were within an ace of piling up on the jagged coral head of Aua Reef, when amidst warning shouts of natives ashore, the loud voice of

A Samoan House under Construction

These houses which look so simple when completed are really very complicated as no nails are used and the thousands of joints being made with sennit, a string braided from coconut-husk fibers—the view is from Churchill.

the naval boarding officer who had rushed out in his launch, gave the command "to port." So "to port" went the helm, swinging our bow to starboard as with every good sailing-ship. Unhappily, in the Navy the command means "head the ship to port," the exact opposite. Only the fact that we had good steerage-way, and that our vessel was so short, prevented what seemed an inevitable shipwreck; for only a few yards away lay the reef to our right.

Once safely moored we lost no time in getting ashore, for this was "movie night" at the Naval Station, and the officers had generously invited us to attend. But to some, the invitation of the charming roads leading to the native villages was more alluring. Here they found Samoan houses, called *fales*, like gigantic mushrooms, cosily clustered together near the water, each lit



THE INTERIOR OF A SAMOAN "FALE"

Showing the pebble-floor and the graceful lines of the roof—a Samoan pillow holds the center of the stage.

with a single kerosene lamp set on the pebble-floor. Around the lamp the family lay sleeping or sewing or singing; for built as they are without walls, these houses allow little protection from the gaze of the curious passer-by.

From each *fale*, in turn, came an invitation to enter. We were to find these people as hospitable as the Tahitians. Once inside the circle of pillars that support the eaves of the overgrown roof, and seated on the floor with the rest of the family, we were offered

as a refreshment coconut-water drunk from the nut itself. We were shown fine examples of bark-cloth, or "siapu," which is put to so many uses on these islands. And there was a kava-bowl, deftly carved from a single block of wood, in which the national beverage is prepared. On the edge of the circle sat an old man polishing a war-club with a piece of broken glass, doubtless for sale as a souvenir to some tourist passing through on the next steamer. So passed our first evening in Samoa, smiling and chatting with these happy, hearty people, or following the adventures of a movie star on the screen at the station theatre.

The following day was spent on board, for the most part. There were letters to read, reports to prepare, provisions to buy, and calls to make on the officers of the station. Commander Baughman was an old friend of Captain Ault. They had met in Washington when the Navy Department was preparing its first pilot-chart for the upper air. So during our short stay in Pago Pago, Captain Ault lived with the Baughmans.

The Naval Dispensary was kind enough to allow us the use of their equipment for replenishing our low stock of distilled water, which was used in chemical work aboard. The privileges of the Commissary were offered, and from their cold storage we withdrew rich cream, and meats from Australia, vegetables and fruits from California—welcome fare indeed for a ship which must subsist chiefly on canned goods.

During the remaining two days of our stay gasoline and other stores were taken aboard, while the staff prepared the mail for forwarding to headquarters, or collected biological specimens on the reefs. We were later to become better acquainted with the infinite variety and gorgeous coloration of the life under the waters of this magnificent harbor.

The evenings were as full as the days. Naval officers arranged bridge-parties or tennis-matches. Swimming was superb in the balmy waters of the bay. To demonstrate that our life in the tropics had not melted away all ambition, Soule and Diefenderfer, the director of education for American Samoa, swam the whole length of the harbor, a distance of about three miles. But night was generally the occasion for strolls or for attending native dances

Samoan Boy Dressed for a "Siva-siva" Dance

His beads are made of the bright red fruit of Capsicum—the pillars of the house are decorated with the green leaves of the coconut palm.

called "siva-sivas." Some of these dances were quite elaborate affairs, where the whole village would join in the merriment.

In the Samoan dance, the hands and arms perform most intricate motions, chiefly symbolic; whereas the body and feet play

A Samoan Chief Dressed for the "Knife-dance"

This dance is little more than an exhibition of marvelous juggling. (From Krämer. "Die Samoa Inseln.")

a distinctly minor rôle. The face maintains a stolid expression which might almost be called sullen, except that a short acquaintance shows it to mean peace and quiet dignity. A great circle is formed by the spectators, and within this the performers take turns. A small band of guitar and ukulele players furnish the

accompaniment. Each "verse" is begun by a melancholy high-pitched voice in the gathering, and everyone joins in a chorus in which the rhythm is accentuated by general clapping of hands or thumping of floor-mats.

The most spectacular part of the program is the "knife-dance," performed by one or two of the young men. They step out into the circle, tattoed limbs glistening with coconut-oil, ankles trimmed with leaves, heads adorned with flowers, and their necks surrounded with a string of boar's tusks. The appalling head-knife gyrates dangerously, as it is juggled from hand to hand.

These dances display to best advantage the handsome, café-au-lait bodies of the young Samoan men and girls, kept so trim in youth by work in the hillside plantations, and fishing on the reefs. Unfortunately, as they assume the more sedentary duties of chieftainship or motherhood, they quickly become obese.

Before leaving port we held a reception on board for the naval officers and their families. We took this opportunity for demonstrating some of the equipment, including a pilot-balloon flight.

But on April 5, the time had come for us to move on to Apia in British Samoa, where long days of magnetic and electric observations on shore awaited us. Leaving the exquisite harbor of Pago Pago in mid-afternoon allowed us to skirt the southern and western coasts during sunset. Between us and the irregular peaks of Tutuila lay a jagged coast on which the thundering surf filled the air with salt-spray. Great blow-holes spouted forth their columns of water as the long rolling swells swept in. Here and there an indentation disclosed a fishing-village on the beach, where a Samoan long-boat was being cautiously eased out of the troubled waters of the cove by its twenty or more oars, laden with taro and bananas for the city-dwellers of Pago Pago. Looking across our port bow we could just distinguish the rounded outline of the island of Upolu, on which Apia stands. The two islands are only some forty miles apart, so that by dawn we were standing-by outside the port awaiting the pilot.

After the usual calls had been made, the party turned to on the various duties assigned them. Arrangements were made at the Apia Magnetic Observatory for comparisons of the electric and

magnetic equipment, and suitable sites were chosen for establishing shore-stations. This work required the continuous attention of several observers for the greater part of a week. Repairs to the vessel were begun. The new sounding-machine was modified to hold more piano-wire. Rigging was set up and tarred down. The new Nansen bottles from Norway had arrived and were prepared for use. Specimens of marine life were obtained from the bottom of the harbor and on the reefs. Chemical solutions

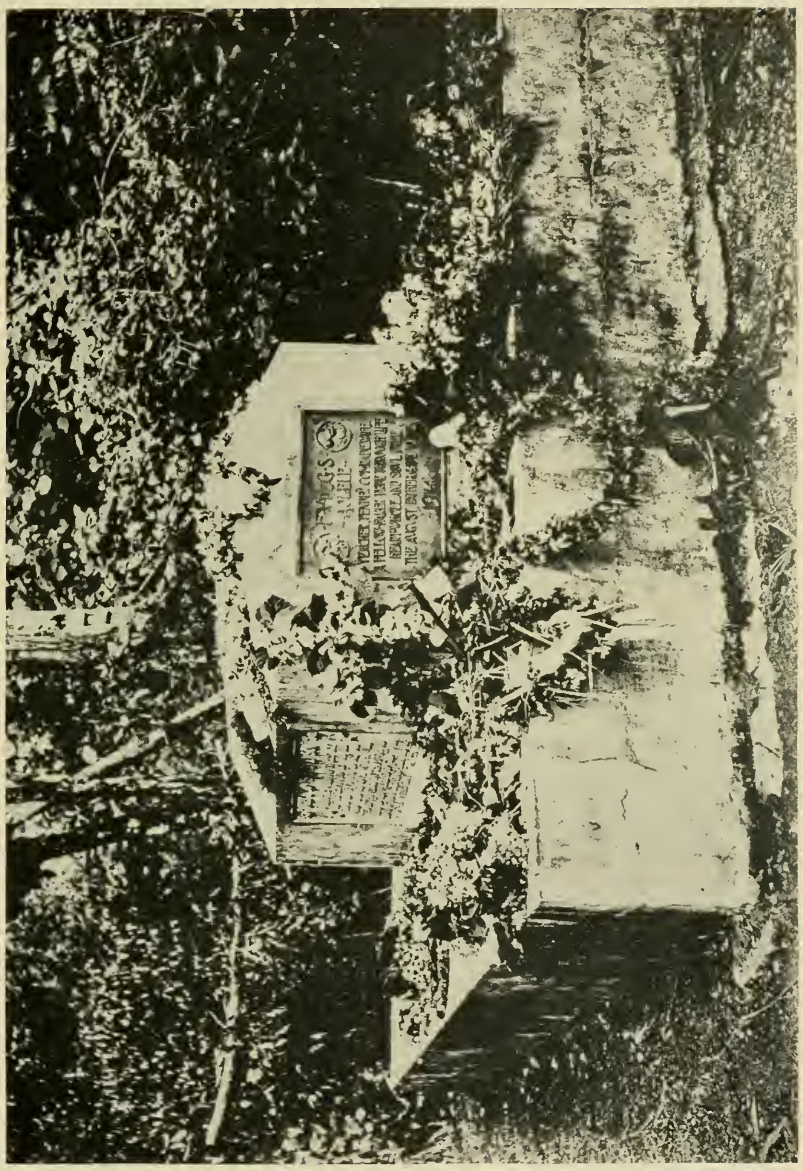
THE BEAUTIFUL GROUNDS OF THE MAGNETIC OBSERVATORY AT APIA

The instruments of the *Carnegie* were compared with those here just as they were in Germany, Peru, and Japan.

for the next stretch had to be standardized. All in all, busy days under a searing sun, without the relief afforded by the trade-winds, which set in only during our last day in port.

The site chosen for the comparison of the potential-gradient apparatus, was located on the reef just outside the Observatory grounds. Unfortunately for Parkinson, the reef was covered with water at times, and he was obliged to roll up his trousers while he stood at the instrument. The experience all but confined him to bed for the remainder of the stay; for he received a merciless sunburn about the legs and ankles.

THE ATMOSPHERIC-ELECTRIC STATION SET UP ON THE REEF NEAR APIA
Simultaneous observations were made with instruments on board.



TOMB OF MR. AND MRS. ROBERT LOUIS STEVENSON ON MOUNT VAEA, NEAR APIA

So greatly was Stevenson loved by the Samoans that the chiefs themselves cut a trail through the jungle and carried the body to this beautiful spot.

We found in Apia the same cordiality on the part of the townsfolk that featured our visits everywhere. The hospital staff and Government officers, as well as the many members of the commercial community, went out of their way to make us feel at home. We were invited to visit several interesting plantations; tours of the Island were arranged for Sunday, and tennis- and badminton-matches all helped to offer us relaxation.

Some of the plantations near Apia were fascinating studies to those of us who had never seen cocoa, coffee, teak, rubber, and tropical fruits grown on a large scale before. We saw the whole process of cocoa-bean harvesting from the tree, through the fermentation and drying to the export sacks. The labor employed in collecting the rubber latex and coconuts is chiefly Chinese, since the Samoans are not anxious to work for a money wage and are not very steady workers. Here and there one comes across a black Solomon Islander who is employed on the plantation.

Several excursions were made by members of the party, which were noteworthy. One, a sunrise visit to the tomb of Robert Louis Stevenson on Mount Vaea, which required a long climb beginning at three in the morning. Besides seeking the magnificent view obtained at dawn from this point, there was another good reason for choosing such an early hour—brisk walking would be practically impossible in the intense heat which envelops the Island when the sun is high. Other trips included Vailima, Stevenson's estate, now occupied by the Governor; Malololelei rest-house, high up on the mountain behind Apia; various waterfalls, and native villages along the coast.

On the evening before sailing, Captain Ault and Paul were invited to spend a night in Solo Solo, one of the largest, purely Samoan, villages. After a long drive along the coast they were challenged by an outpost stationed at the entrance to the village. A few words from the driver and they were admitted to what proved to be a hotbed of rebel activity. It is in this village that about sixty chieftains have retired to escape punishment by the British authorities for failure to pay taxes and for preaching resistance to the New Zealand Administrator. Here they are cared for by the natives without having having to do a stroke of work.

They sit in a great *fale*, drink kava, make interminable speeches to each other and watch the "siva-siva" dancing of the young folks. Truly, the life of Reilley.

They were very gracious to us and gave us a supper in old Samoan style before treating us to the inevitable exhibition of dancing and singing. A kava-ceremony with much display of oratory had been held for us on our arrival. We were afraid

GIGANTIC BANYAN TREE NEAR APIA
This tree is passed on the road to Vailima, Stevenson's famous estate.

these people would interpret our visit as a sign of sympathy in their anti-government agitation. They were very flattering to our country in its administration of American Samoa and implied that they desired to see Western Samoa in the same hands. Their preoccupation with political matters extended to every detail of the singing and dancing. Extemporaneous poems were composed for the occasion, mostly symbolic, and extolling the audience to rebellion. After a few hours of this we begged for a chance to retire for we were to leave port next day

On the day before we sailed, Oscar, the cook, was thrown from a horse, dislocating his shoulder. Fortunately, he was not far from the hospital, where he was cared for until the vessel sailed.

With our scientific program completed, we made our arrangements for departure, and on April 20 set our course northwest towards Guam by way of Wake Island. We were to sail short-handed because Seiwell, who had been in charge of the biological and chemical program, returned from Apia to the United States.

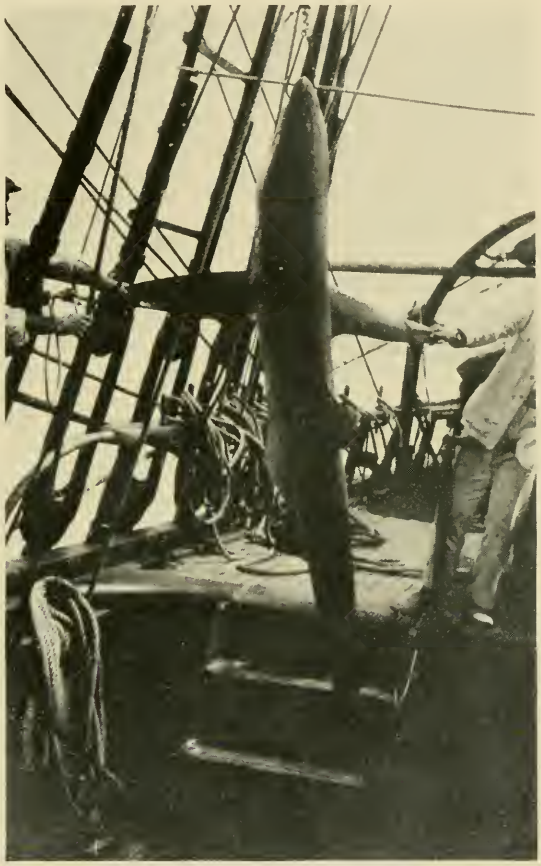
Collecting Biological Specimens on the Reef at Low Tide, Apia

The apparatus for determining the electrical potential gradient of the atmosphere was set up on this reef.

Paul was then designated to carry on this work until Graham joined the ship in San Francisco.

While at breakfast the first morning out from Apia, a sailor shouted through the cabin-skylight that two stowaways had been found in the forepeak, a dark unventilated storage-space in the bow of the ship. When Captain Ault came on deck they begged to be allowed to work on board without pay—even offered to swim back to Apia, a distance of sixty-five miles, to avoid going

to jail. But Captain Ault gave orders to put back to port, since we had no room on board for two extra hands, and since returning them from Guam would be very expensive. The boys were set to work cleaning the winch and polishing brass until late after-



SHARK

These sharks furnished good steaks and were a happy hunting ground for the biologist.

noon, when they were locked up to prevent their jumping overboard to swim for land in waters infested with sharks.

We hoisted signals for the pilot-boat to come out for the stowaways and just after sunset they were put over the side. As the

little launch sped away a voice was heard in the distance shouting "Thanks for the buggy-ride, Captain!" The incident cost us a day and a half of precious time, and a considerable quantity of gasoline. We later heard that the youngsters had hatched the plan carefully, after getting a hint from a movie. They had even rehearsed the act the night previous to our departure so that no hitch would occur in their hiding in the forepeak. They were driven from their lair by the stifling odors of the locker. One of these boys had twice previously begged Captain Ault for a job on board, but had been refused.

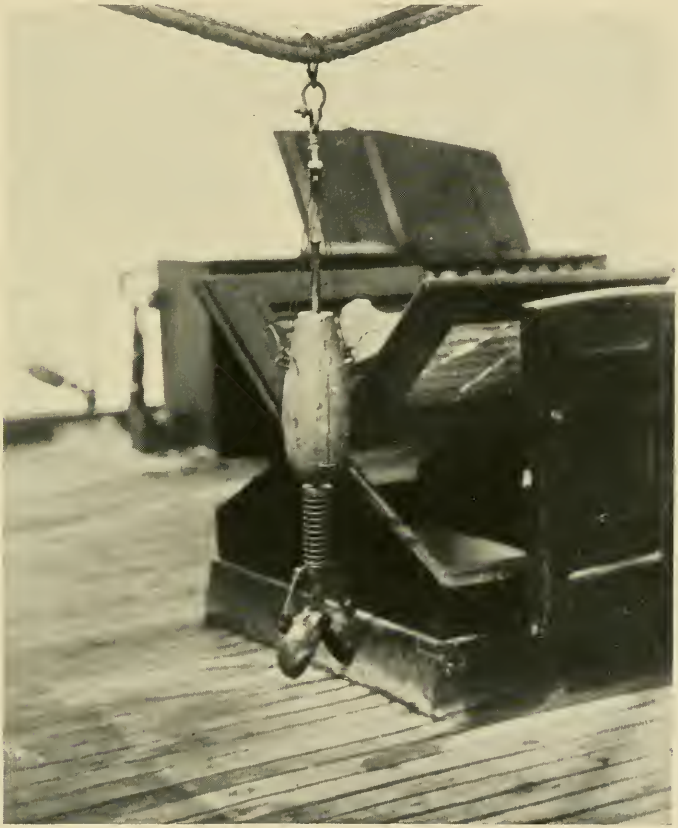
And so we turned the ship about to catch the trade-wind which had begun to spring up, and headed again towards the Union Islands on our way to Guam.

The return to Apia with the stowaways at least brought us a fair wind, although it had been expensive of gasoline. Jones had taken advantage of the delay by building a new amplifier, using the transformers received in Pago Pago. Paul started spring housecleaning in the laboratory. Parkinson set up his table on deck for the tedious task of replacing defective silver-chloride cells, hundreds of which were used in the atmospheric-electric batteries.

The first oceanographic station was occupied on the morning of April 22. The sounding-machine, which had been remodeled to hold six thousand meters of piano-wire, was given a trial; but this time the control-handle broke. After one more attempt to use this machine for bottom-sampling, it was discarded; for again we lost a "snapper" by the parting of the wire during a sudden roll of the vessel.

At the station on April 24, a much more serious loss of equipment was narrowly averted. The heart strands on our aluminum-bronze wire, which was used to lower the reversing Nansen bottles, broke in seven or eight places. This wire had been in use since leaving Panama, and apparently had become invisibly corroded. It was necessary to discard about twenty-seven hundred meters. Had this wire completely parted, we should have lost many hundred dollars worth of instruments, and should have been seriously handicapped until replacements could be made from Europe.

On the morning of April 28 we picked up the northeast trades which blew without interruption until we reached Guam. We celebrated this event by catching a fairly large shark. Excellent steaks were served that night. Almost everyone on board had



A "Snapper" Type of Bottom-sampler

Equipped with trigger-device and detachable lead weights which may be left on the bottom thus saving considerable power on hauling in the sample.

a hand in the killing. Paul collected several bottles of parasites from the skin, including the little sucker-fish *remora*, and hundreds of tiny crustaceans marvelously adapted to their life upon the host. The stomach was searched, but only a few large feathers

and a fish's eye were recovered. Tony, the cabin-boy, collected some teeth, which he cleaned for souvenirs.

During the oceanographic station on this day we had to repeat the deep-series of water-bottles, because the messenger which was sent down the wire to reverse them had become caught by the tentacles of some marine animal like a jellyfish. This creature had plagued us before and we were to meet him again and again. While we were at work on deck someone noticed smoke rising from the roof of the electrical laboratory. It was discovered that a distilled water-bottle had acted as a lens and had set fire to a towel. We at once made canvas covers for the bottles to prevent a more serious accident in the future.

But May 2 was a blue-letter day in our calendar. Seven hours elapsed in collecting our samples, instead of the usual three. The surging of the vessel in the rough sea fouled the piano-wire and bottle-series. To untangle them we were forced to sacrifice two thousand meters of the wire. Not content with this setback, Father Neptune had more tricks up his sleeve, and the deep-series had to be repeated three times for various reasons—and all this was in the rain.

To cheer us up after these discouragements a dinner was arranged for May 5, to celebrate our hundredth oceanographic station and the end of one year at sea. The printed menu, giving fanciful names to very familiar dishes, did its part to disguise the fact that we were living by grace of the can-opener.

Crossing the 180th meridian took May 6 out of our log-book, although there were two Greenwich mean noons on May 7.

The trade-winds we were now enjoying carried the pilot-balloons out of sight in ten minutes or less. Although our supply of hydrogen was low we tried tying two of them together to make them visible for longer periods.

The fresh winds, together with the fairly strong currents in our neighborhood, caused an excessive surface-drift of the vessel. The angle of the bottom-sampling wire reached 75° from the vertical on May 9; and Captain Ault decided to modify the method so as to allow the use of two sixty-pound weights instead of one. But it would use far more power than we could spare to bring these

weights back from the bottom. So a Sigsbee releasing-device was removed from a sampling-tube and attached to our snapper in such a way that when it touched bottom the weights would be released and left down below. Unfortunately, when we first tried the outfit the wire broke at a splice, due to the great strain caused by so much weight. The method looked promising in spite of this accident, and when we reached Guam we had some suitable weights cast for this apparatus.

On May 11 the *Carnegie* approached treacherous Wake Island, an isolated speck in the ocean only twenty-one feet high. On a previous cruise the vessel might well have come to grief here. The watch-officers could hear the surf half a mile away before the Island itself was visible in the darkness; and only a prompt change of course saved the ship. But with a steady wind and a brilliant day we were able to pass within a quarter-mile of Peacock Point. Our observations checked the position of the Island as given by the U.S.S. *Tanager* expedition of 1913, and our own-dead reckoning of 1915.

Here there are no coconut-trees, only low spreading shrubs. Otherwise the Island is a typical coral atoll, with an exquisite blue-green lagoon which could be easily seen from the rigging. Innumerable sea-birds circled our masts as we passed by, but no signs of human life could be made out ashore. We kept sharp lookout for castaways, as the Island is seldom passed by ocean-traffic. Captain Ault remarked that it might well be made a sea-plane harbor in the future, because of its position midway between Hawaii and Guam, and in a direct line between Los Angeles and Manila.

Echo-soundings were made frequently as we approached and departed, to secure more data on the shape of the pedestal on which this isolated atoll rests. The whole stretch between Apia and Guam was characterized by a very irregular bottom. Rapid changes of three or four thousand meters in the depths were not rare. On May 18 a sounding of 8,060 meters was obtained, showing that we were crossing the northeast end of the famous Nero Deep near Guam. The previous sounding of 2,900 meters was only twenty miles away!

WAKE ISLAND IN THE MID-PACIFIC

This isolated coral atoll lies about half way between California and the Philippines and might some day be a seaplane base for trans-Pacific aviators.

With the heavy rolling of the vessel and with the high speeds we were making, the extraneous water-noises in the microphones of the depth-finder became very annoying—often obscuring the echo entirely. Accordingly, we sent a radio message to the U. S. Navy asking whether filter sections might not improve things. They replied that a five-hundred-cycle filter might well end our

Chamorro Houses near Agaña, Guam

Picturesque carabao or water-buffalo at work in the fields are seen as one drives over the beautiful automobile roads.

difficulty and two of these were ordered by our headquarters in Washington.

About this time a total eclipse of the sun was visible over this part of the ocean but we were several days late in reaching the proper zone. We had had so much cloudy and rainy weather that it is doubtful whether we could have enjoyed the event in any case.

On May 19 we had our first sight of the Mariana Islands, Rota

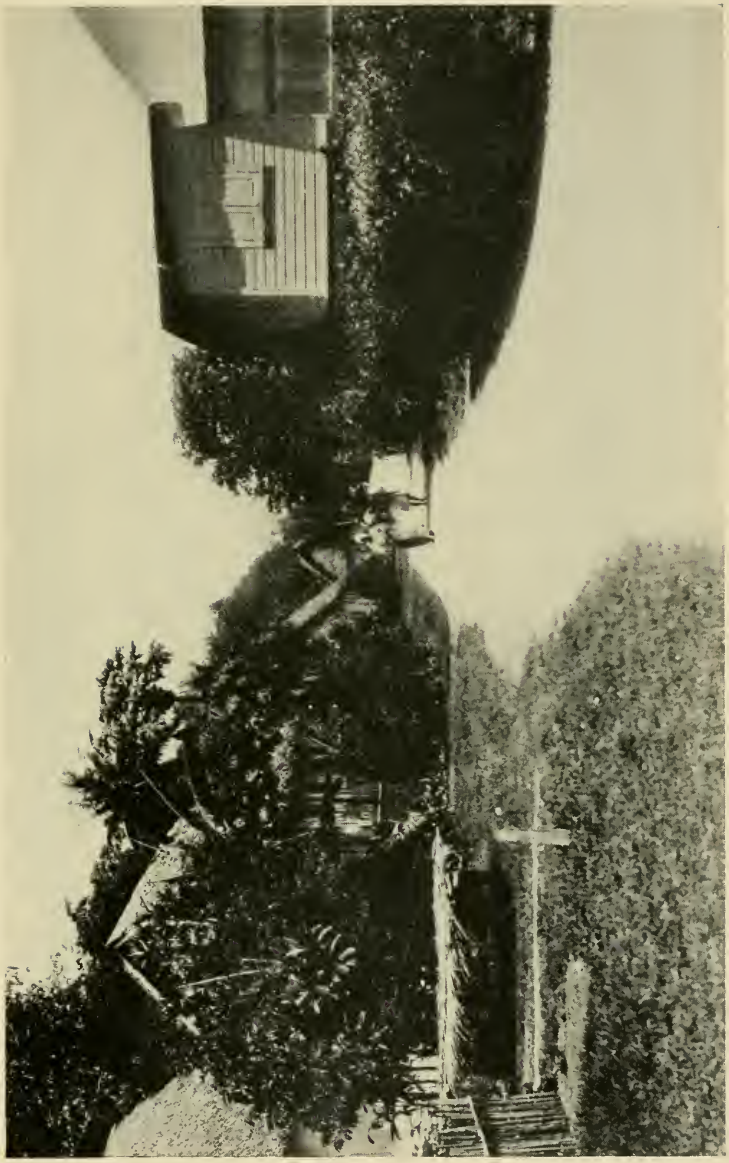
being visible during the morning and Guam itself appearing at sunset. By sunrise we had arrived off the bold cliffs of Orote Point at the entrance to Port Apra. The winds had been so fair that we had covered almost four thousand miles in four weeks, in spite of heaving to on alternate days for oceanographic work.

By properly apportioning the work we were able to accomplish a considerable amount of work in our five-day visit here. Six thousand meters of new aluminum-bronze wire was reeled on the winch to replace the old. The chemical laboratory was repainted —no easy task when all the complicated apparatus must be removed and remounted. New lead weights were cast for the modified bottom-sampler. The main engine-exhaust required brazing. Torn sheathing was repaired. Gasoline and provisions were taken aboard. Water-tanks were filled. And a hundred odd jobs about the ship kept the men busy.

Once the official calls had been made, those assigned to shore-duty were able to pitch into their work. Captain Ault, Parkinson, Scott, and Soule took part in the reoccupation of the Sumay magnetic station. Paul made a two-day trip with a native guide to collect bird-specimens for the National Museum. Another day was spent on the rich Luminao Reef. The commanding officer of the marine sea-plane base generously furnished a launch and necessary equipment for collecting the varied life found in these waters.

The stay was all too brief. Governor and Mrs. Shapley, as well as the whole Naval, Marine, and Cable Station personnel, were very generous in their hospitality. Dances, bridge-parties, and luncheons were arranged; and a memorable dinner at the "Palace" was given in our honor. At this, dishes of native products were featured. It will take long to forget the heart-of-palm salad, and that fresh coconut ice-cream. Throughout our visit the local community had placed themselves and their cars at our disposal; so that many of the hours ashore were spent in long drives into the country, where we could observe the native life.

The people of Guam are called "Chamorros" and are a mixed race in which the Malay strain is predominant. During the centuries of Spanish control, these folk have absorbed many of



A Lane in Agaña, Guam

In this capital city of Guam the family wash is laid flat on coconut-leaves to dry as shown on the left of this picture.

the gracious customs of this people as well as their blood. The Catholic religion seems perfectly suited to them. One can best compare these gentle friendly inhabitants to the Philippine Island-

A Chamorro Woman, Guam
She is wearing the characteristic dress of the native women.

ers. They, too, use the picturesque carabao, or water-buffalo, as beast of burden and are fond of cock-fighting.

Among their many interesting customs may be mentioned the licensing of coconut-trees as we do automobiles. For centuries

the natives have made a mildly intoxicating beverage from the fresh sap of the coconut-tree. In order to discourage this practice and to preserve the trees for nut-bearing, the Government allows each family to set aside one tree for making this drink. The selected tree is issued a license, a simple band of metal; and collecting sap from any other constitutes a punishable offense.

On one of our last evenings in port, the members of our party were taken to Orote Point for an old-fashioned picnic, by the

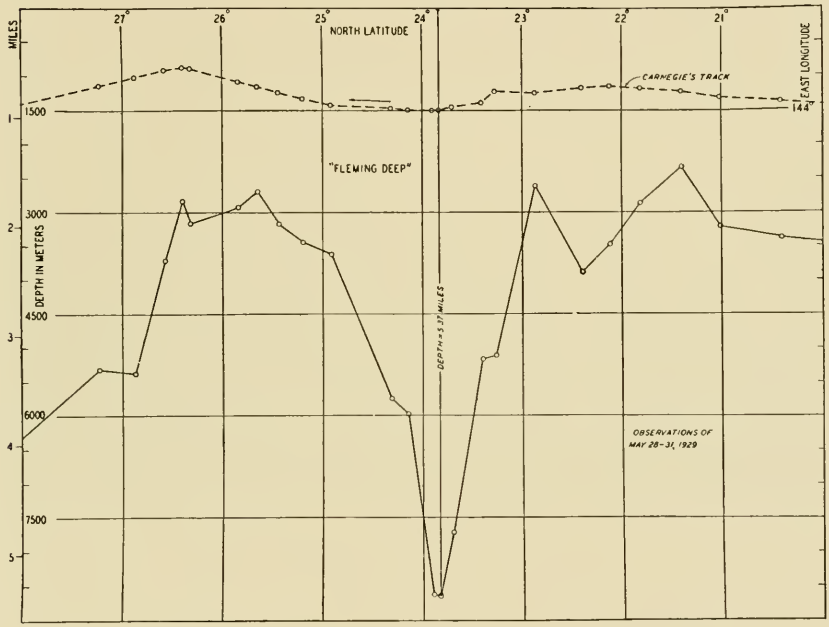


Chart Showing Bottom-profile in the Vicinity of "Fleming Deep"

hospital staff. Swimming, light from a bonfire, real American picnic-fare, and good fellowship made it a glorious event. The chief excitement during the outing was a hermit-crab sweepstakes, in which each person placed his favorite crab in the center of a circle drawn in the sand and watched the very uncertain progress of his steed to the periphery. Of course there was much friendly wrangling over the non-starters. But a little singing of old-fashioned songs brought peace to the family, and we returned under

a magnificent tropical moon. Never had the *Carnegie* looked so beautiful as it did that night. The sails in their gaskets suggested a heavy fall of snow on the yards.

After a visit to the ship by Governor Shapley and his party, and after a reception had been held on board, we made our preparations for leaving. As Guam has very infrequent steamship-service, we had offered to carry mail to Yokohama. So, on May 25, when the sacks were safely stowed, we set sail in a fair breeze northward through the Mariana Islands to Japan.

On May 29, in 24° north and 144° east, we made the deepest sounding of the cruise—8,350 meters. This is about equivalent to the height of Mount Everest. We named this new hole "Fleming Deep" in honor of our Acting Director in Washington. Only a few areas of the ocean-floor are known to be deeper than this.

On the evening of May 31, all eyes were glued to the barograph for the mercury was dropping steadily and we were in the region of the famous "typhoons." By morning there was no doubt about its meaning. The wind and sea had increased, and the ship seemed to be shaking herself awake after her long peaceful months in the tropics. Jones had been picking up daily reports from the Manila Observatory, relayed through an amateur in Guam; and he was able to plot the probable course of the storm-center. The predicted path intersected our course; so at once we headed east by south to draw away from the center. We then hove-to while the wind moderated, and the barometer began to climb. By noting the changes in the wind we were able to tell when the storm had passed our course, and at once set sails to "ride the tail of the typhoon" towards Yokohama. This was our first experience in handling a storm by radio, and as Captain Ault said, everything went like clockwork, just as predicted. By nightfall on June 2 we were wallowing in the swells the typhoon had kicked up and there was not a breath of wind to steady the ship. The next day found us tacking back and forth against a head-wind. The seas had torn away many pieces of sheathing, so that we would have to do some repairing in Yokohama.

While we were in Guam we had secured a native flying-fox, or "finihi," as a pet. This little beast found the cool weather near Japan intolerable and we had to kill it. It resembles a large bat and subsists on tropical fruits such as papaya and bananas. They become quite tame and make interesting pets, if somewhat mischievous.

However, if we really needed more pets on board, little Lena, our Easter Island kitten had grown up and was ready to supply the deficiency. She presented us with nine tiny Easter Island

JAPANESE FISHING-BOAT, THE *Ichio-maru*

This boat was met once after a typhoon near the Mariana Islands and again off the east coast of Japan while we were "swinging ship" a month later.

half-castes about this time. Tom, the big Washington cat did not seem the least interested in his offspring and left them to Lena to bring up. He was far more interested in the fish the sailors caught from the jib-boom or in the shark which was captured about this time.

On June 4, just as we entered the Japan Stream, a Japanese fishing-schooner came alongside, and with excited gestures and much jabbering the crew tried to communicate with us. None of them spoke English and we never found out what they wanted. Some of us thought they were looking for a dory which might

have been lost in the typhoon. Others, that they wished to know if we were fishing or if we had seen any whales. Three weeks later, as were were "swinging ship" for compass-deviation off the east coast of Japan on our way to San Francisco, this same vessel, the *Ichio Maru* again came alongside, the crew this time wreathed in smiles. Then we had to order them to stand clear for fear that her iron and steel would interfere with the magnetic observations we were making.

None of us will forget the heart-breaking night of June 5. For days we had worked prodigiously to whip our records into shape for mailing so that we would not have to spend the first days in port doing clerical work. We had hailed the sighting of Miyake Island at sunset as a sign that we were only a few hours from anchorage in Tokyo Bay. Most of the party stayed up until the reflected rays from Nojima Zaki Light were seen; for this Light was on the southeast point of the mainland. But the barometer had a story to tell. For several hours it had been steeply gliding downward—but were we not within fifteen miles of the bay?

At one-thirty in the morning conditions became so threatening that there was nothing to do but heave to awaiting developments. By three-thirty we were forced to turn tail and beat our way back to the open sea in the face of a rising gale; for we were far too close to shore to weather another typhoon. For five hours the game little engine fought the increasing wind and waves, in our dash for deep water. But it soon became too rough and the vessel was compelled to heave to only twenty miles off shore. We had nothing to do now but to ride it out, hoping that the Japan Stream would help us clear the coast which threatened to the north. All this time the barometer continued to drop, the wind became more violent and the vessel did her best to dip her yards in the seething sea. The first sail to go was the fore topmast-staysail. Then with a loud report went the main-staysail. The next damage was the loss of a scupper-door which was ripped off when we shipped an unusually big sea. Luckily no masts or stays were broken. On a previous cruise the gallant mast snapped and caused considerable trouble.

But by noon the barometer steadied, the wind shifted to west-

ward and we knew that the second typhoon was safely out-maneuvered. Had we pushed on into the bay during the night, we would have met the storm head-on in the uncomfortably narrow waters of Tokyo Bay; a radio message informed us that it passed ten miles to the northward. After the usual "eye" of the storm had passed, during which a dead calm prevails, we took advantage of the northeast wind that followed, and headed once more for

THE *Carnegie* HOVE-TO AFTER A STORM
Waiting for the sea to moderate.

the entrance. No stars were visible to determine our position, but a mail-steamer, bound for Yokohama, came along and enabled us to improve our course. Racing to the entrance at ten knots with a booming breeze we were now forced to tack against a strong head-wind up the bay. Almost nine hours were required for this short stretch and we had to anchor outside the breakwater till morning. We lay within a few yards of the spot where our former magnetic survey-ship, the *Galilee*, was blown aground and sunk by a typhoon in 1906.

By noon of the next day we were safely moored inside the breakwater, and our round of port duties had commenced. Because we

Two Japanese Flappers
Their English was a Japanese version of American slang.

were a week behind schedule it was decided to shorten our stay in Japan to two weeks. Arrangements had been made for our

twenty-fifth anniversary celebration in San Francisco; so we must not be late for that. Then, there was another reason for getting to the United States on time. As Captain Ault stated in a letter to the Office in Washington: "The necessity for scientific conferences, visits back and forth, inspection of equipment on board, and intercomparisons (or the magnetic and electric instruments with those on shore) made it rather difficult to find time for much-

MAGNETIC OBSERVATORY AT KAKIOKA, JAPAN
While comparing our instruments here the observers enjoyed a real earthquake.

needed relaxation." Such a rest could much better be taken at home than in a foreign port.

Throughout our visit, the party was shown every courtesy and attention by the Japanese, many of whom were scientific colleagues or former acquaintances. Paul had the good fortune to meet his father who was in Japan on business at the time.

Various members of the staff inspected the work of the Kakioka Magnetic Observatory (where we compared our instruments), the Meteorological Office, the Marine Observatory, and research-ship *Synpu-Maru* in Kobe, the Observatory at Kyoto, Hydro-

graphic Office, and Bureau of Weights and Standards, as well as certain other departments of the Government and Imperial University interested in physical and biological work.

On board, nets were mended, rigging set-up, the sails which were torn in the typhoon renewed, scientific and ship's supplies replenished, instruments conditioned, and the damage from the

THE STAFF OF THE KAKIOKA MAGNETIC OBSERVATORY

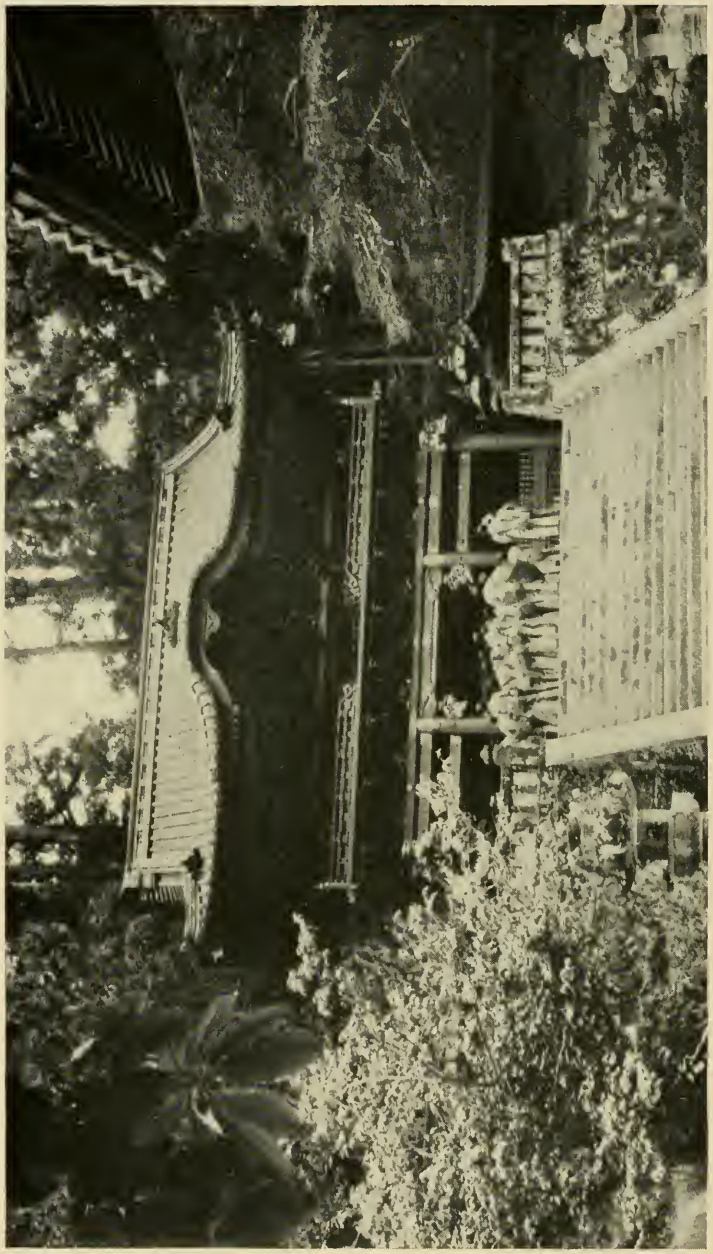
These men were chiefly trained abroad and maintain a splendid station for collecting magnetic data.

air-tank explosion repaired. Besides this, we had just received the bronze anchor which was lost at Easter Island under such exciting circumstances. This anchor had been fished up by native divers, had been carried by the little Chilean tug *Antartico* to Valparaiso and had crossed the Pacific on a Japanese liner.

The *Carnegie* was moored in the inner harbor throughout our stay. It was a very interesting spot. Not since Hamburg had

KEGON FALLS NEAR NIKKO

Every year some Japanese students romantically commit suicide by jumping into the chasm below.



School Children on Pilgrimage to Shrine at Nikko

we seen such a busy port. Steamers were arriving continuously from every part of the world. Behind us were the great shipbuilding-yards where giant motor-ships were being constructed to give Japan a modern merchant marine. From our mooring we could get occasional glimpses of Mount Fuji in the distance—a very impressive sight.

SACRED RED LACQUER BRIDGE AT NIKKO

Only the Emperor may cross here—a recent American President gracefully refused an invitation to break the ancient taboo.

After arrangements had been made through Dr. Nakamura and Mr. Ono, Captain Ault and Parkinson took ashore the magnetic instruments for the comparisons at the Kakioka Observatory which is about forty miles northeast of Tokyo. They were engaged in this work until Sunday when they made a trip to Nikko. While they were at the Observatory they experienced a first-class earthquake. Captain Ault writes: "About five-thirty one morning a rumbling noise was heard resembling a heavy train crossing a wooden bridge in the distance. The suspended magnet

began to tremble; the wooden building in which we were working began to creak and groan as though in a violent windstorm; and our chairs began to bump along the floor. After our first startled shout of 'earthquake,' Parkinson and I just sat and grinned at each other during the minute and a half of the disturbance and hoped that the building would hold together."

They had no more than arrived back in Yokohama when a delegation of Japanese scientists invited our party to visit the oceanographic research-ship, the *Synpu-Maru*, in Kobe; and the meteorological station at Kyoto. It was impossible for all of us to leave our work so Captain Ault and Parkinson again packed up for the two-day trip.

The survey-ship was found to be well equipped and the officers were justly proud of the work they were accomplishing in physical and chemical oceanography in the waters surrounding Japan. A visit was made to the marine laboratories as well. On the way back to Yokohama, Captain Ault and Parkinson stopped off in Kyoto, the ancient capital of Japan, to see the Meteorological Observatory there. Wherever they went they found excellent equipment, splendid buildings, and enthusiastic scientific workers.

While they were away on their trips to other cities, Captain Ault and Parkinson had several opportunities for eating in Japanese style. At Kyoto they had a lunch with Dr. Tsukuda which they described on their return. As soon as they entered they removed their shoes and were taken to one of the many dining cubicles for the guests do not all eat in the same room as in our public restaurants. They had no more than seated themselves on the floor-cushions when a bowl of hot barley-soup was handed to them. Preparations were now made for cooking the meal. A shallow chafing-dish was brought in and placed on a low table in the center of the room—over a hidden gas jet. Everything they ate except the soup and rice was cooked in their presence. Dishes of sliced fresh meat, onions, celery, bamboo-shoots, and sauce were arranged about the table and the waitress placed them in the chafing-dish as required. When the meat and vegetables were ready, small bowls of boiled rice were brought and everyone pitched in. Each guest had his chopsticks and with

THE JAPANESE OCEANOGRAPHIC RESEARCH-VESSEL THE *Synpu-maru*

OFFICERS AND CREW OF THE *Synpu-maru*

The Japanese research-ship which makes oceanographic studies of the waters near Japan.

them he removed whatever he wished from the chafing-dish in the center, or from the side-dish of pickles. When everyone had finished, steaming towels were passed around to take the place of our napkins.

By some magic, Captain Ault himself found time to see a base-ball-game in Japan. In describing this game he says: "The ball-game was a good one and we nearly collapsed from laughter at the unusual manner of playing baseball in Japan. They were up to all the tricks, bunts, hooked slides, pulling off a double steal of second and home twice. It was odd to see each batter bow to the umpire behind the plate when he came up to bat and if a runner spiked a baseman when sliding, he bowed and ceremoniously tipped his cap. Nobody bawled out the umpires, of which there were three—regular world's series style. But the home-plate man was the chief "shogun." For an outfield catch he would rush down the field as far as second base and for a foul catch he would outrush the catcher by five yards. He insured good pitching by calling everything a ball that did not cut the heart of the pan. Everybody was smiling—even the third baseman after making three wild throws. They say baseball is even more popular in Japan than in the United States."

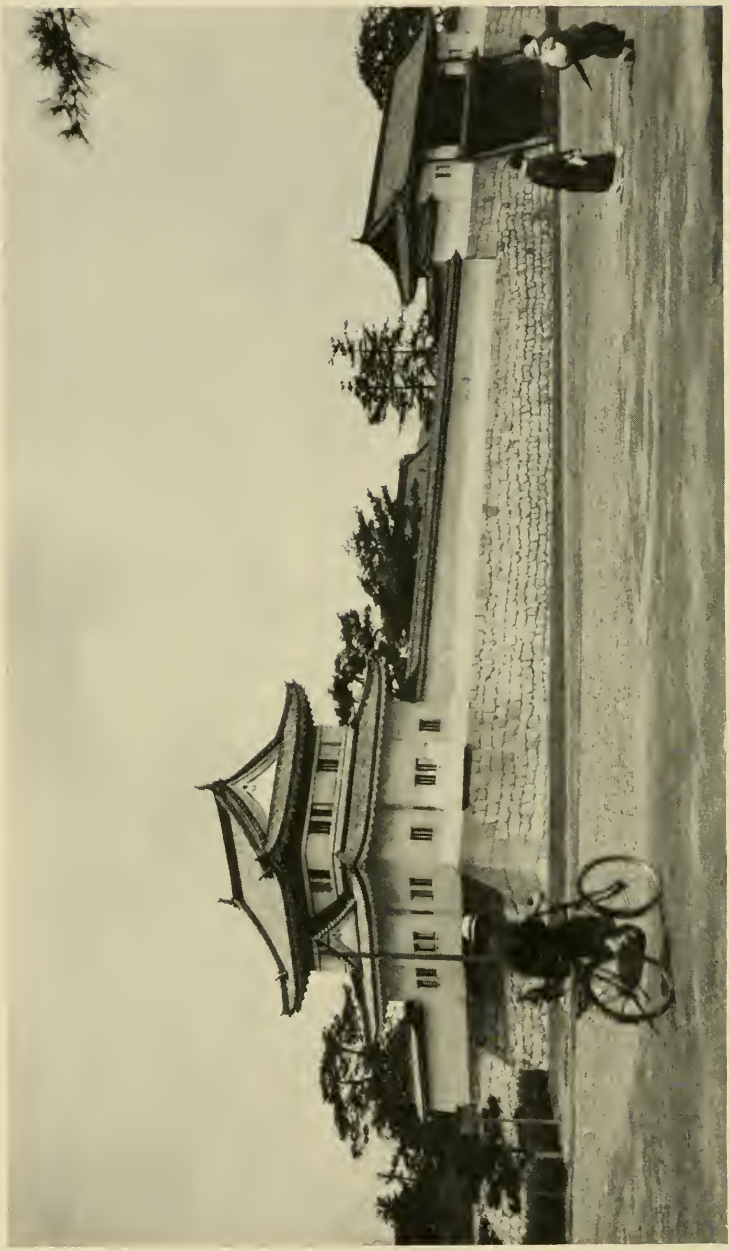
During our stay in port, several dinners were given in our honor. The most impressive of these was at the Imperial Academy of Sciences in Tokyo. There were about fifty members present. The average age of our hosts was sixty-two, so even Captain Ault felt like a youngster. Several addresses were delivered felicitating us on our work and at the end of the ceremonies we were presented with a fine copy of the two-volume report on the Pan-Pacific Scientific Congress held in Japan in 1926. From the roof of the building in which we dined a magnificent view of Tokyo was obtained. On the areas destroyed by the great earthquake and fire there now rise substantial cement and steel buildings with wide boulevards and canals replacing the narrow, crooked streets of former times. It is impossible to admire these people enough for the energy they have shown in rebuilding one of the largest cities in the world—all in the space of a few years!

Another dinner was given in Kamakura a seaside resort not

far from Yokohama. This city is famed as the place where the Great Buddha is located. We were the guests of about fifteen Japanese scientists from the various observatories in and about

The Old Japanese Method of Sawing Logs
The weight of the saw does most of the work.

Tokyo. After the dinner one of the Japanese gentlemen suggested that we sign a few postal cards and forward them to our Director, Dr. Bauer, and to our families at home.



Wall Around the Old Imperial Palace at Kyoto

On June 20, we held an "at home" aboard the ship and throughout the day boatload after boatload of keenly-interested scientific men and technical students inspected our equipment. Cameras clicked, pencils scratched, and questions were fired, as the visitors made the rounds. Nowhere had a more lively and intelligent interest been displayed in the vessel. Virtually every laboratory and observatory in this part of Japan had sent its delegation.

We had passed a delightful fortnight in the invigorating atmosphere of this busy, progressive country. We had made most satisfactory contacts with Japanese men of science and our necessary shore-work was completed. So on June 24 we sailed down the bay—Homeward Bound!

We were to be short-handed in the crew as well as in the staff; for the Tahitian sailor who had signed on in Papeete did not report for duty on sailing day. No substitute could be found. There was an additional handicap in that the piano-wire ordered from Germany had not arrived in time to be taken aboard. It would be necessary to use the utmost caution in getting bottom-samples for by now we had no reserve supply of wire.

YOKOHAMA TO SAN FRANCISCO TO HONOLULU TO TUTUILA TO APIA

The head-wind encountered in sailing out of port made it necessary to use the engine and fore-and-aft sails; so we required even more time to make the southward passage than in coming in. Tacking was most difficult in a bay cluttered up with junks and fishing-boats, often in long tows of six or eight, or connected by seines.

The first ten days brought calms and variable winds so that we averaged only ninety miles a day even with the engine running. However, these calms gave us favorable conditions for "swinging ship" for magnetic deviations. On the Fourth of July we entered the cold fogs and drizzle of the North Pacific. In this region we were to see only fleeting glimpses of the sun for two weeks or more. The copper stove was put into commission to heat the cabin, and was not removed until our arrival at San Francisco four weeks later. Adverse winds drove us three hundred miles

out of our course between July 9 and 12; yet the fair breezes we encountered on the 14th drove us through the water toward home at the rate of two hundred miles a day for twenty days.

The overcast, foggy weather seriously interfered with much of our work. Declination-observations, in which the position of the sun is used in determining the compass-error, had virtually

CAPTAIN AULT ABOUT TO DESCEND IN THE DIVING-HELMET

To untangle the sounding-wires which had fouled the oscillator in the keel during an oceanographic station.

to be abandoned. Pilot-balloon flights were impossible; and atmospheric-electric work was considerably hampered. However, the most discouraging result of this wretched weather was that the whole party came down with heavy colds and Parkinson was so ill that he was confined to bed.

The first oceanographic station after leaving Yokohama required seven hours to complete. The strong currents fouled the piano-wire with the bottle-series. This event was more serious

than usual, because we were now using the last of our piano-wire and we could not afford to sacrifice it to save time. Captain Ault was forced to don the diving-helmet to locate the tangle which seemed to be in the vicinity of the ship's keel. The use of this apparatus at sea is dangerous at best and we were rolling and pitching so badly that it was difficult for him to keep the helmet on his shoulders. It was found that the piano-wire had fouled

Observing the Flight of a Pilot-balloon

Captain Ault devised a special chair for the sextant in which the weight of the instrument is taken up by a coil spring eliminating the tremendous physical strain on the observer's arms in holding up the sextant from 20 to 70 minutes.

the oscillator. By lowering a lead weight down this wire the obstruction was cleared without a loss of equipment.

While we were in Japan the steward had bought a canary. He found that it did not sing well enough and before he left port he bought it a portable phonograph and a "canary-record" to give it encouragement. He had bought a second record at the same time, some sort of a Danish dance-tune. So from morning till night we heard either one or the other of these selections. It got on our nerves so much that in self defense we presented him with some of our own discs.

On the voyage from Guam, Captain Ault had designed a more elaborate sextant-chair than the one we had been using. It was constructed in Japan and we were now giving it a trial. The whole chair was mounted on an azimuth-turntable so that the sextant observer could not only give the theodolite man the altitude but also an approximate horizontal angle, should the latter lose track of the balloon. It was found to check within two degrees on the average—much better than expected.

Our bottom-sampling program was very successful. Leaving the weights at the bottom reduced considerably the time of operation and saved power. At several stations duplicate samples were obtained, one to be used by the American Telephone and Telegraph Company in experimental work on corrosion of various metals.

The frequent use of our main engine during the first week had so seriously depleted our stock of gasoline that we made plans to stop in at Dutch Harbor, Unalaska, to refill our tanks. However, after we had picked up the strong southwesterly winds we decided to stay on our course.

The strong winds and currents encountered in the latter half of this passage resulted in large angles of the aluminum-bronze wire to which the reversing deep-sea thermometers and bottles were attached. Here we met with an old difficulty; the bronze messengers sent down to release the bottles descended with too little force to be effective. By drilling out large holes in the messengers and filling them with lead the weight was almost doubled. This expedient was so successful that we were able to secure data on salt-content and temperature down to a depth of 3,500 meters with a wind of "force 6" on the Beaufort scale.

We crossed the 180th meridian on July 14 so that we repeated that date. The sea was so rough that Captain Ault gave orders to break the usual routine by making magnetic observations as on the previous day instead of heaving to for oceanographic work.

On July 6 while waiting for the deep-sea thermometers to reach the temperature of the surrounding water we amused ourselves by catching a "gooney" or black-footed albatross. These enormous birds, so graceful in flight, are clumsy beyond belief

when placed on deck. The gentlest surge of the vessel sends them sprawling into the scuppers and after a few moments aboard they become miserably sea-sick. An astonishing thing about them is that they do not seem to be able to fly from the deck. Like a sea-plane, they require a long stretch of water as a "take-

A "Gooney" or Black-footed Albatross

These birds are comical when placed on deck, in which case they are unable to "take-off" and become miserably sea-sick.

off." They are easily caught with a strong fish-line to which is attached a triangle cut from a kerosene tin. A piece of bacon or pork is tied to one side of the triangle and when the bird pecks at it a steady pull of the line catches him by his curved beak and he is hauled aboard without injury.

On July 9 the oceanographic station disclosed the interesting fact that the temperature of the water at the 100-meter depth, namely, one and one-half degrees Centigrade, was the same as at 5,500 meters. This showed an enormous inflow of cold water from the Bering Sea.

For the first time in about three weeks we had a few hours of sunshine on July 21. Parkinson and the others had finally recovered from their colds; the vessel was bounding along at over two-hundred miles a day and we were nearing home. To cele-

The "Gooney" or Black-footed Albatross, a Constant Companion in the North Pacific

brate the change in our spirits the whole sea burst into bloom for we entered an area where for hour after hour we plowed through millions of "by-the-wind sailors" or *velella*, and goose-neck barnacles; with here and there wind-rows of white froth stretching to the horizon, made up of myriads of tiny shells, with only their mucus floats visible. A single dip of the hand-net would sometimes fill a pint bottle with these delicate purple pteropods. At night we used the depth-light to illuminate the water from below. Long whitish streamers which proved to be colonies of salps were

visible just below the surface. Some of these had disintegrated to such an extent that what seemed to be a solid object in the water was almost impalpable when caught in a dip-net. In this region the goonies came around the ship in whole flocks and not in twos or threes as previously.

We were so far in arrears in our declination-observations due to the continuously overcast skies that someone was posted on deck to give the alarm should the sun show promise of being visible for a few minutes in the morning or afternoon. These heavy clouds not only interfered with the magnetic work but made taking time-sights an arduous task. Then one day we found that our patent-log had been carried away. We never knew whether some large fish had taken the whirling-vanes for a trolling spoon-hook, or whether the log had become entangled in some refuse thrown overboard.

On July 27 the sea was extremely rough with a very strong northwest wind blowing. Surprising enough, the wire-angles at the oceanographic station were quite small. Apparently the wind-drift of the vessel and the sub-surface currents were in the same general direction.

Radio conditions were excellent on this voyage and daily schedules were maintained with the amateur station KUP of the *San Francisco Examiner*. This station arranged to call us every hour as we neared port so that our numerous friends waiting in San Francisco might know when to expect us. For several days we had been listening in on music broadcasts sent on the ordinary long-waves, something we rarely did at sea.

So monotonous had the sound of our little fog-horn become during these weeks that we almost welcomed the ear-splitting roar of the fog-signal from a liner which all but ran us down as we closed in on the California coast. As our time-sights were a little uncertain on the last day out we navigated by soundings. Jones also improvised a radio compass on the back of the Joshua chair. Our landfall was the ugly grunt of the Point Reyes fog-signal which we picked up slightly off our port bow.

By six o'clock on the evening of July 28, we were riding at anchor off quarantine in San Francisco Bay, the gloomy passage

from Yokohama behind us and four weeks of sunny shore-work and relaxation ahead.

On shore, many of the party found relatives and friends awaiting them. Captain Ault was met by Mrs. Ault and his two daughters, Soule was greeted by his parents, Scott was welcomed by his sister, Paul found his mother and brother. But these reunions were not to postpone our immediate duties; everyone wished to complete these as soon as possible to allow time for leave.

Accordingly, sites for magnetic intercomparisons were surveyed, tents were set up, instruments mounted, and all made ready for the long day of "swinging ship" on July 31. As the vessel sailed back and forth in the spacious bay on different headings, making observations with the marine instruments, Parkinson and Paul were simultaneously taking readings on shore at Goat Island. Completing the program of swinging ship that evening we entered dry-dock where we were laid up for ten days for a general overhauling for the voyage to New Zealand and round the Horn.

Extensive repairs were made in dry-dock. All the old composition sheathing was removed and replaced with heavier plates. The winch was equipped with roller-bearings to prevent the overheating which developed at many oceanographic stations. The rigging was set up and tarred down. Many repairs were made in the engine-room and galleys. While this work was being done Captain Peters was in charge of the vessel for Captain Ault had gone away to spend a few days with his family.

A considerable change in our personnel took place in San Francisco. Forbush, whom we had met in Peru arrived to relieve Torreson as navigating-officer and as observer in magnetism and atmospheric electricity. Seaton came to relieve Jones, the radio operator and magnetic observer and computer. Graham took over the duties of biologist and chemist from Paul who had been temporarily in charge of this work since April. The men who were leaving us here stayed until we sailed to introduce the new members of the staff to their duties. Changes in the sailing-staff were more extensive: Sturk and Stenstrom replaced Leyer and Bagelman as Engineer and Mechanic; three replacements were made in the forecastle; while the three watch-officers remained the same.

In port we were fortunate in having the help of many members of our Washington staff and of other research workers. Mr. Fleming, our Acting Director; Mr. Peters, who had been Captain of the *Carnegie* on her early cruises; Mr. Gish, who was to make the passage with us to Honolulu in connection with our atmospheric-electric work—all came from headquarters. Dr. McEwen and Dr. Moberg made the journey from La Jolla to help us calibrate our deep-sea thermometers and other oceanographic

Gish Testing the Penetrating-radiation Apparatus at Crystal Lake, San Francisco

The "rays" which are measured with this instrument are the most powerful known; they can penetrate many feet of lead and seem to originate outside our solar system.

equipment. Dr. Moberg also joined us for the voyage to Hawaii to help Graham take hold of his duties as biologist and chemist. Dr. Wright installed the pendulum-apparatus for determining gravity at sea, and instructed Forbush in its operation. Mr. Leahy of L. T. Snow and Company, San Francisco, took upon himself many of the irritating tasks incidental to the overhauling of the ship and reprovisioning.

Mr. Gish brought us some new equipment. He had tested out

a new Kolhörster penetrating-radiation apparatus in Pasadena and with Parkinson subjected it to further trials under the waters of Crystal Lake near San Francisco. This instrument registers the quantity of penetrating-rays reaching the earth and may be lowered into the sea to determine the depth at which this powerful form of energy is absorbed. Mr. Gish also supervised the installation of a photographic conductivity-recorder which had just been designed and constructed in our shop in Washington.

Forbush had brought with him several new chronometers and a photographic time-signal recorder with which time-comparisons could be made accurately to one-tenth of a second and approximately to one-hundredth. These delicate time-checks were necessary for the "gravity-apparatus." He also brought new silk plankton-nets for capturing organisms floating in the sea.

Graham had just come from the Scripps Institution in La Jolla where he had spent a month in studying the methods used in chemical oceanography. He and Dr. Moberg spent most of their time in San Francisco in reconditioning the oceanographic laboratory and in preparing new standard solutions. It was impossible to use the delicate chemical balance on board so these men set up the instrument on the pier. Graham also found time to calibrate the bottles which were to be used in determining the amount of oxygen in sea-water. We had had such difficulty in obtaining distilled water of sufficient purity for our chemical work that it was decided to buy a small still of our own. Before Graham could take it on board he had to sign five copies of an affidavit that it would not be used for making liquor.

The gravity-apparatus which was installed in the cabin by Dr. Wright was now to be tried out for the first time on a surface-vessel. Cruises in Dutch and American submarines had shown that it might be expected to give reliable measurements if the roll of the ship did not exceed 10°. Besides this we were not bothered with constant vibration due to engines. The pendulum-equipment was designed by Dr. Vening Meinesz of Holland and was perhaps the most delicate instrument on board. It recorded photographically the swings of three pendulums and recorded on the same paper the beats of a chronometer whose rate was known

THE *Carnegie* DRESSED FOR THE CELEBRATION OF THE TWENTY-FIFTH ANNIVERSARY OF THE FOUNDING OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM

Several thousands of visitors inspected the vessel and its equipment following the formal exercises held on the quarter-deck.

with great accuracy. From this trace the force of gravity at any place could be calculated.

When the "swinging of the ship" for compass-deviations was completed, the scientific program ashore resolved itself chiefly into magnetic and electric observations at Fort Scott. On board there were instruments to repair, plankton- and bottom-samples to ship to our laboratory, bird-specimens to forward to the National Museum, scientific supplies to stow away, and hydrogen-tanks

VISITORS ON THE QUARTER-DECK
At the twenty-fifth anniversary celebration in San Francisco.

to be refilled. However, between these duties we all had opportunities for visiting the various laboratories in California where physical and oceanographic research were carried on—Mount Wilson Observatory, the Scripps Institution at La Jolla, Leland Stanford laboratories at Palo Alto, Coast and Geodetic Survey ships, Hopkins Marine Laboratory at Pacific Grove, and the University of California laboratories in Berkeley.

While we were in San Francisco the *Graf Zeppelin* arrived from

Japan on her round-the-world flight. She appeared at sunset and made a very impressive sight as she sailed in over the Golden Gate. She was surrounded by swarms of escort-planes which looked as small as flies in comparison.

San Francisco annually celebrates what is called "Harbor Day." At this time all the ships in port are dressed in their best bunting and are open to visitors. So on August 22, the *Carnegie* was aflame with flags and pennants, as though in rehearsal for its own anniversary, which was to be held later amid pomp and circumstance.

At this celebration, on the 26th, Dr. Merriam, President of the Carnegie Institution of Washington; Mr. Storey, one of our Trustees, Dr. Pritchett, President of the Carnegie Corporation; Dr. Adams, Director of the Mount Wilson Observatory; Dr. Campbell, President of the University of California; and about fifty invited guests collected on the quarter-deck for the ceremonies. Short addresses were given outlining the world-wide work of the Department of Terrestrial Magnetism during its first twenty-five years of activity. For several days letters and cablegrams of felicitation arrived from every part of the world.

On the following days, the ship was open for inspection to the general public. Instruments were labeled and transparencies were mounted in the chart-room to show the activities of other departments of the Institution. The staff acted as guides about the vessel. As many as three thousand visitors were counted, attesting the great interest in our unique ship.

Throughout the stay the members of the party took leave for a few days; some to camp in the Sierras, some to motor through the state, others to visit relatives; but all to enjoy a break from routine. The few days spent in a hotel, while the ship was in dry-dock came as a relief from the noise, confusion, and cramped quarters of the ship.

Parkinson made good use of his leave by going to Los Angeles to see moving-pictures being made. He had written to Mary Pickford and had received an invitation from her which opened every door in Hollywood. He was introduced everywhere as "Mary Pickford's friend." Before he left he had seen Charlie Chaplin directing his own play.

Tom, our Washington cat, must have found the attractions of San Francisco too great to resist for he walked ashore one night

THE DOME FOR THE 100-INCH TELESCOPE AT MOUNT WILSON OBSERVATORY, CALIFORNIA

Several of the party visited this Observatory while we were in California.

and never came back. A few days later a kitten came aboard and made herself at home. This one we called "Rosie."

Our long-postponed departure for the South Seas on September

3 was exciting. We had been docked in the midst of the busy ferry-slips and when our lines were cast off it was found that the engine-clutch refused to engage. We were now at the mercy of the strong tide sweeping up the harbor; and with the busy

THE SCIENTIFIC PERSONNEL OF THE *Carnegie* ON LEAVING SAN FRANCISCO IN SEPTEMBER, 1929

Front row, left to right: Parkinson, Captian Ault, Soule; back row, left to right, Forbush, Seaton, Scott, Graham, Paul.

steam-traffic shuttling around us, it was very uncomfortable. The engineer and mechanic struggled to cool the overheated clutch while the officers on the bridge did their best to conceal their disgust. Fortunately, we were drifting southward past the less active piers and soon began to make steerageway under fore-

and-aft sails. The afternoon was well spent before we took departure from the Golden Gate; for we were forced to tack repeatedly in the face of a brisk west wind.

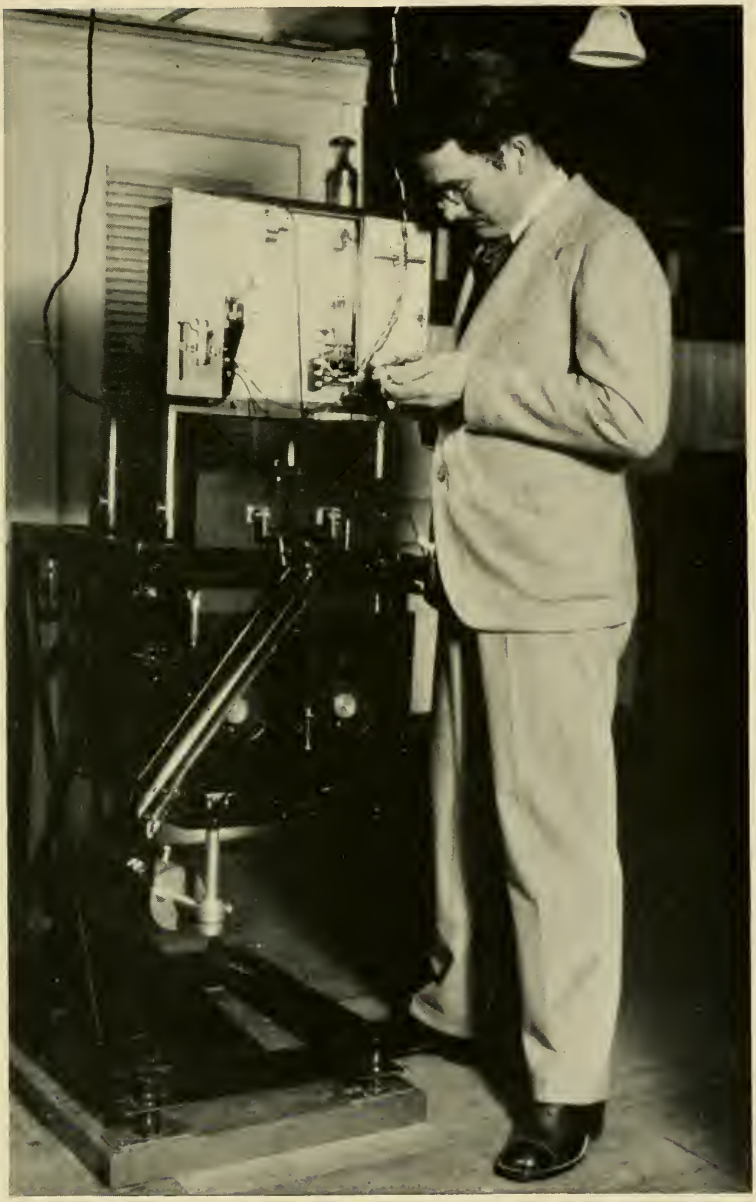
We pushed our way out into a cold, grey evening and into a heavy coast sea. The new men were having an unfair breaking-in, for the vessel rolled and pitched as violently as it had in the stormy waters near Japan. There was much scurrying about of the men as they finished restowing our new supplies before breakage occurred.

The cabin was quite crowded with the addition of Dr. Moberg and Mr. Gish to our ranks. It was necessary to bring out air-mattresses and to take turns sleeping on the floor. Graham had a difficult time keeping himself in bed on one of these cushions. When it was inflated to high pressure he found himself rolling off; when blown up only slightly, he scraped the floor with every roll of the ship. However, a little experimentation and he discovered that the mattress made a perfect gimbal and his difficulties were over. Seaton made himself a hammock.

The whole passage to Honolulu was made in calms and light airs with the exception of a day or two when the trades were picked up. Our engine was given hard usage. The new engine-room gang was initiated by having to spend a thirty-hour session in repairing the Buffalo engine, one of the cylinder-blocks of which had cracked. This machine was our only source of electric power so that there must be no delay in getting it in order.

Dr. Moberg and Graham divided the duties in the chemical laboratory, thereby allowing Paul time to record for the pilot-balloon flights. This relieved Captain Ault, for Scott now read off the sextant-altitudes. Graham was slightly handicapped in his work because of an accident he had suffered a few days out of port. As he emerged from the chart-room one day the heavy door was slammed shut by a sudden lurch of the vessel and his finger was crushed in the lock.

The new triple-size bottom-samplers, made up in San Francisco, were a grand success. With these we were able to secure about four pounds of material instead of about one, thus making it unnecessary to make multiple soundings when large amounts of



FORBUSH MEASURING THE FORCE OF GRAVITY WITH THE PENDULUM-APPARATUS

The *Carnegie* was the first surface-vessel to be equipped with this instrument, previous investigations having been made in submarines.

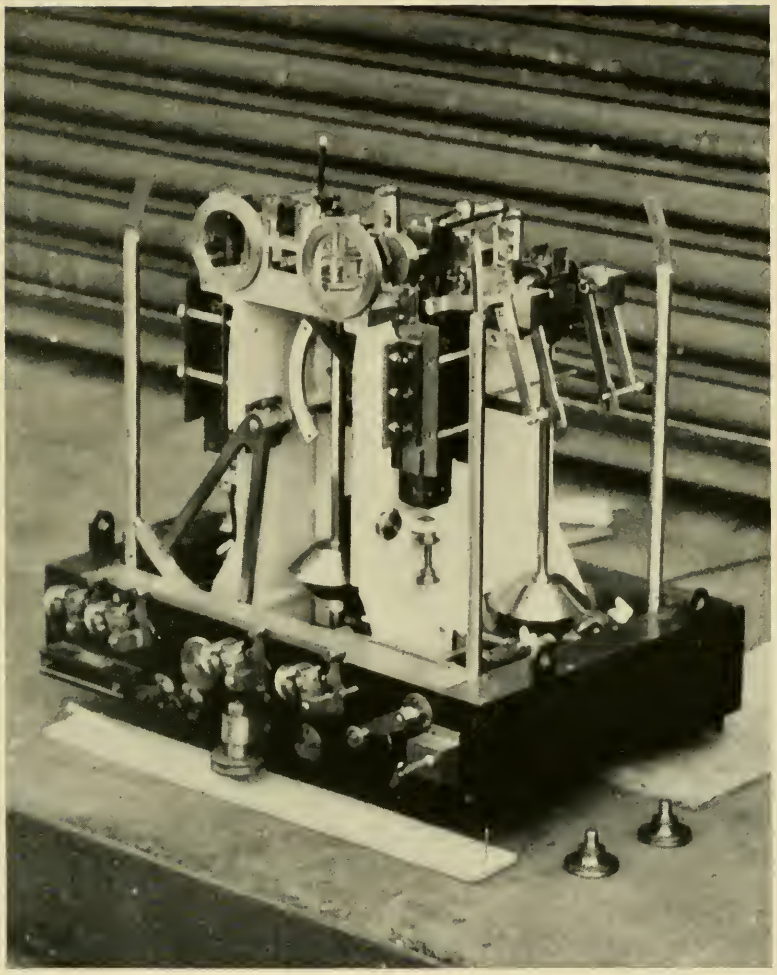
deposit were required. The new theodolite sent to us by the Navy Department was a great improvement since the field of vision was increased.

Forbush gave the gravity-apparatus its first trials. As this instrument had never before been used on a surface-vessel, but only on a submarine, difficulties were anticipated. They came—thick and fast. First, the heavy rolling threw a pendulum out of its support. On the next trial, it was found that the foot-screws were not rigidly enough clamped down. Then it became apparent that some means must be devised for damping the motion of the apparatus. Finally, it was decided that only a new mounting would solve the difficulties. Notwithstanding these setbacks several useful traces were secured.

On September 7 a new peak on the ocean-floor was discovered. This submarine mountain rises about ten thousand feet above the general level of the bottom. We named this Hayes Peak after Dr. Harvey C. Hayes of the Naval Research Laboratory in Washington who had developed the sonic depth-finder for the Navy. The slopes are very steep, there being a rise of 8,500 feet in the distance of six miles.

For a long time we had been casting about for some good form of evening relaxation. There was little enthusiasm for card-playing, while reading books and magazines failed to give us what we wanted. So at Parkinson's suggestion a grand ping-pong tournament was arranged. There were difficulties. Some of the men had never played the game while others were almost experts. The problem was solved by holding a preliminary meet to determine handicaps. During the final games Soule stood by with a slide-rule and calculated the standing of each player to three or four decimals. In the end, the new men came out far ahead for they had shown the greatest improvement in their game.

On September 13 we again entered the region where the sea is covered with *velella* or "by-the-wind sailors." These creatures cannot be captured in a dip-net without destroying the delicate blue tentacles which surround them. It was quite an art to catch them in a canvas-bucket with the ship under way and rolling heavily.



THE PENDULUMS OF THE VENING-MEINESZ GRAVITY-APPARATUS

Installed on the *Carnegie* at San Francisco to obtain measurements of the force of gravity in different parts of the world, which are of great interest to geophysicists in their study of the Earth's crust—these pendulums are made of "invar," an alloy which does not contract or expand with changes in temperature.

One day Parkinson reported abnormally high values for the atmospheric potential-gradient with correspondingly low readings of conductivity and ion-count. Seaton had also noted a severe decrease in radio signal-intensity on the seven-thousand-kilocycle band. These observations indicated that the earth was having a "magnetic storm" so a radiogram was sent to the Cheltenham Observatory in Maryland and to Mount Wilson in California for confirmation. Their instruments had indeed recorded severe disturbances during this period. During these days Seaton had rigged up a shorter radio antenna which increased the strength of the time-signals about seventy per cent.

Our supply of fresh food had been exhausted about a week, when four "dolphins" weighing fifteen pounds each were landed with a hook and line. These made up the most delicious steaks we had ever served as a result of our own fishing. These beautiful fish are called "mahi-mahi" in Hawaii where they are a common article of diet. The play of rainbow colors on their skins when they are taken from the water is exquisite.

By this time the new men had been broken in and had become accustomed to the motion of the vessel. The aid rendered us by Dr. Moberg and Mr. Gish who made this passage as our guests allowed a certain increase in our scientific schedule. They were both favorably impressed with the conditions for work on board and Dr. Moberg, at least, expressed regret that he was unable to continue as a permanent member of the party.

By the effort of our little engine we were now nearing the Hawaiian Islands. Bo'son-birds and flying-fish were seen every day. On the morning of September 22, Maui was sighted with Molokai Light blinking its welcome all evening. After an unusually quiet approach, we docked in Honolulu about noon on the twenty-third.

Our short stay in this port gave us an opportunity to visit the Honolulu Magnetic Observatory, the Bishop Museum for Polynesian Studies, and the Seismological Observatory on the Island of Hawaii. The marvelous collections in the Bishop Museum, which is under the direction of Dr. Gregory, enabled us to identify many plants and animals, besides native products,

which we had seen in our South Sea passages. The staff was most generous. They organized an expedition to Mount Tantalus on which Graham and Paul were able to make a splendid collection of the fast-disappearing native flora of Oahu Island. On September 30 the Museum personnel invited our party to a luncheon where we became better acquainted.

The excursion to the Island of Hawaii took about three days. Forbush, Graham, Gish, and Paul left by the Inter-Island steamer

A "Wiliwili" Tree, Coral Plains, Oahu Island, Hawaii

one evening and entered the harbor of Hilo at sunrise. Here they made a morning's trip by rail along the magnificent coast, later ascending Kilauea Volcano by automobile. For many days earth-tremors had been felt in this region and it was predicted that the great fire-pit was about to become active. In fact the shocks were so frequent and so severe that while inspecting the seismograph set up on the crater-rim the instrument was twice dismantled before their very eyes. Such a coincidence is rare

indeed. But Queen Pele, the Hawaiian goddess of fire, was not to oblige us further, for on the next morning we walked safely over the great lava-lake to see the famous pit of Halemaumau. Lava-moulds, steam-cracks, and trees with clumps of lava entangled in their branches from recent activity made the walk down the crater unusual.

In one of these steam-cracks we were astonished to find whole nests of tiny crustaceans which resembled some of the marine

The Pit of Halemaumau at Kilauea Volcano, Island of Hawaii

This picture was taken at night and shows the lake of molten lava with islands of solid material bobbing up and down with the rise and fall of the liquid fire.

forms we catch in our silk-nets. Specimens were collected for study. How these delicate organisms can exist in the intense heat of these fissures is a mystery.

Back in Honolulu, the Pan-Pacific Union gave a dinner in our honor at which Captain Ault described the work of the *Carnegie*. Following this event we made our preparations for departure.

While in harbor we had had the company of two very interesting sailing-ships. One, the *Vigilant*, Captain Mat Peasley, a five-

masted schooner which still makes the passage between Oregon and Honolulu with lumber and sugar. The other, the *Tusitala*, Captain Barker, out of New York. This full-rigged ship is about the last of such to sail under the American flag.

A Chinese Woman at Work on a Plantation in Hawaii
These enormous sugar-estates have been built up with the help of imported labor.

The *Tusitala* left harbor about an hour behind us on the same course. We were all eager for a trial of speed with her. With her towering three masts and her enormous spread of canvas (including the almost obsolete studdingsails), we had expected to be left far behind. But her heavy cargo was too great a handicap and by sunset only her rose-tinted skysails were visible over the horizon in our wake.

So out we headed to northward, steering close to the trade-winds until we should be far enough north to clear them for the thousand-mile section of the North Pacific along the thirty-fifth parallel.

On the morning of our first day out from Honolulu, we hove-to for an oceanographic station. Everyone was hoping that this three-hour delay might enable the full-rigged ship, *Tusitala*, to catch up; for she had dropped behind us during the night. We

A "Gannet"

Like an albatross this bird is unable to fly from the deck as, like a hydroplane, it needs a long "take-off."

might then start at scratch for a race to clear the trade-wind belt. But she was not sighted again.

The course set by this ship emphasizes the advantage of steam over sails. The *Tusitala* was bound for the Panama Canal, and yet she had to sail a great loop *northward* to escape the northeast trade-winds, before she could make headway east or south. The distance by steamer from San Francisco to Callao for example, is about forty-six hundred miles, while a sailing-vessel to make the best time will cover seventy-six hundred between the same ports!

The seven-week passage to Samoa gave us ideal weather but feeble winds. The engine was used frequently so that we would not fall behind schedule and have to sail round the Horn in an unfavorable season. The full program in magnetism, atmospheric electricity, oceanography, and meteorology, was carried out without interruption; but heavy cross-currents near the Equator caused appalling losses of oceanographic equipment. On October 11 two silk-nets were lost when the tow-wire jumped its sheave and

THE "GANNET" SALUTES
These birds are common in the Pacific.

wore through. To avoid this trouble in the future, the rubber shock-absorber rope was attached directly at the forecastle-head, eliminating blocks entirely. The same day brought another accident, in which we lost a complete bottom-sampling and bottom-temperature outfit, through the catching of a splice in the meter-wheel. But on the 25th we were to suffer the most serious blow of all. The confusing currents below the surface entangled the bottom-wire and the bottle-series. In clearing them, the new aluminum-bronze cable was cut by catching on

an outboard platform. We lost forty-two hundred meters of wire, nine reversing-bottles, and eighteen of our precious deep-sea reversing-thermometers. We could ill afford such depletions in equipment, so from this time on the thermal and chemical series was not lowered until the bottom-sampling was completed. This change almost doubled the time required for a station.

By this time we thought old Neptune had exhausted his supply of practical jokes. But on October 19 we had to repeat the whole

Young Bo'son-birds of the South Pacific

deep-series of chemical and temperature-determinations, because a tiny piece of rope-yarn, caught by the messenger in descending, had prevented it from reversing the bottles. After this the first thought that came into our minds as we came on deck for the day's work, was: "What next?"

Referring to our losses in equipment in a radio message to our headquarters on November 1st, Captain Ault remarked: "From our dynamic computations, the Counter-equatorial Current is a mighty river in the Pacific Ocean flowing thirty miles per day

on the surface near its northern boundary at nine degrees north, with no velocity at two hundred meters depth. . . No wonder our fishing-lines get tangled."

While sailing northward from Honolulu we were struck by a series of wind-squalls that reached such force as to rip the middle staysail, gallant, and foresail. The old sails, some of which had

Captain Ault Releasing Pilot-balloons

These balloons trace the direction and velocity of air-currents in the atmosphere as they rise from the deck.

seen ten years' service, were going one by one. Nevertheless, they were repaired and put back into use to save the new suit of canvas we carried for the voyage from New Zealand around the Horn. Two days later we encountered some remarkably long swells from the northwest. The statoscope was brought out to measure the distance between trough and crest. By observation, the swells were about six hundred feet apart.

The new men had by now learned appropriate *Carnegie* table-manners. In heavy seas, the bent-wood dining-room chairs had a habit of sliding away from the table. The first impulse of the uninitiated was to grab for the nearest support and tug the chair at once back to the table. They soon discovered that proper etiquette required them to sit quietly and wait for the return roll to bring them back to the meal.

At the oceanographic station on October 24 we were surprised to find that the plankton-pump came up much discolored by its immersion in the sea. Over its dull brass surface were spread areas of black and bright green as though it had been suspended in a corrosive fluid. We were at a loss to explain this. Someone suggested that it might be due to some sulfurous acid in the water, for we were in a region where the bottom showed signs of recent volcanic activity. We inquired as to what had been thrown overboard while we were hove to. The cook had emptied a vessel of water in which the ham and cabbage had been boiled; but experiment showed that this fluid did not affect the metal in the same way.

On the following day Forbush put on a vaudeville act. He had rehearsed it in Honolulu and the performance that day was perfect. The stunt consisted of a slide down the cabin-stairs on heels and elbows. Not everyone witnessed the exhibition so he repeated it in a matinee the next day. For a long time he went about the ship with vivid purple elbows.

October 29 was Captain Ault's birthday. Oscar made one of his pastry creations with fancy icings. The Engineer, Sturk, presented the Captain with a beautifully machined miniature flag-pole made out of solid brass with a tiny house-flag flying from the top. The dinner was notable for we had our first meal of canned baked chicken. The evening ended in a hilarious game of "500" where everyone's ambition was directed to lowering the score of the high-stand man instead of accumulating points for himself. On many occasions everyone's score stood several hundred points below zero.

The month of November was ushered in by a terrific downpour of rain, almost five inches falling during the night. When these

heavy showers came during the day, they offered a chance for a fresh-water bath, and were a source of distilled water for rinsing our chemical apparatus. A small sailing-vessel like the *Carnegie* must issue water-rations on these long stretches just as it does food—so much per man per day.

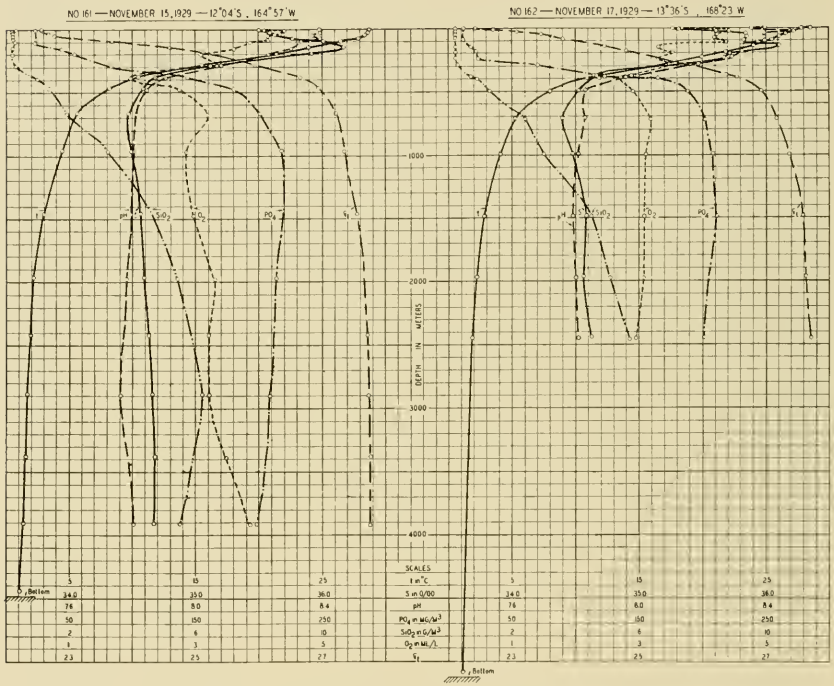
Three things happened on the first to break the monotony of our daily routine. During the night a bo'son-bird struck the main sail with such force as to land stunned on deck. Graham snatched a few moments here and there throughout the day to prepare a suitable skin for museum use. Late in the morning we sighted a steamer, the first sign of human life we had seen for almost a month. Then in the afternoon a handsome brass-bound wooden barrel floated past whose origin caused much speculation. Could it have been that some vessel in distress had floated it with letters inside? We were riding a squall at the time so that it was not feasible to investigate.

By this time we were well down toward the equator again, and our clothing was a good indicator of the temperature. Short pants became shorter every day. The photographic dark-room was like an inferno. Parkinson would appear on deck after changing the traces of his recorders, dripping wet and gasping for air. The heat did not discourage Seaton from the tumbling exercises he took daily on the quarter-deck. There was no need to take sun-baths as we were exposed only too much already during the three-or-four-hour oceanographic stations in our abbreviated costumes.

As we neared the equator, the neophytes aboard were beginning to show a little uneasiness, for tales of the horrors of a Neptune ceremony were circulating about the ship. But when November 5th came around, and the line was crossed, one could hear only the scratching of pencils, the rhythmic buzz of time-signals, and the click of typewriters, as the staff went about the routine that recognized no labor-laws.

When we had arranged to tow the plankton-nets from the bow of the ship we had dismissed from our minds any possibility of their becoming entangled with the quarter-deck wires. But on November 5 the unexpected happened. We were fortunate in losing only two thermometers and in tearing the nets slightly.

We had been trying to lay a course which would take us past Penrhyn and Manihiki Islands but the wind continued to make that difficult. On the third Captain Ault suggested that unless the wind veered around he might consider calling at Christmas Island instead, for it lay well to leeward. This would have enabled us to make a gravity-determination in quiet waters and



Scientific Results from Oceanographic Stations Numbers 161 and 162

would have given us a chance to visit the domain of Father Rougier, our host in Tahiti. However, a day or two later brought a fair breeze for our intended course and we proceeded southwestward.

We were taken by surprise on November 8. At seven-thirty A. M., the sonic depth-finder gave a sounding of fifty-two hundred meters. During the station, beginning at eight A.M., the lowest

bottle of the series was lowered to four thousand meters. But when it was brought up, it contained globigerina ooze, showing that it had been on the bottom. A second sounding was made at once, and confirmed the shoaling of twelve hundred meters in a few miles. All through these regions such irregularities of sea-floor had been noted, but seldom so striking as this. On this day Tony our cabin-boy caught four bonitos which furnished fresh fish dinners for everyone.

Since Graham had joined the party, the chemical program had been expanded to include determinations of silicates, phosphates, oxygen, and hydrogen-ions at each station. With his help it was

THE BOAT-HARBOR, LAGOON, PENRHYN ISLAND

The resident white man, Mr. Wilson, was washed ashore here in 1888, following the wreck of the *Derby Park*, and has never left the island.

possible to add a vertical haul of a silk-net from one hundred and fifty meters, at each station, besides occasionally checking the plankton-pump. The pump determined the number of organisms floating in the water and to check its efficiency one filtered a known volume of sea-water collected in a large bottle through a small silk-net, and counted the marine plants and animals so captured.

On November 10, it was decided to heave to in the lee of Penrhyn Island to get a good measurement of the force of gravity. The apparatus had not proved a success on the open sea. This short stop enabled us to collect biological specimens and diatoms from the lagoon, and furnished a little recreation. This tiny atoll lies about midway between the Marquesas and Samoa, and is

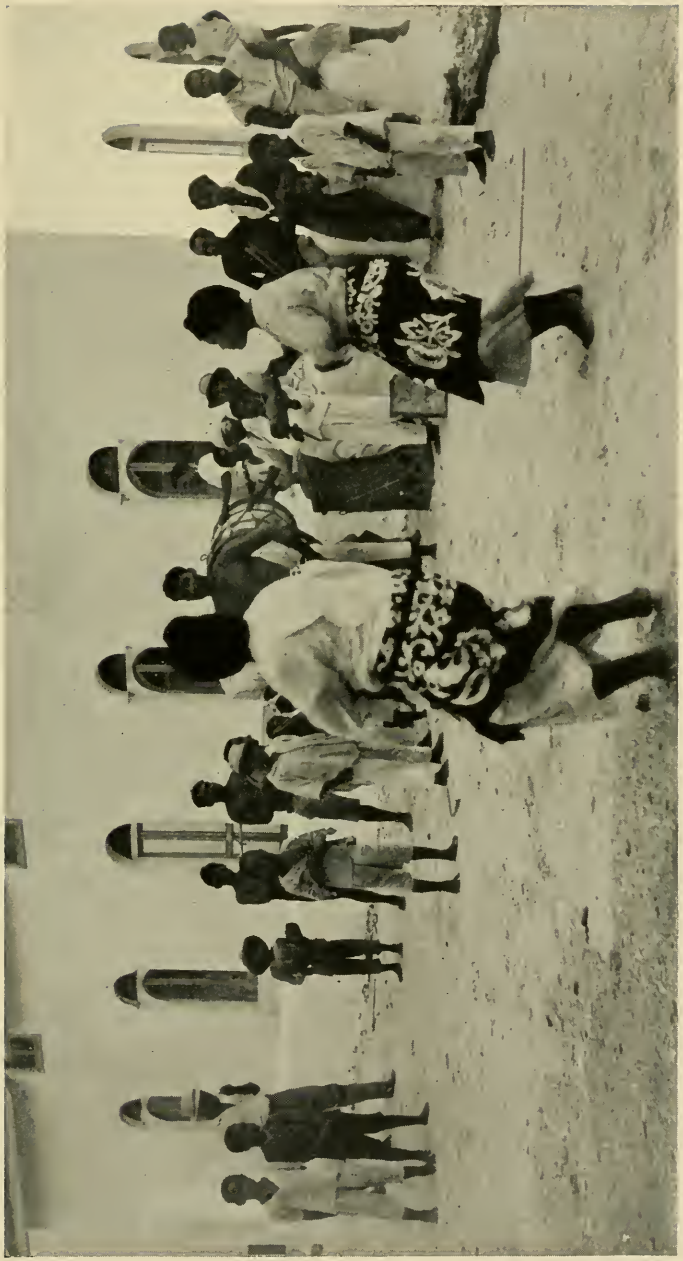
rarely visited by ships. The *Carnegie* had stopped there on a previous cruise, so that we were certain of a welcome from the white resident, Mr. Wilson. He was a castaway from the shipwrecked *Derby Park* in 1888, and he has never since left the Island.

Once ashore we found, besides Mr. Wilson, a white merchant named Wilkinson, whom we had met in Tahiti in the spring; and a pearl-trader by the name of Woonton. These men at once prepared a grand feast for us, while we rambled about the village, or fished the lagoon for specimens. Our hosts regaled us with many a South Sea yarn, as we sat on the verandahs drinking fresh coconut-milk.

The natives are chiefly engaged in the pearl-fishery. On bringing up a good specimen, they take it to the trader, who allows a withdrawal of goods from his store to the value of the gem. There is no system of credit, so the lucky diver simply carries five or ten bags of flour, or a few cases of canned meat, to the center of the village, and invites everyone to help himself. In the long run, it is fair enough to everyone, and the natives seldom lack food and clothes. Of course, there is no chance for building fortunes; but all through Polynesia we noted the same happy-go-lucky way of living.

Two days later we made a similar call at Manihiki Island; here the gravity-measurements were not so successful, due to the swells coming in from the west. The Resident Agent, Mr. Williams, an old friend of a previous *Carnegie* cruise, gave us a hearty welcome to his charming island empire. This atoll offered a striking contrast to Penrhyn. Immaculate coral paths divided the neat little houses and flower-gardens into "blocks." The natives were well dressed; the coconut-palms were properly spaced and pruned for maximum production. Everywhere were evidences of a fatherly care on the part of old Mr. Williams. To the *Carnegie* this Island is chiefly remembered for its characteristic dance. On a previous cruise photographs and moving pictures of this unique performance were destroyed by an accident in developing. And we were fated to lose ours for another reason.

In the afternoon, Mr. Williams rounded up the villagers in the large white building that serves for town-hall, post-office, and



A Rehearsal for the Unique Native Dance of the Manihiki Islanders
The orchestra consists of percussion-instruments only.

school. The natives, who had just completed a hilarious celebration of Armistice Day, were on the verge of physical exhaustion; but they were willing to repeat it all for our benefit. The orchestra for the grand "fandango" was unique. It consisted of a collection of some twelve or fifteen percussion-instruments: large drums made by stretching pigskin over the hollowed trunk of a coconut-tree, smaller drums of conventional design, hollow blocks

Dancing in the Churchyard at Manihiki Island

of wood, hard-wood sticks, and an empty kerosene tin. With this apparatus they were able to play the most complex patterns of rhythm, perfectly suited to their dance—a performance which amazed us all.

The whole of the able-bodied population participates. Ranks are formed as for a military drill, and leaders take their places at the head of each file. The "orchestra" now strikes up its barbaric rhythm, and at the shouted commands of the leaders, the dancers

start their wild shakings and gyrations—motions which would reduce a white man to pulp in a few moments.

We found here exquisite inlay-work in native woods, besides the fine plaited hats and fans for which the Island is noted. The wood of the coconut-tree, which we had believed valueless, is here used for many purposes, and looks well when polished. Almost everyone on board had been bartering for these products, and for small pearls. The "singlet" was the most usual medium of exchange, just as it had been in Easter Island and Penrhyn; although dark trousers or old coats were much in demand. Some of the party in this way accumulated a respectable number of seed-pearls. Captain Ault was presented with two very fine specimens by the Resident Agent as he bade us farewell.

We were now but a few days from Samoa, and the fast dwindling supply of gasoline was eked out by catching every breath of air that blew our way. Reports and computations for the voyage about to close kept all hands at work till late at night.

The temperature of the ocean-bottom had been measured at almost every oceanographic station since Honolulu, but just outside Samoa we recorded our lowest—one and one-tenth degrees Centigrade. Another interesting observation was that in this region of long-continued calms, the surface may be almost a whole degree warmer than the water five meters below it; differences of one or two hundredths degrees are usual, when winds mix the surface-layers. There was also a two-degree diurnal variation at the surface due to the sunshine.

The outstanding result of our echo-sounding was the discovery of a new submarine ridge just north of Hawaii. We were able also to show that there is no deep trough between Penrhyn and Manihiki, as the charts would lead one to believe. The slopes of these two islands, as well as that of Tutuila, were carefully plotted.

Pilot-balloon flights had been very successful, thanks to the fine skies and the new theodolite. This instrument was so well adapted to conditions, that the sextant-chair designed by Captain Ault was seldom used.

Radio conditions had been unexcelled throughout the entire trip. Daily schedules with many amateurs in the United States,

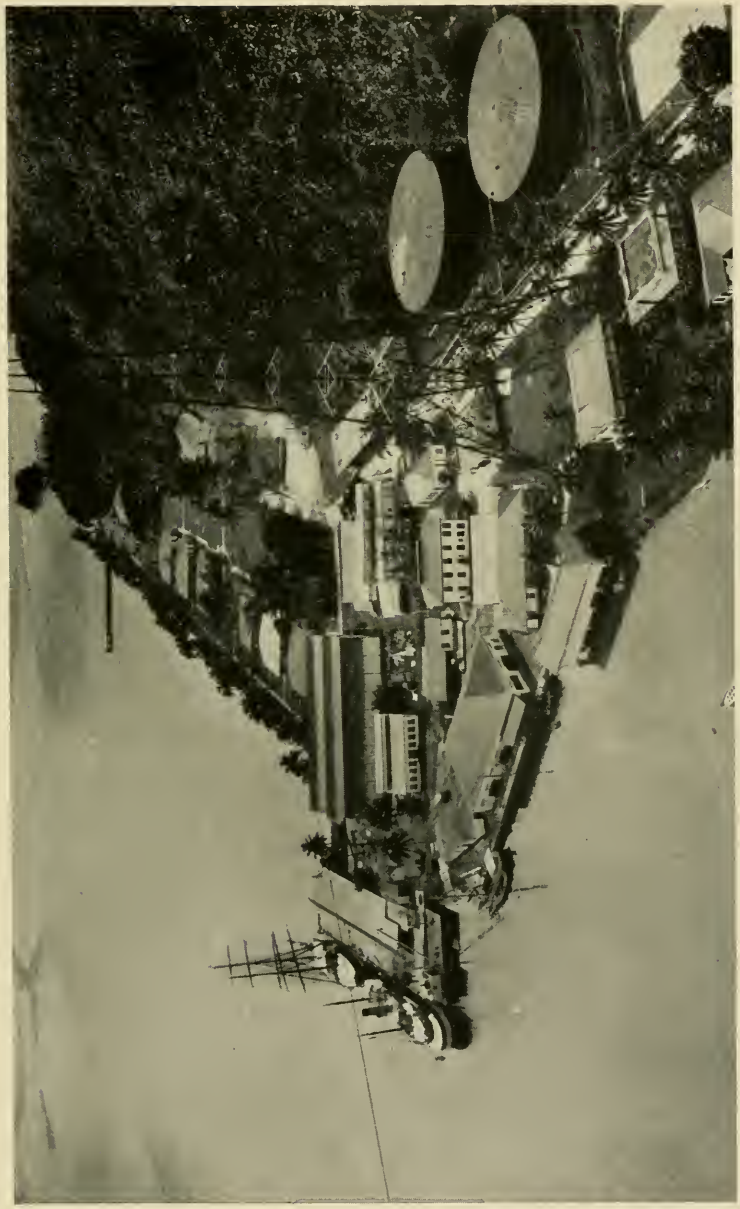
Hawaii, and Australia had brought us the news of the world, and had kept us in constant touch with our home office. As an instance to show the faithful services of these enthusiasts, we might mention the operator of station W6DZY. He transmitted a two-hundred word technical message for us and finished by stating that he had just broken three fingers, due to the fall of a heavy piece of machinery.

Entering Pago Pago Harbor in the early afternoon of November 19, we did not have darkness to contend with as we did in the spring, when we nearly piled up on the reef. But this time the little engine was pushed to the limit in bucking the powerful windsqualls that swooped down from the mountains surrounding the bay. Time and again we were stopped dead in our tracks by these sudden gusts, almost losing steerageway at times. Because of the danger in tying up to the wharf under these conditions, we made fast to a buoy until the following morning.

The landing this time was almost a home-coming. Our friends of the spring were on hand to welcome us, with here and there a new face among them. The hospitality of the Naval Station was extended to us, as before. Since we were to remain here over a week, we had a better opportunity for observing Samoan life and for making collections on shore. Once the records and specimens were forwarded to headquarters, we found time to make several delightful excursions to native villages and into the mountains.

A native chief from the Leone district invited the party to make a "malaga," or overnight outing to his village. So on Saturday evening we chartered a bus, and drove along the palm-shadowed shore road to the western end of Tutuila. We found the chief's own "fale," or house, dressed up in fresh coconut-leaves and ginger-blossoms for our use. The party was at once seated on mats, inside the circle of pillars supporting the thatched roof, for the Samoan "kava"-ceremony.

The old chief, with his talking-chief beside him, relayed to us his flattering words of welcome, while the village virgin with her two maids went about the task of preparing the national ceremonial beverage. Large pieces of kava-root are powdered be-



THE *Carnegie* AT DOCK, NAVAL STATION, PAGO PAGO, AMERICAN SAMOA

The photograph was taken from the radio tower and shows the U. S. S. *Ontario* which came to our aid when the ship was destroyed in Apia in November.

tween stones, and placed in an ornate shallow bowl carved from a single piece of wood. The "taupo's" helper pours water on the shredded root from a coconut-shell, while the young mistress of ceremonies stirs the mixture with her hands. She then takes a long switch made of bark, rolls it into a ball, and sweeps it around

Bowl, Coconut Dipper, Switch, and Dried Root Used in Making "Kava," the Ceremonial Drink of Samoa
The natives do not use intoxicating liquors. (From Churchill.)

in the bowl until all the root-fibres are caught in it; then she throws it over her shoulder to a young man outside. The "taupo" now announces through her "talking-maid" that the kava is ready. The chief then chants "The kava is clear," and claps his hands for silence.

Each guest is served in turn from a common coconut-shell, the chief indicating whose turn it is by singing in a high-pitched voice a complimentary description of the guest, if his name is unknown. When one's name is called, it is customary to clap the hands, so that the serving-maid may know to whom the kava is to be served. The coconut-shell is held over the kava-bowl, while the taupo half-fills it with beverage wrung from the switch.

With a long-low, sweeping gesture, the drink is presented to the guest, who takes it at a gulp. A trace must be left in the bottom which he spills on the pebbles outside to rinse the shell for the next man. And so around the circle, guests being served strictly according to rank. The drink itself has an insipid flavor which is hard to describe. It is a pearly grey color and leaves a refreshing though faintly peppery taste in the mouth. It is said that the taste was far better in the old days when the root was first thoroughly chewed by the "taupo" before being macerated in water.

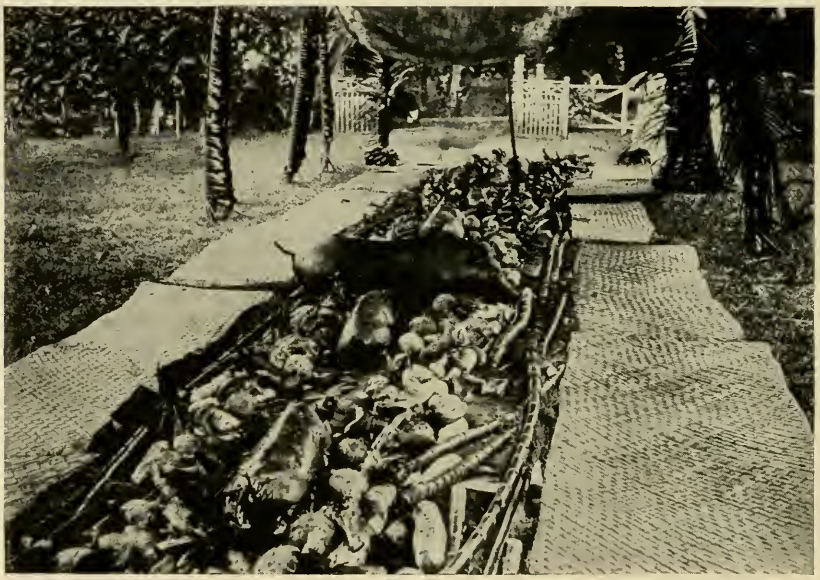
The party now dispersed over the village, while the natives prepared the grand feast—to be served in true Samoan style. There were games of basket-ball, boxing-matches, and other sports to amuse us; but many of the party were more interested in watching the old women weaving mats or making bark-cloth, or plaiting coconut-leaf shutters for the "fales."

At sundown we were all assembled at the table, which was no more than a long stretch of green banana-leaves laid flat on the ground. Here were piled breadfruit, taro, bananas, pigs, chickens, and fish, all baked out of doors in the famous Samoan fireless cooker, except that at one end, where Captain Ault was seated, a lone browned chicken was standing, cooked in a manner reserved for high chiefs. After blessing the food, our host invited us to attack the mountain spread before us. None of us made use of the knives and forks which had been sent over from the neighboring town; for the Samoan style of eating with the fingers makes everything taste better.

The feast was followed by an elaborate "siva-siva," in which the whole village participated. This exhibition had been seen on our previous stop in Pago Pago. This time the chief's wife,

dressed in the ancient Samoan costume, gave us a superb performance of the intricate motions of hand and arm which characterize the dance. It was well for her that the feet and body play a minor rôle, for she weighed over two hundred pounds!

By midnight we became drowsy; the monotonous rhythm of the dance having anything but an exciting effect on a white man. "Beds" were prepared, simply by piling mat after mat, one on top of the other, on the pebble-floor. Instead of the usual bark-



A Samoan Feast

The meats are prepared in such a way as to retain their flavor and juices by the Samoan fireless cooker.

cloth, "siapu," we were each given cotton sheets in which to wrap ourselves.

At break of dawn the whole village was deserted for the little churches, but the lazy white man slept on—a scandal to the countryside. Hot gruel made from about ten native vegetables brought a more immediate response than church bells and we scattered for the day, some to take photographs, some to penetrate the wooded slopes of the mountains nearby, some to collect birds

and plants for museums at home, and others to wander at random about the villages along the coast, revelling in the peaceful atmosphere which surrounds these people from birth to death.

Graham and Paul spent the following Monday in collecting biological specimens. A guide was furnished by the chief who

A Samoan Girl

Spends half her time in the water, either fishing with a spear under the water of the reef or bathing in the stream near the village.

had entertained the party over the week-end, and before they returned to the ship they had walked over a greater part of the Island, crossing the mountains several times. A large number of native birds were secured for the National Museum and a good

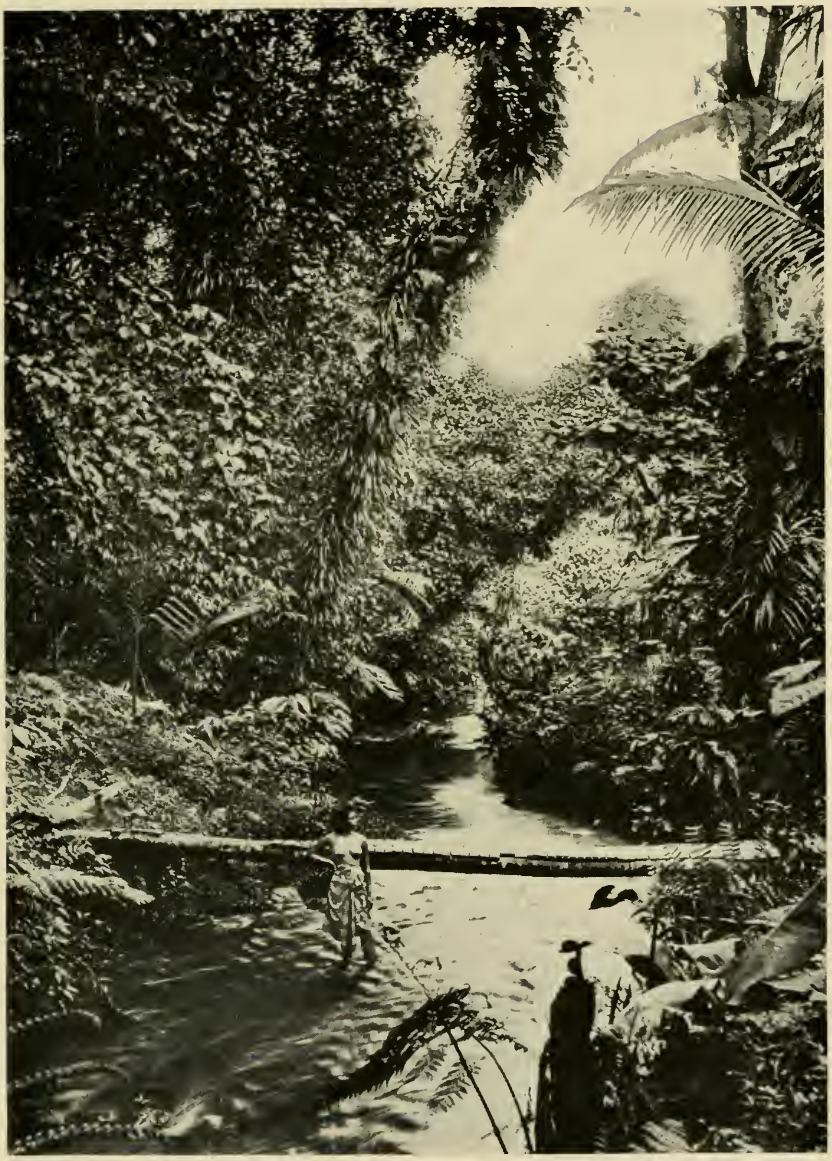
collection of characteristic plants was made for the Carnegie Museum in Pittsburgh.

A minor accident with a loaded gun was the only thing which marred the excursion. In Fagasaa, while they were seated in a

Typical Samoan Types

The Samoans have learned the fine art of living—they require few of the contrivances and stimulants necessary to the white man in order to be happy.

"fale" awaiting the "kava" ceremony, one of the chiefs had picked up the little 22-caliber gun which was lying on the mat beside Paul. The gun was loaded with tiny bird-shot and had been set at "safety." When it was noticed that the gun was being played



A Samoan Stream
In Samoa one is never more than a few minutes' walk from a stream like this.

with, Paul reached for it to remove the cartridge lest it be discharged by accident. As he took it from the chief it went off since it had been cocked while he was not looking. In the crowded quarters of the "fale" it was almost impossible not to hit someone. An old chief sitting some ten yards away was the victim. Fortunately he was struck only on the foot where the thick skin was penetrated by only a few of the pellets.

Some uncomfortable moments followed. It remained to be seen how the affair would be taken by the assembly. However a few words of regret and a prompt removal of most of the shot with a sterilized needle smoothed matters wonderfully. Perhaps the brilliant red of mercurochrome painted on the injured foot worked the magic which changed expressions of consternation to reassuring smiles.

Entering this same village from the mountains we had been startled by loud shouts of "Wu-hu-hu." The yell was repeated at intervals and was answered from all parts of the village. We had stumbled upon the "tafolo"-ceremony which is becoming uncommon.

This is a sort of "free lunch" supplied sporadically by the young men of the village. A long line is formed beginning at the Samoan hot-stone oven and ending at the chief's "fale." Breadfruit is taken from the bake-oven by two of the men; the charred skin is removed by the next pair; the steaming-hot breadfruit is then thrown into a large wooden bowl where it is crushed by the third pair with a green fruit used like a potato masher. And so it passes down the line being pounded until it has the consistency of bread dough. Hot coconut-cream is poured over the mass and it is again pounded until it is made somewhat thinner. As each batch is finished the cry of "Wu-hu-hu" is repeated and the preparation is rushed into the "fale" still steaming hot. Here it is distributed to the villagers by the chief who dishes it out with a coconut-shell cup into banana-leaves.

It was good fortune that our visit to Samoa coincided with the annual swarming period of the famous "palolo." These marine worms live in dead coral throughout the year, but on two days a year, once in October and once in November, they swarm. The

posterior half of the worm is set free, to swim to the surface for the "wedding-dance" in which fertilization takes place. These free-swimming portions are really no more than sperm-and-egg cases which discharge their products and disintegrate in a few hours. They are highly prized as food by the natives, who know in advance on which night they will appear and are always on hand to capture them with dip-nets from their canoes.

BREADFRUIT

The useful breadfruit, larger than a canteloupe, and very starchy, and green bananas when baked are the staple articles of diet in Samoa—not the coconut.

So on the night of November 23, the first day of the last quarter of the moon, Captain Ault, Graham, and Paul took the dinghy and crossed the harbor to the village of Aua, where the swarm was usually abundant. As the worms would not appear till moonrise, the evening was spent in the native "fales" where excitement reigned, as the torches and dip-nets were prepared.

By one o'clock the harbor was aflame for each canoe carried flares and lanterns. The long wait was made an occasion for singing and good-natured horse-play. By two, false alarms were sounded here and there along the line. By two-thirty, although the moon was not yet visible in the harbor, the sea was swarming with jade-green and ivory "palolo"-worms, swimming in every direction a few inches below the surface—elusive creatures which broke into fragments if grasped too roughly. We had brought bottles con-

Samoan Boys in Their "Pao-paos" or Outrigger Canoes

These little dugouts are handled with marvelous skill in the turbulent waters of the reef.

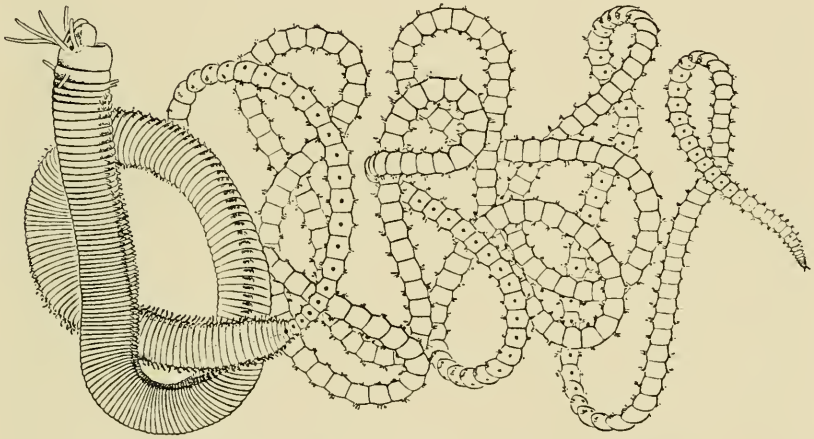
taining formaldehyde which we proceeded to fill to the disgust of the natives. For was not the "palolo" the year's greatest delicacy —and made to be eaten? With specimens secured, we each turned to and dropped a handful of these wriggling worms into our mouths, while the others bore horrified witness. The experience was disappointing for the fragile creatures melted in the mouth, leaving only the taste of sea-water.

Mysterious as this natural calendar is, some of us were more impressed by our first meeting with fish that climb rocks and trees! We had all read stories about the weird habits of certain

South Sea fish, but here before our very eyes we found them scampering about the blocks of lava, just as much at home on land as they are in the water.

The day of our departure was drawing near and we had preparations to make. Supplies for the galleys and laboratories had to be stowed away and long-neglected letters answered. On November 26 we pushed off for Apia, arriving there on Thanksgiving morning.

The day was to be no holiday for us. Parkinson proceeded to compare his instruments with those at the magnetic observatory;



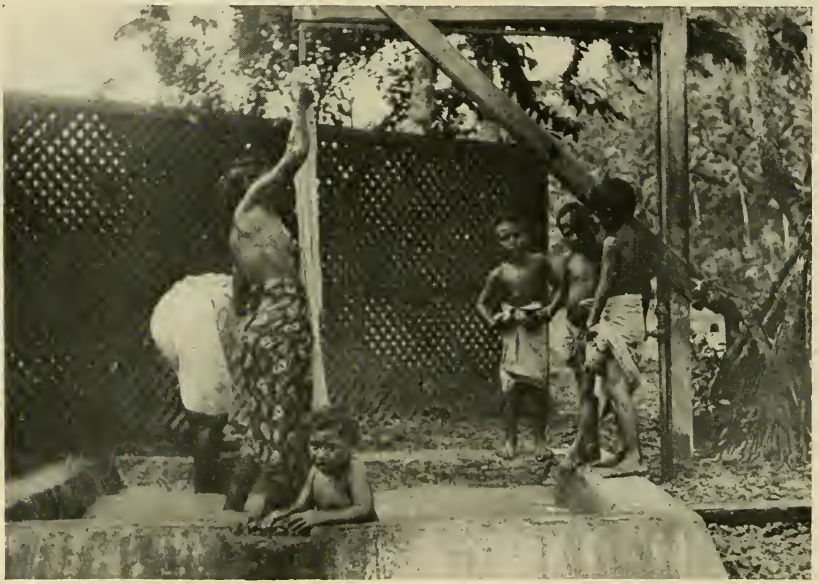
THE PALOLO-WORM WHICH LIVES IN DEAD CORAL IN SAMOA

In response to some mysterious stimulus these worms break in two to allow the lower portion to swim to the surface for a grand "wedding-dance," this occurring only on two days a year (once in October and once in November)—the *Carnegie* was in Pago PAGO harbor for the November swarm. (From Krämer, "Die Samoa Inseln.")

Captain Ault made his official calls, and ordered gasoline and oil; Paul arranged for further supplies of distilled water; Graham took silk-nets ashore for repairs and the others were busy about the ship at their various tasks.

But on the 29th two excursions were arranged. One, a sunrise visit to the tomb of Robert Louis Stevenson and his wife, at Vaea, in which Soule, Forbush, Graham, and Paul took part. The other, a trip to the eastern end of Upolu, in which Seaton joined Graham and Paul in collecting specimens for museum use at home.

All morning, Captain Ault and the remaining members of the staff were at work on board, the crew was engaged in loading the last of the barrels of gasoline into the ship's tanks. There remained only one hundred and fifty gallons to stow away when lunch-time came. After the noon meal, the crew resumed their task; Captain Ault unfolded a chair and sat on the quarter-deck where he could watch the men at their work; the Engineer and



PUBLIC SHOWER-BATH, SAMOA

Most Samoan villages have been supplied with a public shower-bath—the natives keep themselves meticulously clean.

Mechanic were below in the engine-room; and the others were scattered over the forward half of the ship, at various duties.

With a rumbling roar the ship was shaken from stem to stern by an explosion—then another. Captain Ault was thrown into the water. The men at work over the tank-room were hurled to different parts of the ship. The Engineer and Mechanic were trapped in the engine-room and in a moment the whole quarter-deck was enveloped in flame.

The steward and Soule, rushing on deck, dived overboard to

save the Captain. Sturk and Stenstrom fought their way out of the blazing engine-room by raising themselves through the

NATIVE CHIEF AND HIS WIFE, APIA
The chief is wearing a skirt made of the bark of the paper mulberry.

gaping hole in the deck. The uninjured men dragged the others free of the flames. To save the vessel was out of the question and all attention was directed to the saving of lives.

Small boats had been launched at once from the other ships in the harbor. Captain Ault, who had been holding on to a rope as he floated in the water, was helped into one of these and with the other injured men was taken ashore. Apparently he was suffering only minor injuries; but his injuries were serious and on

THE LAST OF THE *Carnegie*

This photograph was taken about three hours after the explosion which killed the Captain and a cabin-boy.

the way to the hospital, our Captain died as the result of them and of shock.

The other men who had been on the quarter-deck suffered fractures and severe burns. They were given immediate surgical attention by the hospital staff, who had been notified by telephone of the accident.

When the survivors were collected ashore, Tony the cabin-boy

could not be accounted for. He had last been seen in the after galley, immediately next to the tank-room; so it was apparent that he too had lost his life. His remains were not discovered till December 4, when salvage operations on the charred hull of the vessel were commenced.

Seaton, Graham, and Paul returned from their collecting-trip about three hours after the tragedy. The hospital staff and Government officials had done everything in their power for the survivors. There was nothing further to do but to await the arrival of the U.S.S. *Ontario*, the naval vessel from Pago Pago which the Navy had ordered to our aid.

The Engineer and Mechanic were too severely burned to stand the journey to Pago Pago, so they were left in the hospital at Apia. Parkinson, as second in command, also stayed to take charge of affairs there. On the day following the explosion, all the others were taken to American Samoa to await the steamer from Sydney. The three injured seamen we brought with us were put in the Naval hospital while the members of the staff were taken into the homes of the Naval officers, and the crew was quartered in the barracks.

Everything was done to make us comfortable. We were furnished necessary clothing—for the ship and all its equipment together with our personal effects, had been a total loss. Governor Lincoln, on behalf of the Navy, arranged immigration papers for entry into the United States for those who were not citizens.

On December 6, the survivors accompanied the body of Captain Ault aboard the *Ventura* for the sad journey home.

Sans Tache

Sans Tache

IN THE "elder days of art" each artist or craftsman enjoyed the privilege of independent creation. He carried through a process of manufacture from beginning to end. The scribe of the days before the printing press was such a craftsman. So was the printer in the days before the machine process. He stood or fell, as a craftsman, by the merit or demerit of his finished product.

Modern machine production has added much to the worker's productivity and to his material welfare; but it has deprived him of the old creative distinctiveness. His work is merged in the work of the team, and lost sight of as something representing him and his personality.

Many hands and minds contribute to the manufacture of a book, in this day of specialization. There are seven distinct major processes in the making of a book: The type must first be set; by the monotype method, there are two processes, the "keyboarding" of the MS and the casting of the type from the perforated paper rolls thus produced. Formulas and other intricate work must be hand-set; then the whole brought together ("composed") in its true order, made into pages and forms. The results must be checked by proof reading at each stage. Then comes the "make-ready" and press-run and finally the binding into volumes.

All of these processes, except that of binding into cloth or leather covers, are carried on under our roof.

The motto of the Waverly Press is *Sans Tache*. Our ideal is to manufacture books "*without blemish*"—worthy books, worthily printed, with worthy typography—books to which we shall be proud to attach our imprint, made by craftsmen who are willing to accept open responsibility for their work, and who are entitled to credit for creditable performance.

The printing craftsman of today is quite as much a craftsman as his predecessor. There is quite as much discrimination between poor work and good. We are of the opinion that the individuality of the worker should not be wholly lost. The members of our staff who have contributed their skill of hand and brain to this volume are:

Keyboard: Viola Schneider.

Casters: Charles Aher, Kenneth Brown, Ernest Wann, Mahlon Robinson, Henry Lee, Charles Fick, Martin Griffen, George Smith, Norwood Eaton, George Bullinger.

Composing Room: Arthur Baker, Charles Bittman, John Crabill, James Jackson, Ray Kauffman, Richard King, Robert Lambert, Theodore Nilson, Andrew Rassa, Charles Wyatt, Edward Rice, Henry Shea, George Moss, Henry Johansen.

Proof Room: Alice Reuter, Mary Reed, Ruth Jones, Audrey Knight, Betty Williams, Ruth Heiderman, Dorothy Fick, Catharine Dudley, Alice Grabau, Virginia Williams, Shirley Seidel, Jean Hyman, Angeline Johnson.

Press: Hugh Gardner, George Lyons, August Hildebrand.

Folders: Laurence Krug, Clifton Hedley.

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