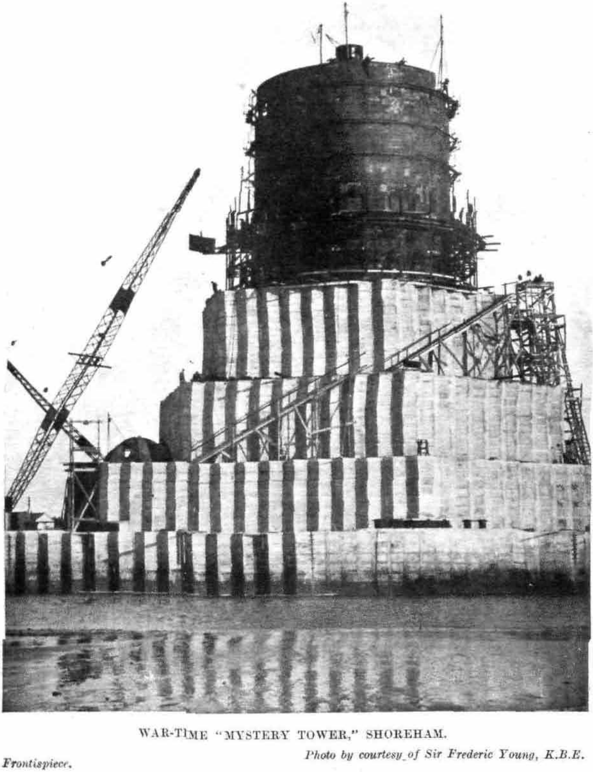
MARVELS OF MODERN MECHANICS:

THE MASTERY OF LAND, SEA AND AIR.

By HAROLD T. WILKINS

ILLUSTRATED

T. FISHER UNWIN LTD
LONDON: ADELPHI TERRACE



WAR-TIME "MYSTERY TOWER," SHOREHAM.

Photo by courtesy of Sir Frederic Young, K.B.E.

Frontispiece.

First published in 1926

Second Edition 1928

PREFACE

In the writing of this summary of modern achievement in the laboratory and experimental science, and in the world of engineering, mechanics, and wherever power is used, the author has pleasure in expressing his grateful thanks to the scientists, inventors, and engineers of international fame, who have freely given him assistance of many kinds.

Among those to whom thanks are due are, for the chapter on Wrecks and Salvage: Sir Frederic Young, K.B.E., Hon. Naval Salvage Adviser to the British Admiralty, Simon Lake, Esq., the well-known American submarine inventor, the Italian Minister of Marine, J. I. Merritt, Esq., of the American Merritt, Chapman and Scott Wrecking Corporation, and to English salvage companies; for the chapter on the Atom: the Etablissements Gaiffe-Gallot et Pilon of Paris; on Sun Cures and the Ultra-Violet Rays: Professor Leonard Hill, F.R.S.; on Seal Hunting: Mr. Lucien Pacaud, Secretary to the High Commissioner for Canada, and Mr. Piggott, Secretary to the High Commissioner for Newfoundland, in London; on Coast and Geodetic Surveys: Admiral Henry H. Hough and Lieut. W. F. Dietrich, of the U.S. Navy Department, Washington, D.C., British Admiralty, Swedish Hydrographer, the Secretary-General, International Hydrographic Office, Monaco; on Underground and Miniature Railways: the General Manager, London Underground Railways, and the Chief Engineer, Ravenglass and Eskdale Railway; on the Eötvös Torsion Balance: Captain Shaw, of the Science Museum, South Kensington; on the Gyroscope: M. P. Schilovsky, and the Sperry Gyro Company, New York; on Radio: Messrs. Marconi; on Telephotography and Television: The American Telephone and Telegraph Co., Mr. C. Francis Jenkins, Mr. H. L. Baird; on Safer Airways: M. Oehmichen, M. W. Loth (inventor of the Loth cable guide), Signor Fiamma (of Rome), M. Béchard (inventor of aeroplane fire-extinguisher), M. René Tampier (inventor of motor-car-plane); on Stage Mechanism: Sir Alfred Butt and Mr. Mather (Engineer, Drury Lane Theatre), M. Eugène Frey (luminous scenery inventor, Paris); on the work of Deep Sea Cable Ships: the Eastern Telegraph Company, the Western Union, and the Commercial Cable Company; on Motor Ships: Burmeister and Wain of Kjöbnhavn, Armstrong-Whitworth Company and others; and on Rotor Ships: Herr Anton Flettner.

CONTENTS

LIST OF ILLUSTRATIONS

MARVELS OF MODERN MECHANICS

CHAPTER I

THE CONQUEST OF THE ATOM

NEW "PHILOSOPHER'S STONE"—WHAT IS RADIUM?—"SEEING" THE ATOM—SOLAR SYSTEM IN MINIATURE—ELECTRONS AND PROTONS—ALPHA, BETA AND X RAYS—SIZE OF THE ATOM—KENOTRON'S POWERS—EXPLODING THE NUCLEUS—MEASURING A HALF-MILLION VOLTS—SUN AND STAR STORMS—LIBERATING THE ATOM'S ENERGY—WORLD CATASTROPHES—ETHER AND ENERGY—THE ENIGMA OF THE UNIVERSE—A TOUR OF TEN MILLION CENTURIES!

MANY people will recall David Tenier's amusing and pathetic picture—in Dresden Museum—of the old Dutch alchemist, abstractedly blowing his bellows under a small furnace, whilst his little dog lies asleep on a cushion at his feet, and a group of frowsy boors, crowding round a table in a corner of the room, derisively discuss and dispute about the utility of his "chymical" researches.

True, he and his kind turned gold into lead and ashes, if we may speak in metaphor, rather than lead into gold in their feverish search for the philosopher's stone. But modern physicists and radiologists may greet this poor, "blind philosopher" among their predecessors, with sympathy, and even respect; for in ways undreamt of by him, science is slowly and surely advancing towards the *time when much more than the transmutation of elements* will have been achieved. On the memorable day when the atom gives up its secret, the transmutation of metals will be but a minor result of the victory.

What do we know of the atom, and of the mysteries of the infinitely small molecular phenomena hidden in the womb of Nature? The Russian genius, Mendeleef, some twenty or more years ago, enlarged our knowledge of the atom by his remarkable classification of elements, known as the "Periodic system." He arranged the elements in order of their atomic weight, and predicted* that certain gaps existing between the known elements would presently be filled by the discovery of other elements, then unknown, whose atomic weights would correspond to the lacunae in the chain of elements. His prophecies came true.

The first great step forward in our knowledge of the atom and of the transmutation of elements was gained at the end of the nineteenth century, when Pierre and his wife, Madame Curie, and another Frenchman, Henri Becquerel, showed us that certain elements—radioactive elements—known as uranium, polonium and radium, emitted energy. This spontaneously discharged energy could be detected by the eye of the camera and the photographic plate and by the naked eye. It greatly perplexed

* Two new elements were discovered in 1925 by a Berlin chemist. He named them "masurium" and "rhenium." This discovery, made by X-ray spectroscopy, was subsequently confirmed by chemical analysis, and these two new elements have been obtained in minute quantities from platinum ore. The atomic weight of masurium is 43, and of rhenium 75. Both elements take us farther towards the discovery of the 92 elements which science believes constitute the full complement of the chemical elements in the earth's crust. Numbers 85 and 87 yet remain to be found; 61 was discovered in April, 1926, by Professor Hopkins, of the University of Illinois, and named "illinum."

physicists how to explain the nature of this phenomenon, but it was presently recognised that radioactivity manifested a new and profound transformation of matter, nothing less, indeed, than a natural and spontaneous explosion of atoms.

Radium and other radioactive bodies, in their natural emission of atomic energy, shoot out what are called "alpha rays," charged with positive electricity, of dimensions analogous to the electrons but 8,000 times heavier, and speeding at the rate of 18,750 miles a second. The disintegrating radium may be likened to a battery firing high explosive energy-shells. It continues to do this until its atomic constitution is transformed into a stable element—lead, which, so to speak, silences the discharge of the energy batteries and stops the spontaneous breaking up of matter. It may be noted that all the radioactive elements are of very high atomic weight and possess nuclei of 200 and more protons. None of the lighter elements, so far as now known, may spontaneously liberate free energy by atomic explosions, as in the case of radium, uranium or polonium.

A remarkable piece of apparatus invented by Professor C. T. A. Wilson, F.R.S., and exhibited in the Government Pavilion at the Wembley Exhibition, allows one to watch the "trajectory" or flight of the atom. A beam of light is passed into a glass cylinder full of a minute spray of vapour produced by the action of a piston-pump. A little tube of radium is placed near the glass cylinder, and the bombardment of the alpha rays is brought to bear on a thin sheet of aluminium. The rays or atoms of helium hit the aluminium target and hurtle into the cylinder, where they leave a track of visible mist as they pass through the vapour and disappear. One can also hear the electrons as they pass through the cylinder. This is achieved by the aid of the radio vacuum tube amplifier. The noises made by electrons, the infinitely small units of electricity, are heard as they are "bombarded" against the plate in the tube from the hot filament. The electrons carry the current and make possible the operation of the tube, which is capable of tremendous amplification. Thus, a new way of measuring the value of the electron charge has been found, and a method of research opened which may lead to valuable knowledge concerning the electron and its properties. Hitherto, the properties of electrons were studied by observing the movements of minute drops of oil falling between two electrically charged plates. The tiny drops of oil are made to fall slowly or rapidly or are held stationary between the plates, according to the presence of charged electrons in them and the voltage applied to the plates. With proper amplification, the roar of the electrons in the tube can be magnified to produce a volume of sound like that of Niagara's falling of waters.

If we abruptly stop the movement of the electrons in a vacuum tube, we produce the X or Röntgen rays. Vibration of the electrons, exciting oscillations, sets up the waves used in wireless telegraphy and broadcast radio, and causes light.

We have advanced very far in our knowledge of the constitution of the atom; we know that the atom is a kind of solar system in miniature, with a nucleus, at its centre, of inconceivable minuteness and colossal density, wherein is concentrated nearly all the mass of the atom, and around which, at distances relatively enormous, rotate light "planets" of negative electricity, called electrons, bound to the nucleus, which is positively charged. These opposing electric charges of the nucleus and of the associated electrons are equal, and so the equilibrium of the atom results. The electrons nearest the outside of this "solar system" are less strongly bound to the nucleus than those nearer the nucleus. One atom differs from another, as gold from iron, for example, by the charge of its nucleus, and, consequently, by the number of electrons circling round it. These positive charges of the dense nucleus are called "protons," or first particles; they appear to consist of nuclei of the gas hydrogen, and they give the element its atomic weight.

So much has been established by the well known physicist, Böhr. If an electron is expelled from the atom, another electron takes its place in the gap, where it emits radiations characteristic of the atom—light rays in the outer orbits of the electron-planets, and Röntgen or X-rays in the inner and deeper orbits closer to the centre.

There are reasons for thinking that in the *nucleus* of the atom, a second system of electrons rotates around the protons, and that this second system is entirely different in size from the first, more complex, but governed by the same law of discontinuity. When this nucleus rearranges itself, it emits rays characteristic of the nucleus, which are gamma rays, or very hard X-rays. At the moment, all that we know of the constitution of the nucleus is due to radiation from radioactive bodies. This radiation has shown that we can begin to act on the exterior of the atom, or the system of electrons, if we can bring to bear on it an electric charge of half a million volts. This will aid us to study its spectrum of rays.

It may be said here that the rays used to attack the atom are X, alpha, and beta rays. The beta rays are really electrons speeding with a swiftness approaching light, and the alpha rays are atoms of helium charged with positive electricity and attaining a speed of about 18,750 miles a second.

The grand problem of the atom is how to attack its apparently impregnable nucleus. To explode this nucleus of the atom it is estimated we need rays shot out on a charge of from 5-10 million volts. Sir Ernest Rutherford showed that the nucleus of certain atoms, such as that of helium, can be forced to part with an atom of hydrogen under the violent bombardment of rays, flying at the astounding speed of 18,000 miles a second. By measurements of the thinness of films of gold and soap,† chemists have shown that the atom cannot be greater than the millionth part of a centimetre, and other estimates have fixed the smallest size of atoms at one-hundred millionth part of a centimetre. They have also reckoned that the mean free path over which one molecule can travel without colliding with another is between one-hundred-thousandth and a millionth part of a centimetre.

To explode the atomic nucleus, the tremendous charge of 5-10 million volts would have to be *direct* current, and a generator of constant tension would be needed. A great step towards this achievement has recently been made in Paris by the production of a generator of a constant tension of 500,000 volts. Its powers were demonstrated in May, 1925, before a company of famous scientists, physicists, and surgeons, who assembled at the laboratories of the Etablissements Gaiffe-Gallot et Pilon.

The vital part of this powerful generator is the "keno-

† "The census of the atom," said Sir Ernest Rutherford in his lectures at the Royal institution, in 1925, "shows that 100,000,000 particles can be placed side by side in 1 inch space, the radius of a single molecule being 1/50 millionth and 1/10 millionth of an inch." Many years ago, the great physicist, Michael Faraday, obtained gold films about 1 millionth of an inch thick, and these, Sir Ernest estimates, contained from 10-50 layers of molecules.

tron."* The kenotron is a development by the General Electric Company of the discovery by Edison of the "hot filament valve," in which an incandescent filament of tungsten is placed in a glass bulb, from which the air is exhausted. Opposite to this glowing filament, which is heated by an auxiliary current of electricity, is a cold electrode, made of molybdenum, and constituting the other pole of the valve. The kenotron filament emits "thermions," and will allow an electric current to pass only one way, when the electrode is negative, and scarcely, or not at all, in a contrary direction.

This is very important, because only a *direct* current—one whose direction and intensity are practically constant—of very high potential and constant tension will shoot out the electric particles in one tremendous bombardment, smashing right through the field of electrons on to the nucleus of the atom. An alternative current, whose direction and intensity periodically and rapidly change, would be useless in the attack on the citadel of the atom; but as alternative currents will be set up in the circuit, the function of the kenotron is to bar their passage in more than one direction. The current may pass onward, but not backward.

It is possible to pass a current of 100,000 ampères in one direction with a flow of extremely weak current, and to resist at a tension of 150,000 volts when the current flows in the opposite direction. At first, the current comes in from the main, in quality alternative, and at a strength of 220 volts. It passes on to a series of primary transformers, which change it to a direct current, and it then enters and charges the condensers. Next, it proceeds to the keno-

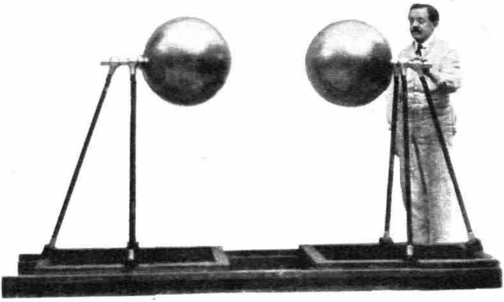
* Greek: kenós (empty or a vacuum). In America, the higher voltage of 1,000,000 is said to have been attained in November, 1925.

trons, thence charging a second series of condensers. These condensers regulate the flow of the current and tone down its wave variations analogous to the way in which the weight of water, filling a tank, regulates the flow from the taps.

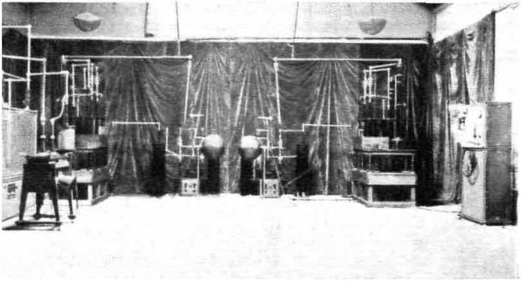
The kenotrons are placed in series with the condensers, and the latter are charged with a direct current, so that each condenser, if of sufficient capacity and insulated, will have a strictly continuous potential given by the secondary transformers at high tension. It is possible to use only a single alternation of the current supplied from the main, but if, on the same transformer, another condenser and another kenotron are mounted, the kenotron being "grafted" on in a reversed position, the second alternation of current can be used to charge the latter condenser at the same potential. Then, if two condensers are connected in series a tension twice as great is obtained. A generator of 600,000 volts can thus be obtained by adding other elements to the apparatus.

The electric current so obtained is not exactly direct, for it contains wave-lengths derived from the frequency of the alternative current fed from the main. Still, for all practical purposes, it is direct and of high tension, since the variations of the alternative current, set up in the circuit of the generator, do not exceed the mean tension by one-tenth. It is therefore permissible to call the flow of current thus obtained of constant tension.

It is a very difficult matter to measure these direct currents of very high tension, and up to the moment of writing, the dial even of the latest voltmeter—that of Abraham-Villard—will measure only up to a maximum of 250,000 volts. Any higher voltage can be gauged only by estimating the air-gap between the points of discharge on the



COPPER SPHERES BETWEEN WHICH SHOOT THE 500,000 VOLT SPARKS.
Photo by courtesy of Établissements Gaiffe-Gallot et Pilon, Paris.



A HALF MILLION VOLT GENERATOR.
Photo by courtesy of Établissements Gaiffe-Gallot et Pilon, Paris.

face page 21.

spheres, through which air-gap the tremendously powerful charge of half a million volts burns and blasts its way like a lightning discharge from a storm cloud.

When the Kenotron-generator is in action, the observer in a darkened room has not before his eyes a continuous stream of sparks, as the reader might imagine. He sees an intermittent flow of sparks, thick and spreading, and of a yellowish flame colour. The sparks are intermittent because, otherwise a single discharge would empty the condensers, and this is not desirable, since it would interrupt the bombardment of the atom.

How would such a charge, theoretically, act on the atom? Let us in answering this question, try to picture what probably happens inside the incandescent sun of our system, or in the interior of other molten stars, forming the suns of other systems in the infinite void beyond the confines of our own universe.

When a solar or stellar storm takes place in the interior of these giant bodies, some of whom have a width greater than the orbit of Mercury or Mars, the nuclei of the atoms are hurled against each other with inconceivable velocity. They form heavier and heavier particles, and liberate the continuous heat and light waves we know as sunshine and light. So, under the bombardment of electrified particles, or electrons, of enormous velocity, the projectiles fired from a 10 million volt gun should leap the zone of repulsion in the atom, and smash into the nucleus, where they should unite, forming a newly welded nucleus, which would be probably radioactive. Soon, the new nucleus would rearrange itself, and expel a nucleus of hydrogen, with *greater energy than the projectile had on impact.*

Thus, when we have batteries of millions of volts at our command we shall create projectiles greater than those now given us by radioactive substances; we may liberate tremendous heat and energy from the atom, and create by-products in the form of new elements or old elements transmuted. And if ever the day comes when our earth, swaying gyroscopically on its axis shall enter another Ice Age, deprived of its minerals, fuel and oils, when a pale, wintry sun, shining without heat in a sky of mocking blue, may not melt the eternal glaciers covering what once were temperate lands and continents, humanity, living in subterranean cities, will have a source of beneficent light, heat and energy freed from the conquered atom, to outlast the long years until the day dawns and the shadows of the Ice Age flee away!

Of course, it is possible that the breaking up of the nuclei of atoms on a large scale may be attended by peril not only to the scientist but to the world at large. This possibility has been the theme of scientific or pseudo-scientific romance. It is feared by some that the scientist may unleash an etheric force beyond his control, and that the disintegrating violence may spread from atom to atom ultimately presenting to an observer outside our planet such a spectacle as is witnessed by an astronomer watching in the midnight hours the titanic explosion of an inconceivably distant star world exploding into the relative annihilation of the primitive ether. We can only hope that the knowledge of the control of the atomic force will accompany the discovery of the method of its liberation. At the moment both are dreams well within the realm of scientific fantasy, but capable of actualisation at some perhaps not distant day.

Apparently, the phenomenon of radioactivity seems to involve the destruction of the principle of the conservation of matter which lays down that one cannot destroy or create matter. The famous French scientist-philosopher, Gustave Le Bon, was one of the first to affirm that matter was only condensed energy, and that the atom was not indestructible. Radioactivity, he defined as being the vanishing (*l'évanouissement*) of matter, and he pointed out that this phenomenon was not confined to exceptionally occurring bodies such as radium, or polonium, but that, under the influences of light, heat, and chemical reaction, or even spontaneously, the atoms of all bodies may be dissociated, accompanied by the emission of cathodic rays. He also referred to the fact that a body radiating heat loses thereby a part of its mass, and added that heat and electricity may be simply manifestations of intra-atomic energy liberated by the disintegration of the atom.

But, as a matter of fact, all that has been "destroyed" is not matter but the outworn conception, derived from Newton, of matter as consisting of "dead, separate particles dancing to and fro in empty space and acting at a distance." We are realising more and more clearly that we cannot separate ponderable matter from imponderable matter, or ether, whose principal functions include light, radiant heat, electricity, magnetism and all forms of energy. Ether,* at the moment, has little more than a hypothetical existence, in the sense that we cannot give concrete proof of its existence although we may have no doubt this continuous substance fills all space not occupied by matter, is not composed of atoms, has probably no chemical quality, and is the ultimate cause of all phenomena.

This theory of condensation of etheric energy was luminously explained by the brilliant German physicist, J. C. Vogt, as far back as 35 years ago. Vogt assumed

* "Ether" is here used as referring to the underlying substratum of energy.

that the primitive force of the world was derived from the condensation of a simple primitive substance which fills space in an unbroken continuity and is possessed with a tendency to contract and condense. This mechanical property is its sole form of activity, and causes infinitely minute centres of condensation to come into being which may change their degree of volume but are constant as centres of activity. These centres of condensation float, not in empty space, according to the older kinetic theory, but in the extremely attenuated intermediate substance which is the uncondensed portion of the primitive, undifferentiated matter. Vast masses of these centres of condensation unite to form constellations and as a result of the pull exerted by them over the surrounding primitive matter, there arise two kinds of substance. The centres of perturbation which positively exceed the mean consistency of the undifferentiated matter form ponderable bodies, which we call *matter*. The extremely thin substance, filling the space between these bodies, and falling negatively below the mean consistency of the intermediate substance, forms the ether or imponderable matter.

Between the ether and matter there goes on an eternal struggle which is the source of all energy and physical processes. The positive and ponderable matter struggles to complete the process of condensation, and in the battle it accumulates a vast sum of potential energy; but the ether continually resists this strain, and thus gathers the utmost amount of actual energy, in the form of light, heat, electricity, magnetism. It is, of course, true that this theory postulates the existence of a *third* substance, the primitive thing which Sir William Crookes called "protyle"—a substance which could have had neither beginning nor end, to which causation cannot, therefore, apply.

Niels Böhr, the well-known Danish physicist, winner of the Nobel prize in 1922, is one of the founders of the theory called the *quanta*, which regards the atom as an automatic distributor of energy. He warns us not to push too far the analogy of the movements of the solar system when we are speaking of the internal movement of the atom. Contrary to the movement of the rotating earth around the sun, the atomic satellites do not continually follow the same path or orbit. From time to time, they leap out of their atomic orbit,* and continue turning at a greater or lesser distance from their "sun" or nucleus. They absorb thereby amounts or *quanta* of energy, and, when they resume their original place, they distribute the energy they have accumulated.

Böhr, Rutherford, Ramsay, Planck and other physicists have even succeeded in measuring the dimensions of the proton, and their work has been carried forward into the field of the infinitely great by Einstein, in his theory of relativity. He has shown that each gramme of matter possesses enough energy, if it could be liberated, to raise a cube of stone of 100 square metres to the top of the Eiffel Tower. Einstein has gone farther still. He has even succeeded in measuring the size of the whole universe, stellar and solar. The universe, he says, is a curve, and if a traveller could speed through space on a luminous ray with a rapidity slightly less than that of light (186,300 miles a second) he would repass his point of departure at the end of 10,000,000 centuries! He would reach the sun

* This jumping, so to speak, of the electrons out of their orbit, is believed by physicists to explain the phenomenon of the emission of light from a gas in a state of incandescence, as in the photosphere of the incandescent sun. The atom emits light only when its electrons jump from one orbit to another nearer the nucleus. If they move in the reverse direction, no light is given. This constant movement of the electrons is the cause of the coloured lines seen when light is split up by a prism.

eight minutes after leaving the earth. Modern science, in the hands of world-famous physicists, has thus shown that the measurement of the infinitely little—the proton *of the atomic nucleus—in comparison with the linear* dimensions of the entire universe, solar and stellar, is a number of 43 figures, and that man is somewhere about two-fifths of the interval separating the infinitely little from the infinitely great.

CHAPTER II

STRONG ROOMS OF THE SEA-BED

"LUSITANIA": A WILL-O'-THE-WISP?—DIVING ARMOUR FOR GREAT DEPTHS—ARC LAMPS FOR THE OCEAN BOTTOM—HOW DROWNED DECKS ARE BLASTED OPEN—MECHANICAL FINGERS FOR ARMOURED MAN—THE LOST BRITISH SUBMARINE M.1.—MAGNETIC SALVAGE MACHINE—SIMON LAKE'S "ARGONAUT"—MODERN TREASURE HUNTS—ROMANCE OF THE SUNKEN "*LAURENTIC*"—*THRILLING* ADVENTURES ON THE SEA-BED—STRANGE STORY OF THE LOST "LUTINE"—THE CROWN JEWELS IN THE WASH—SALVING CENTURY-OLD WRECKS OFF THE SWEDISH COAST—PATCHING UP RENTS IN STEAMSHIPS' HULLS—DIVER'S LIFE DEPENDS ON HIS MEMORY—HOW A SCHOOLBOY "*FAN*" ASHORE SAVED A SUNKEN SUBMARINE—U.S. SUBMARINE F.4. RAISED—BRITISH SUBMARINE K.4'S TERRIBLE EXPERIENCE—SALVORS TOWED INSIDE U. BOAT—THE "MYSTERY TOWERS"—RIGHTING AN UPSIDE-DOWN DREADNOUGHT—RECENT SALVAGES OF TREASURE WRECKS—LIST OF WRECKS AWAITING SALVAGE

THE Bank of England, guarded nightly by a company of crack soldiers who pace in the dark hours up and down its echoing courtyards, is said, every midnight, to submerge its bullion vaults in 20 feet of water. Yet is its wealth infinitesimal compared with that which lies on the sea floors of the world. If Davy Jones's locker, clasped and clamped with adamantine bands, and locked with massy keys, could be made to yield but one quarter of the heaped treasures of gold and silver and precious jewels scattered on the sea floors since the first galley manned by sallow-faced, dark-eyed Phoenicians, drove on the rocks of the Western ocean, the whole world's war debt would vanish like mists before the rising sun.

Full 40 fathoms deep on the hard-shell bottom of the Irish Sea lies the liner "Lusitania," sent to her doom by the torpedo of a German submarine which lay in wait for her off the Old Head of Kinsale. She has lain there for over nine years, and over her have swept the mighty tides of the Atlantic and the great waves lashed to fury by the sou'-westerly gales. Her hull is crusted and corroded, and her great girders buckled by the torpedoes, which smashed at her through the sea water, crushing her with the force of electric hammer-blows.

Inside the cavernous darkness of her vast hull, lurks the gigantic conger eel, and the loathsome octopus has his lair where the fishes have long ago eaten the flesh off the bones of the hapless men, women and children swept to death when the liner plunged to the depths with the sea pouring in through great rents in her hull.

Deep down in the ship, under the wreck of twisted girders and jammed cabin-ways, is a strong-room containing a purser's 30 ton safe, holding £1,200,000 of bullion, jewellery and valuables which she is known to have carried with her, besides costly general cargo. Marine salvors are asking themselves whether the safe can be brought to the surface? Many dismiss the project as chimerical. Others say the plan, even if it succeeded, would not remunerate the wreckers for the vast outlay of money expended in raising the hulk.

At this great depth, a diver encased in the ordinary helmet and rubber suit would be tossed aside like an egg-shell or crushed by the tremendous weight of the water, which at only half the depth at which the "Lusitania" lies would press on the diver's 2,160 square inches of surface with a total force of 144,072 pounds!

But an American syndicate of salvors who have purchased the rights in the "Lusitania" do not believe that this herculean task is too great for modern salvage science. The man in the street knows nothing of the marvels of sea-salvage. Great are the risks, but so are the prizes!

The "Lusitania," which cost £1,800,000 to build, lies upright on the hard bed of the Irish Sea, parallel with the sweep of the tide, which rises and falls here about 12 feet. Gales and currents sweeping from the Old Head of Kinsale and the Seven Heads have a free course over and through the waters in which the wreck lies.

The cleverest brains and inventive genius are grappling with the problem. An American, Mr. B. B. Leavitt, has devised a suit of powerful diving armour by which he succeeded a few years ago in descending over 60 fathoms into Lake Huron and salving the valuable cargo of the s.s. "Pewabic," wrecked in 1865. He remained for nearly an hour under water directing the salvage operations. Leavitt's armoured diving dress is made of bronze and weighs 90 lbs. under water owing to displacement by immersion. A strong, steel cable, which cannot twist, lowers the diver to the sea-bed, and raises him again to the deck of the salvage steamer. The cable is attached to the top of the diver's helmet.

Once on the sea-floor the diver will turn on the rays of his submarine electric lamps to dispel the gloom, and will see shoals of fish dart away frightened by the strange monster groping his way in their watery home. The electric lamps will burn and frighten away the prowling shark or octopus lurking in the gloom of the hull. He will breathe in fresh air from a regenerating cylinder borne on his back, and containing caustic soda which absorbs the carbonic acid gas expelled from his lungs. Compressed oxygen inside the cylinder will make good the oxygen used up by his body during his exertions on the bed of the sea. A reducing valve will admit enough of the precious gas into the diving suit to last him for two and a half hours.

As his eyes become used to the gloom of this under-sea world, and he finds his position, the diver will telephone to the deck of the salvage steamer, 240 feet above him, and ask to be moved nearer the hull of the liner. The message is conveyed by an electric wire running from the top of his helmet through the sheath of the thick steel cable by which he was lowered to the sea-bed. An operator in a cabin on the deck of the salvage ship moves a switch which controls an electric derrick, and forthwith the diver is lifted bodily and moved nearer the wreck. There is no fear that his air-line will be jammed under water, and he is equipped with flexible, mechanical arms and legs moving on ball-bearings and ringed shoulder-joints to keep the water from soaking into his diving suit.

Next, the diver places a charge of dynamite with a time fuse on the deck of the drowned ship. The telephone buzzer again sounds on deck and once more the derrick-cable hoists him away from the wreck to a safer place, whilst a tearing, crashing explosion rends open the "Lusitania's" outer deck, sending hundreds of stunned fish up from the depths to float helpless or dead on the surface of the sea.

Two more decks will have to be blown up by explosives before the way to the strong-room is clear. At last, the deep-sea electric lamps will light the divers at their herculean task of hoisting by an electric crane the precious 30-ton safe from the cavernous depths of the "Lusitania" to the deck of the salvage steamer.

Another armoured diving suit for deep-sea salvage, where nothing can be done by the ordinary diver, is that of Chester MacDuffee. It has twelve mechanical fingers worked from within the armoured suit by a sliding rod, and it is so delicately adjusted that it can actually pick up a piece of thin paper from a flat table! Diving armour, weighing over 600 lbs. with ballast and a man inside, can not only resist the tremendous pressure of the water, but enables the diver to breathe at the ordinary atmospheric pressure. This device would dispense with the necessity of a slow ascent to free the nitrogen from the diver's tissues or of a frequent adjustment of the escape valve of the diving-helmet to meet changes in depth and pressure. A crane could pick up the diver and drop him 600 feet below the surface, where he could use the mechanical hand and even slip steel hawsers under the hull of the wreck.

The remarkable story of the German armoured diving suit used in the attempt to locate the M.1, the ill-fated British submarine which was sent to the bottom of the sea near Start Point, Devon, apparently as the result of a collision with a Scandinavian steamship when M.1 was coming up to the surface after submersion, will be fresh in the memory. The tragedy occurred, it will be recalled, in November, 1925. In stormy weather a German party set out from Cawsand Bay, Plymouth, on board an obsolete warship, H.M.S. "Moordale," to try to find the position of the wreck. The seas round about are strewn with the wrecks of vessels torpedoed by German U boats, but it was believed that trawlers using a form of mine-sweeping apparatus had located the wreck of M.1, and the position was buoyed.

A twenty-year-old German diver, Otto Kraft, was lowered into the armoured suit and swung by a boom from the side of the warship into the air and lowered into the sea. The suit was fitted inside with a comfortable bicycle seat, and the diver was furnished with a mask fitting closely over his nose and mouth. He breathed in fresh air from one tube and through another tube in the mask exhaled used air which passed into a purifying chamber, where the carbonic acid gas was absorbed. A tong, at the end of the great artificial arm, enabled him to grip and use tools or pick up objects on the sea bottom. The mechanical arms could be moved easily. Down to a depth of 100 feet, Otto Kraft could see with the use of artificial light, and he saw a line attached to what was thought to be the drowned submarine. As he went deeper his powers of vision grew smaller and on the bottom he could see nothing at all. He took only four minutes to come up to the surface from a depth of 41 fathoms, as against 51 minutes which a man would take to emerge from the water, after 12—20 minutes' submersion at 34 fathoms.

Next day a storm arose, and the "Moordale" fouled the cable, which tore away from the buoy. All trace of the position was lost, and the task had to be started all over again. Otto Kraft went down three times in an attempt to find the broken cable lying on the sea-bed. He reached the tremendous depth of 250 feet, but after groping around for a period of 37 minutes in all he had to give up the attempt to find the broken cable, and telephoned to the surface to be drawn up to the warship's deck.

The latest idea—now being tried out in America—is to use helium instead of nitrogen in the air forced down to the diver. The gas helium is less soluble in the blood than nitrogen. When the diver begins to come up from the sea-bed, the mixture of oxygen and helium is replaced by air. The helium is given off quickly from the lungs, which avoids the possibility of the formation of bubbles in the blood, giving rise to caisson disease. At very great depths of 300—400 feet the amount of helium in proportion to oxygen in the mixture inhaled by the diver is largely increased, this being done to avoid the danger to the diver at great water-pressures of breathing excess of oxygen.

A British inventor recently displayed at an engineering exhibition in London an armoured diving suit which he claims is superior to that of the Germans used in the attempt to find the lost submarine M.1. He says that this new invention, which is made of stainless steel, not liable to rust or corrosion under water, has frictionless arm joints in imitation of the human knee. Just as the knee is lubricated by a natural fluid, the arm joints of this armoured suit are kept free and frictionless by a cushion of water in a rubber bag, which, whilst being displaceable, renders the joints loose and unfettered by the water pressure from without. The invention has the mechanical hands, which enable the wearer of the suit to pick up a penny or heavy articles. Tests are said to have shown that a diver attired in the steel suit, which weighs 550 lbs., can safely descend to a depth of 650 feet.

In some respects the suit resembles the German equipment used to find the submarine M.1, but is claimed to be superior in the arm joints, and air is pumped down through an armoured tube instead of being provided by means of oxygen cylinders.

To get rid of the great danger caused by a diver's air pipes getting fouled with an obstruction as he moves about on the sea-bed, a British naval expert has invented, in 1926, a diving suit entirely dispensing with airpipes, and leaving the man free to wander about on the bottom after he has left the ship. He carries his air and oxygen supply in a cylinder on his back. By its aid a diver could get out of a submarine, through a special air lock, and repair her hull as she lay on the bed of the sea.

Diving-bells, made of colossal armour plate, may be lowered 300 fathoms to the sea-floor, and men inside can work electrical drills, claws and hammers projecting from the diving-bell, and turned by current furnished from the salvage ship's dynamo. Inset in the wall of such a diving-bell it is proposed to use marine port-holes of thick clear glass through which the men can peer at the wreck on the sea-bed. Propellers would be used to move the diving-bell from place to place around the hull of the wreck, and telephones and electric lights would make the interior of the bell a submarine factory.

Harry Bowdoin, of New York, marine inventor, has perfected a salvage machine which will move under water towards the hull of a wreck, and adhere to it by powerful electro-magnets. It will clasp the hull by two steel arms, and a pontoon is then lowered and fastened to the wreck. More pontoons are similarly fastened until the wreck can be lifted and towed into shallower water or dry dock.

But the most wonderful of all machines which have invaded the under-water world is a craft that runs along the sea-bed on motor-driven wheels, and in which a diver can open a door and step out on to the bottom! Simon Lake, the well-known U.S. submarine inventor, christened this under-water craft "The Argonaut." He transferred 15 tons of coal in nine minutes, under water, from the hold of a sunk barge to a freight-carrying submarine, and sent the submarine to the surface by the mere turn of an air-valve. By it, cargoes from sunken vessels can be removed almost as quickly as lighters discharge freight ships in dock. This bottom-navigating submarine is connected with the salvage ship by a tunnel, called an "access-tube," passing from a well under the pilot-house of the surface ship to her stern and then down through the water to the submarine's bow. The salvage ship may be tossed and rolled by the waves on the surface, but the submarine is not moved on the bottom, for it embeds a spike on its keel deep in the sea-floor. The access-tube is also kept steady by anti-friction bearings on the side of the salvage ship's well.

After passing down the tube-tunnel to the submarine, the diver enters an air-lock compartment, opens a hatch, and then walks into the diving compartment where compressed air is turned on at the same pressure as that of the water outside the hull. The sea being thus held at bay, and prevented from entering the submarine, the diver now opens a sliding door and steps straight on to the sea-bed.

When a wreck is found, divers first examine her and find if she is worth salving. Then comes the salvage steamer, which is moored over the wreck and lowers the access-tube to the submarine. The moorings are controlled from inside the operating chamber of Lake's submarine, and when the salvage steamer is anchored, the lower end of the access-tube can be swung in a wide circle below the surface steamer.

Next, the diver views the wreck from an aquascope or under-water observation glass, or he may open the bottom door and walk across the sea-floor to the wreck's hull. Brilliant electric lights illumine the under-water scenes, and telephones direct the operator on the salvage ship to shift the access-tube. If needed, the decks of the wreck may be blown up with explosives and the working parts of the semi-submersible wrecking apparatus lowered into the wreck. Storms may rage above and the seas lash themselves into fury, but, provided the salvage steamer's anchors hold, no harm can come to the submarine below. Powerful submarine lamps light up the hold of the wreck all the time, and cargo is shot up to the salvage steamer's decks by power hoists and electric cranes. It is remarkable that the diver descends the access tunnel-tube to the submarine breathing air at the ordinary atmospheric pressure and with no more difficulty than one has in going downstairs above ground!

A romantic career lies before Mr. Lake's submarine and wrecking-apparatus. Davy Jones's locker in Long Island Sound contains rich treasure. The wreck of the s.s. "Lexington," lying off Bridgeport, Conn., has a fortune in her safe, and in the waters about Hell Gate, in Long Island Sound, four million dollars are waiting to be found by some fortunate salvor. They were destined as the pay of British troops in the Revolutionary War, and they sank with the frigate "Hussar," and have been the eager quest of salvors who, also, are still seeking the whereabouts of the sunk barge, lying off the Battery, and containing a fortune in block tin. In fact, from Newfoundland to Florida the coast is dotted with sunk treasure ships.

Modern treasure-hunts had another chapter added to their romance when, at the end of the summer of 1924, after six years' work, gold and silver bullion and coins worth £6,250,000 were raised from the wreck of the liner "Laurentic," torpedoed and sunk by a German submarine at the entrance to Lough Swilly, Donegal, Ireland. She was carrying money which was intended for the pay of American munition workers when she was sent to the bottom in January, 1917. A British naval sloop, the "Racer," began in earnest the task of salving this treasure in 1920, when the salvors found that under the pressure of strong currents the "Laurentic" had broken up into a confused mass of steel plates. They raised 600 gold bars that year, and 300 the next year, and, in 1922, by the use, it is stated, of a secret gold-finding instrument, costing only £15, they recovered 900 bars of gold and silver. Divers had to blast their way with dynamite to the liner's strong-room.

The secret instrument made use of for salvage consisted of a remarkable spear which, when thrust into the mud of the sea-bed, registered the presence of gold on a galvanometer (or so it is alleged).

In 1923, 1150 precious bars were recovered and there now remains only a small amount of specie in the wreck. On board the "Racer" an exact model of the wrecked "Laurentic" was kept, and as depth charges below daily removed parts of the wreckage so the corresponding parts of the model were taken away.

A diver on board went down each morning to make a tour of inspection, and when he came up, the "Racer" slipped from her moorings, and the charge inserted in the wreck was fired by a torpedo man. It blew the wreckage asunder, and sent many stunned fish to the surface, which were cooked for the crew's dinner. A telephone connected the deck with the diver salving the gold, and when he found the bars he signalled for the bucket to be sent down, calling through the telephone the number of bars sent up in the bucket. Each hour the diver was relieved by another man.

One man bent too low on the sea-bed and was shot up to the surface, where his life was saved by at once placing him in a recompression chamber.

Another diver got his foot in the wreckage as he was about to be raised. His helmet was pulled from his head and the neck ring cut his chin and nose and made them bleed furiously. Luckily, he freed his foot and was safely hauled on board.

A third diver was attacked by a conger eel and had a desperate fight with it unarmed. Others fought with sun fish.

Destroyers guarded the "Racer" whilst the gold was being raised from the wreck, and they conveyed it to Liverpool at dawn, whence it reached the vaults of the Bank of England. Eight per cent. of the amount recovered from the wreck fell as prize money to the salvors.

The romantic story of the recovery of the drowned "Laurentic's" bullion would probably not have been told had it not been for the work of Commander Geoffrey Unsworth, D.S.O., who rose from a bed of sickness to find and buoy the wreck's position. He had gone to the rescue of the "Laurentic's" passengers and crew in 1917, when she was torpedoed, and had saved the liner's human freight after 40 hours' work in a heavy sou'-westerly gale. His trying experiences broke down his health, and all attempts to find the wrecked treasure completely failed until Commander Unsworth once more came on the scene and again found the wreck after five days' arduous search. By a curious and ironical oversight, this war-time mines clearance officer was overlooked when the "Laurentic's" salvors were rewarded.

Somewhere in the shifting shoals and sandbanks of Vlieland Channel, off the entrance to the Zuider Zee, Holland, there lies to-day over £1,000,000 in gold bars, ingots, silver and jewels, the rich freight of the 32-gun frigate "Lutine," which sailed from Yarmouth roads, on October 17th, 1799, carrying nearly £3,000,000 for British troops at war with the Dutch leagued with Napoleon Bonaparte. It is believed that she had on board the Dutch Crown jewels which had been re-set in London.

A terrible storm drove the frigate far out of her course, and nearly all on board were drowned. Much of the bullion in the "Lutine's" magazine room had been consigned to Hamburg merchants from London. Storms and heavy seas alternately silted up and uncovered the wreck as it lay on Vlieland shoals, and, by 1801, Dutch fishermen had salved from her over £84,000 in gold bars and English, French and Spanish coins. Then she disappeared in the shoals, and a lengthy dispute, lasting over 50 years, between Lloyds Shipping Corporation, of London, the underwriters, whom the wreck cost £900,000 in claims, and the Dutch Government, claimants of the wreck, made the treasure lie dormant.

Millions of tons of sand were sucked from the wreck by a powerful salvage pump in 1911, but the salvors of this expedition were made the sport of fortune and the North Sea storms. They drove their way through to the treasure chamber by grenade explosions, only to find a great mass of rusty and closely adhering cannon-balls lying just over the bullion. A violent storm arose and buried the wreck deeper in the treacherous sands of the channel. Not more than £100,000 of the "Lutine's" treasure have so far been salved.

Mr. Lake's method of raising treasure wrecks from the sea-bed is very interesting. He has devised a special salvage vessel which would pump into a drowned ship, such as the "Lusitania," a buoyant solution of cellulose, balsa wood and paraffin wax. The water would be forced out through ports in the ship's hull and cause her to break away from the sea-bed and float on the surface. Three hundred tons of this solution could be pumped in an hour into the wreck's hull, and a dead weight of thousands of tons lifted above water. The cellulose solution, which would fill every part of the wreck's hull, would be dislodged by jets of high pressure steam when she reached dry-dock.

Money, plate, jewels and the Crown treasures of John Lackland, King of England, whose foot soldiers, horses and baggage train were swallowed up by a quick-sand in crossing the Wash, at Welland, Lincolnshire, in 1216, await the salvor equipped with up-to-date appliances. The loss of this kingly treasure, recorded by the old monk of St. Alban's Abbey, Matthew Paris, is said to have completed the work of monastic poisoned peaches and new beer in causing John's sudden death at Newark. This great hoard of wealth is believed to be located in a reclaimed part of the Wash (a low-lying fen), on the site of Cross-keys Wash, which the King forded on the fateful day.*

Old china worth many thousands of dollars was recently

* Sir William St. John Hope, of the Society of Antiquaries, who investigated the matter in 1907, pointed out that the track of the train of horses lay across a line of sands now parallel with the Great Northern-Midland Railway embankment between Sutton and Long Walpole. King John's baggage horses stretched in an enormous train of two miles in length. The Crown is the owner of the treasure trove, but according to regulations issued in 1925, about 50% of the value of the treasure would be awarded to the finders. Obviously, in the long interval of time which has passed since the treasure was engulfed, the drag of the quicksands and the wash and eddying of the tides might remove the treasure far from its original place of deposit; but it is also possible that the treasure may lie buried in a bed of sand and shells, 30-50 feet below the railway embankment. Some such instrument as the Eotvos Torsion balance, or the electrical detectors used to locate buried shells in the devastated zone of France, might prove effective in locating this loot of the gluttonous King John.

recovered by a Swedish salvage boat, hailed by a fisherman who had lost his anchor in a storm off the Archipelago, at Stockholm. Divers who explored the sea-bed found the anchor caught in a Polish gun dated 1623, lying near the wreck of a Swedish man-of-war. On a wreck nearby they discovered tons of valuable "sea-drunk" black oak, and are still searching for another long-lost hulk known to have on board the baggage of a Swedish ambassador and valuable gold and silver metalwork.

But what is to be done when it is sought to raise bodily a huge wreck weighing thousands of tons, in order to salve not only valuable cargo, but the boat herself? Pontoons and the use of compressed air are called in to the salvors' aid. Imagine a flotilla of barges crowded with derricks and lifting gear, and tugs sweeping hawsers under the wreck. Large tanks (the pontoons) are sunk beside the wreck and hawsers passed from them under its hull. Air blown in under very high pressure forces the water out of the tanks, and, swung by the tide, the pontoons tug and heave and drag the wreck nearer to the surface, when it is towed to dock or beached on the nearest shore, where divers seal the holes in its plating and pump out the water.

The British Admiralty war-time salvage corps, under the direction of that G.O.M. of salvage wonders, Sir Frederic W. Young, K.B.E., raised a sunk collier of 3,800 tons, 138 feet by dragging it up from the sea-bottom with the lifting-power of horizontal surface pontoons and steel cables passed under the wreck.

Thousands of tons of water have to be nicely balanced between the pontoons, and each cable and chain has to be adjusted to stand the swaying and heaving of the restless sea, rocking this way and that, pushing up one pontoon and thrusting down the other. How anxiously, too, the salvor watches the sky, for a freshening wind and approaching storm clouds may mean the loss of many months' labour! Caught in a gale, towing a raised wreck, buoyed up by pontoons, the salvage steamer cuts the tow-rope and flees for dear life.

When a ship was torpedoed during the Great War, she sent out a radio message for help, and up dashed a British Admiralty salvage boat, which proceeded to fix to the hole in the hull a "standard patch" of thick planking curved to follow the ship's lines. She could then be towed afloat to dry dock.

To-day, if the ship is under water, divers go down to find out the shape of the rent, by the aid of an adjustable mould, after which the patch is bolted fast inside and outside the hull, and the water pumped out, or expelled by the expensive method of compressed air. The enormous pressure of the water will break the ship in two unless the decks are shored up, when the air and pumps get to work. In the inky blackness, the diver's electric torch is useless three inches away from an object, and he has carefully to memorise the plan of the ship, for his life is forfeit if his air-line catches in a cabin-doorway as he gropes his way beneath the decks.

A deeply sunk ship, which cannot be pumped out, or its decks braced up to stand great air-pressure, is surrounded by a water-tight fence made of very thick timber and plank-frames. The water within this "coffer-dam" girdling the hull is pumped out, and the buoyant coffer-dam floats the ship. The well-known American salvage expert, Mr. Jesse W. Reno, uses pontoons which are fastened on to the hulls of very deeply sunk ships by terminal hooks passing into holes bored electrically into the drowned hulls. Air is siphoned into the pontoons to make them drag the wreck loose from the sea-bed.

A remarkable story of ship salvage by compressed air is that of the American oil-tanker, the F. D. Asche, a steamship of 11,790 tons, pounded for three days on a reef off the Florida coast, on which she was driven by a hurricane. The tremendous inrush of water through the bottom of her hull swept into the engine-room, put out the fires, and tore away nearly three-quarters of her keel. Compressed air was forced into her damaged oil tanks and she was towed on a cushion of air, and practically keelless, to New York.

No more thrilling story of amateur radio has ever been told than the remarkable way in which an American schoolboy's accidental reception of an S.O.S. call rushed destroyers to the rescue of 28 men imprisoned in the living tomb of the U.S. submarine S.5. This under-water vessel had submerged, when, by a mysterious freak of her mechanism, she hung bow downwards, swinging like a pendulum in the Atlantic tides, her stern just glinting above the surface. Her captain at once detached a buoy with a telephone attached and sent it above water, where for an awful day and night its electric bell vainly rung above water. Not a ship passed that way, and despair seized on the submarine's crew, when by great good luck a passing U.S. steamship heard a telephone-bell ringing strangely in mid-ocean. The steamship's crew put off a boat, passed hawsers with great difficulty under the hull of S.5, bored a hole in her armour plate, and pumped in air to save the suffocating men. A radio message calling for instant aid flashed out, but nobody picked up the message, except an American boy trying out an amateur radio set. He promptly relayed the message to a naval yard, and destroyers steamed at top speed to the position indicated. They buoyed up the S.5 strongly, and burned a hole through her hold from which were extricated 28 nearly dead men.

Then, in the early years of the Great War, the U.S. navy had to grapple with the tremendous problem presented by U.S. submarine F.4, which submerged at Honolulu in 300 feet of water and did not re-appear. A heroic diver, sent down to this terrible depth, where it was feared he would be crushed to death by the water's pressure, had to find out if lifting hawsers were properly placed under her hull. Coming up, the poor fellow's shot-rope hitched in the vessel, and he hung 100 feet below the surface, nearly perishing of exposure. He attained the world's record for deep-sea diving, and F.4 was safely towed into harbour.

The crew of the British submarine K.13 had a terrifying adventure in the height of the war, which will raise a shudder for years to come in the story of under-water navigation. She was a fast boat, fitted with powerful steam turbines, as well as electric motors and gasolene engines. The order was given to submerge at her trial trip in a quiet loch on the Firth of Clyde, but the crew forgot to close the ventilating cowls, and a rush of water swept into her stern and drowned 30 men, imprisoning 40 others behind a bulkhead which every moment threatened to collapse under the pressure of the surrounding sea.

Two officers tried to escape by letting compressed air into the conning-tower to blow back its lid. The air burst its way out with terrific force, dashing out the brains of one man, who was hurled against the steel walls, and sweeping the other clean through the conning-tower opening to the surface of the water. He was picked up alive.

The salvage corps arrived, swept hawsers under the hull of the 3,000 ton submarine which had sunk deep in the mud of the sea-floor. They kept up the spirits of the entombed men by flashing with an under-water electric lamp morse code messages through the drowned craft's periscope. Four days of superhuman effort passed before K.13 was raised to the surface, her hull pierced by the oxy-hydrogen blow-pipe, and her crew drawn to safety out of their steel tomb. This was one of many tributes to the great work inspired and directed by Sir Frederic Young, Britain's war-time controller of salvage operations for the Admiralty.

Modern salvage wonders have seldom been better exemplified than in the case of the grain steamship "Araby," which, from 1916-18, lay at the bottom of Boulogne harbour, blocking the fair-way. She broke in two under the weight of her wheat cargo. A ferro-concrete "plaster" was applied to each side of her fractured hull, and she was pulled higher up the haven out of the fair-way. Nearly two years later, she was actually towed, one half of her one day, and the other the next day, 35 miles across the straits to Dover harbour!

The thrilling experience of being towed under water, bumping the sea-bed, inside a German submarine with live mines aboard, befell the salvors of U.44, long sought for by the British naval authorities for torpedoing a steam-boat and taking off and drowning the partly-clothed survivors. The submarine had met an awful end. She released a mine under water, which shot upward and collided with a surface mine in the Irish Sea. For the sake of the secret orders of the German naval authorities, she was raised by compressed air and pontoons, and floated into shallower waters. Tugs towed her over a steep sandbank, as she was still below the surface resting on steel hawsers, and after nineteen days of gales and heavy seas, she was beached, her sealed papers removed and the dead German crew solemnly buried at sea.

One of the secrets of the war for long jealously guarded by the British Admiralty, and even now known to few people in Britain, was the purpose of the "Mystery Towers," huge six-sided floating buildings, rising 130 feet above the sea at Shoreham, on the south coast of England. Their real or presumed use was not for naval *defence or assault, but to raise from the sea-bed many* torpedoed ships lying 20 fathoms deep. The mystery towers were built of concrete, in tiers and boxes, each unit four feet square by two feet, and assembled on a beach where they were strengthened with steel girders. Sluice gates with pumps to admit or expel water were at their base. They were floated out to sea on a high tide.

On reaching a wreck, the sea-water was admitted by the sluices to the base of the mystery towers, which were lowered one on each side of the wreck, and hawsers passed from them under the keel of the drowned boat. Then the water was pumped out, and the mystery towers rose, dragging up the wreck with them. In lifting, the wreck would tend to pull the mystery towers towards each other, and this was counteracted by flooding cellular chambers opposite to the wreck, thus regaining equilibrium. Cradled between the two towers, the wreck was, lastly, towed to dry dock.

In very deep water, the mystery towers were sunk so that their specially curved bases came just under the hull of the wreck, and their conning-towers were exactly awash with the surface. These latter could be closed and the towers completely submerged so that lighters with powerful pumps could come alongside and lift towers and wreck by sucking out the water.

The wonderful feat of raising and righting a colossal dreadnought of 22,000 tons, resting deck down on a muddy sea-bed into which pressed her five heavy barbettes, with thirteen 12-inch guns and her funnels, was, after three years of terrific exertions, accomplished by the salvage section of the Italian Navy. The battleship is the "Leonardo da Vinci," which was moored in Taranto Bay on August 2nd, 1916, when, at midnight, a crashing explosion of mysterious origin sank her and killed 250 officers and men. She quickly capsized and went down keel upwards, hurling into the water men who were then trying to extinguish the flames.

General Ferrati, of the *Italian Naval Salvage* Department, and his staff first experimented on models of the "Leonardo da Vinci" in order to discover how the battleship might be expected to respond to the application of certain forces. She cost about £4,000,000 to build. Salvage and diving operations began in 1917, when holes were drilled electrically in her hull, so that "standard patches" could be riveted over the cavities showing how the battleship had been rent from deck to keel by the explosion. Then, an electric power station on shore forced compressed air into the ship, expelling the water from her reversed hull, and allowing men to enter the ship's bottom by an air-lock and heave out cargo to lighten her.

Heavy oil floating inside the battleship's hull made it very difficult for the divers to discover in the under-water gloom where patches and repairs were necessary. These *difficulties were overcome by the concentration of the* powers of some of the ablest scientific salvors in the world, but their powers were taxed to the utmost in solving the problem of raising a battleship, weighing 22,000 tons, from the clay on which her smoke-stacks rested, without causing her to sink even deeper into the mud of the ocean-bed. For more than a year, until early in 1919, divers hacked and sawed at the funnels and turrets of the upside-down battleship in order to detach them from the deck. They worked inside the hull, in compressed air chambers, and to complete the operations, they had actually to descend 15 feet into the clay beneath the level of the sea-bed on which the ship lay.

Now came a further difficulty; how were they to tow a battleship, drawing some 50 feet of water into a dry-dock only 40 feet deep? This is how it was done.

The "Leonardo da Vinci" was lifted from the sea-bed by the rising of large pontoons attached to each of her sides, her decks hermetically sealed to exclude the sea-water, and then towed *still upside-down* through a specially-dredged channel to the dry-dock, where she finally came to rest on a great bed of timber. Even then, after repairs had been made, two years passed before the battleship was righted, which was done by again taking her out into the bay, placing her in a specially dredged basin, ballasting her, and flooding certain of her compartments. The counterweight at last swung the ship over to the upright position on the 25th January, 1921.

Hardly a summer passes by in which one does not hear of people embarking on the highly speculative venture of raising treasure from the sea-bed. In the year 1925, for example, a well-known London newspaper told us of a thrilling expedition, financed by a sporting syndicate of New York financiers, to salve the treasure of gold, silver and jewels lying in the strong room of the liner

"Merida," which was rammed and sunk in the locality of Cape Charles, Virginia. Wind and weather, rather than pirates, are the great enemies of all these romantic expeditions, as we have seen. Davy Jones's Locker sometimes defies dynamite and batteries of high-powered electric sea-lamps.

It is noteworthy that the best luck in such ventures has often attended the efforts of naval authorities, but, on occasion, civil salvage corps have beaten the "salt, unchanging sea." In August, 1925, one heard of the successful recovery of £100,000 gold bars, by the Japanese Deep Sea Company, who attacked the Japanese steamer Yosaka Maru, torpedoed by a submarine in 1915, and lying in 240 feet of water off Port Said.

Possibly the reader would care to glance at a list of the wrecks now lying and rotting in various seas of the world. Very many more are contained in the records of the British Admiralty, dating back for more than a century. The well-known wreck of the Spanish Armada vessel, "Florencia," at the bottom of Tobermory Bay, has the unique testimony of a seventeenth century master mariner, who petitioned the Duke of York, in the year 1683, for an allowance of expenses. In the petition, which lies among the Rawlinson Collection of Pepys Papers at the Bodleian Library, Joshua Maisee, the petitioner, says he had hooked up from the wreck a crown or diadem, "but being chained, it fell amongst the timbers."

French and German divers, in the spring of 1926, set to work on the wreck of the P. and O. liner "Egypt," sunk in a collision off Brest, on May 20, 1922. She had on board £1,500,000 in gold and silver. A Swedish captain found and buoyed the wreck in 1923.

LIST OF WRECKS CONTAINING BULLION.

Ship.	*Location.*	*Cargo and Its Value.*
Merida.	Cape Charles, Va.	Mexican gold, silver coin, copper—£400,000.
Lizard.	C. of Cornwall.	Gold bullion—£7,000,000.
Islander.	C. of Alaska.	Gold nuggets—£600,000.
Rio Janeiro.	S. Francisco Bay.	Gold, silver, ivory, jade—£200,000.
L'Orient,	Bay of Aboukir.	Gold and silver coin—£2,000,000.
La Lutine.	Vlieland.	Gold and silver specie—about £2,000,000.
De Braak.	Delaware Bay.	Gold and silver coin—£1,000,000.
Byzantine.	Dardanelles.	Gold specie—£600,000.
Kingfisher.	Black Sea.	Minted coins—£1,000,000.
Republic.	Nantucket Light.	Gold coin—£400,000.
Geelong.	Mediterranean.	Gold and jewellery—£800,000.
Wilhelm der Zweite.	C. of Africa.	3,700 bars of silver; also copper.
City of Athens.	C. of New Jersey.	Unknown contents—value £600,000.
Egypt.	Near Brest.	Gold and silver—£1,500,000.
Florencia.	Tobermory Bay.	Gold and silver specie—£3,000,000.
General Grant.	Auckland Islands.	Gold bullion—£3,000,000.
Yosaka Maru.	Mediterranean.	Minted gold and bullion—£2,500,000.
Margarita.	C. of Porto Rico.	Gold bullion and precious stones—£5,000,000.
Span. Treasure Fleet.	Vigo Bay, Spain.	Peruvian gold—£24,000,000.
Medit. Pirate Fleet.	Grecian Harbour.	Gold and antique treasures—£20,000,000.

CHAPTER III

PROBING THE SUN'S SECRETS

DR. SUNSHINE INAUGURATES THE REIGN OF BLOODLESS SURGERY —ULTRA-VIOLET RAYS—IN WOOD AND WARD—HOW THE ULTRA-VIOLET RAYS WORK THEIR MARVELS—RELATIONSHIP BETWEEN HERTZIAN, RÖNTGEN OR "X" RAYS, AND THE ULTRA-VIOLET RAYS —WHAT IS ELECTRICITY?—ANGSTRÖM UNITS—NEW MICROBE DEATH RAY—DR. ROLLIER'S CURES—LIGHT BATHS IN GREAT CITIES—MERCURY VAPOUR LAMPS—ENGINEER'S ACCIDENTAL DISCOVERY—CURE FOR BALDNESS?—WAR TIME SECRET DISCLOSED—INDUSTRIAL USES OF THE ULTRA-VIOLET RAYS—THE DETECTIVE IN THE LABORATORY—OTHER RAYS IN THE SPECTRUM

"BOTTLED sunshine opens a wonderful era in which much of the surgeon's slashing will be unnecessary," said, recently, a well-known English surgeon, Sir Alfred Fripps; and indeed, the age of light is upon us when we may imitate the example of the ancient Germans who cured their children of fever by exposing them naked to the rays of the early morning sun on the top of rude, wooden houses, built in clearings on the edges of primeval forests. Only the other day an explorer, who had returned from the head waters of the Amazon, told of savages who cured and sterilised dreadful wounds merely by lying in the sun. Even so, did their ancestors, the Incas of ancient Peru. They achieved this wonderful result by exposing their bodies to the great, unseen power of the invisible violet-rays found in the spectrum of sunlight, and whose wave-length is so minute that from 30 to 80 of them could be comfortably packed within the space of a red corpuscle, itself 1/3000th of an inch wide in the human body!

In New York, engineers are preparing schemes for the erection of vast, artificial suns to illuminate the city in winter, and in one of London's poorest and most squalid quarters in the region of the docks, a solarium is to be built where poor people can go for sun-cures, just as rich people travel to Switzerland, or seek health in the palm-groves of the South Sea Islands. We are near to the day when every house will have its light-bath as well as its water bath-room.

To-day, the ultra-violet or invisible rays of the sunlight are used not only to cure obstinate diseases, but to sterilise water, to accelerate the growth of crops, to stimulate the laying-powers of hens, to season lumber, to test the permanency of paint and the finish of upholstery on automobiles, and, along with other constituents of sunshine, to produce synthetic food. "An enormous transformation will be brought about in the world's food supply," recently declared Mr. Hoover, U.S. Secretary of Commerce, speaking at Washington, on the coming of the day when the world will eat synthetic food created by the scientific use of sunlight. He referred to the achievement of an English University professor who, in a laboratory experiment, had succeeded in making synthetic sugar by passing a ray of light through an organic compound, formaldehyde.

Sun-baths amid the pomp and glory of green woods under the blue skies of high June touch to life and health the thin and emaciated limbs of bodies and fill with laughter and happiness the wistful eyes of the little stunted children of our slum cities. In Ken Wood, the former residence and grounds of a Russian Grand Duke, which rings the North-Western heights above London, the experiment was recently tried of putting children in little hurdles, breast-high, and set up on sloping field banks facing South on the edges of the glades. The infant patients, who came from cripple schools, wore white sun-hats and bathing suits and lay in the sun. Rickets and bone diseases magically vanished under the vivifying ultra-violet radiations from the sun's spectrum, enriching the children's blood with sorely needed lime and phosphates.

Pass from the sunny freedom of the open air to the ward of a great hospital. A blinding light from an arc lamp of 30,000 candle-power pours down from the ceiling on which it is hung from a wire-cable. Looking like a mysterious conclave of monks assembled in the crypt of some Spanish monastery in old Seville of the Holy Roman Inquisition, are eight deeply bronzed men, hooded to protect their eyes from the fierce rays under which they are seated. The sisters (nurses) and doctors wear special anti-glare glasses and little babies have goggles strapped to their foreheads.

New cases receive half an hour light, at a time; others, deeply tanned, have four hours a day of artificial sunlight. Bad skin complaints vanish magically, dull and stunted boys put on weight; they start to be cleanly, and the light of intelligence shines in their eyes.

How do the ultra-violet rays effect their invisible magic on the body? They are only able to work when their wave-length is in resonance with those of the atoms upon which they fall, and that is when they are absorbed. It must be remembered that the atom is a complex body whose central nucleus, positively charged with electricity, is surrounded by whirling atoms negatively charged, and bound to the central nucleus. The visible rays of the sun warm the small blood vessels of the skin, the heat-rays warm the skin and aid the ultra-violet rays to attack the atoms of the tissues, causing the electrons to give up their negative charge of electricity. The atoms are disrupted, a tremendous amount of energy is liberated, the tissues are reduced and oxidised, and the white army of corpuscles in our blood stream are strongly reinforced and stimulated to absorb and destroy the pathogenic or harmful microbes. No wonder, then, that the rays hasten the cure of wounds, rout the terrible tuberculosis germs, and nerve the body to throw off the elusive and obscure causes of neurasthenia and functional disorders!

The ultra-violet rays show, on examination, three distinct regions of radiation. At their longest they penetrate the skin deeply, but do not kill harmful germs; at their shortest wave-length (2,100—2,960 Angström units), they are germicidal in action, but have no great penetration. They are strongest at 3,000 A.U., when the waves get deep down into the epidermic cells of the human skin, and bring about remarkable curative effects.

The atmospheric dust and clouds of the higher regions of the atmosphere scatter or absorb most of the powerful ultra-violet rays and what reaches us is the sky shine reflected by bright clouds and the blue sky. Clothes, glass windows, brick walls and smoke clouds cut off the sunlight from people shut up in stuffy rooms in cities away from the breezes and the sunshine. The smoke screens which blot out the sky over many of our great cities harm the herds of cows kept on their outskirts, and affect the vegetables grown in market gardens for miles around. They suffer from the absence of sun, and we suffer in our turn.

Radiant energy which comes from the sun is the source of all light, heat, electricity, and of life itself, whether in the ceaseless activity of life going on around us day by day, or in apparently dead or non-living matter. What we cannot see is often even more powerful than the visible, so that it is not surprising that the invisible rays of the sun's spectrum, too long or too short in wave-length to be perceived by the retina of the human eye, have effected transformations in modern life and science far transcending the ruddiest imagination and powers of any tale-telling magicians or genii of the Arabian Nights.

Sunlight, passed through a prism, is split up into a visible rainbow of red, orange, yellow, green, blue, indigo or violet. At the red end of the spectrum, unseen by the eye, are the infra red, or heat rays which impart the sensation of warmth to the hand. Science has found out and mapped 50 octaves of radiation in the sun's discharge of energy, one of which we know as light, because the retina of the human eye, upon which it strikes, telegraphs the sensation to the brain which records it as light, colour and form. Then there are nine octaves of infra-red rays, or heat waves, and below these, pulsating with lesser frequency, are about 12 octaves of Hertzian waves, named after Hertz, the great German physicist whose researches pioneered the way for radio-telegraphy. Lastly, come the wave-lengths used in broadcasting news and pictures. It would thus appear that modern science has gone far towards solving the riddle of the cause and origin of electricity, the great life force which, for us on earth, is now identified with solar, radiant energy, and, over all space, is probably a resultant of the continual strain or tension between ether and matter, throughout the cosmos or solar and stellar universes.

At the other end of the spectrum are three octaves of invisible, ultra-violet rays,* the shortest of which, known as Millikan's rays, overlap the softest X-rays; and beyond them, some seven octaves of X or Röntgen rays up to the gamma rays of radium. To reproduce the gamma rays, in the vacuum tube, a tension of two million volts is needed. The shortest, Röntgen rays, known as "Deep Therapy X-rays," are now used to cure the dread disease, cancer.

Ultra-violet rays range from about four millionths to 16 millionths of an inch, of such microscopic length that science measures them in Angström units, commemorating the name of a famous Swedish physicist; and it is reckoned that 10,000,000 of these units are equal to the diameter of one human hair. Each Angström unit is based on the wave-length of the "softest" X-ray. It may be noted that whilst the visible light rays cover only one octave, the ultra-violet rays are five octaves in length.

The red ray of the spectrum ceases to be visible after 7,500 Angström units, and the violet end after 3,900 units, and some wonderful exploration of the range of these rays has been done in the last 10 years by scientists of international fame. The invisible rays have been made visible by fluorescent chemical screens and photographically recorded by lenses and prisms of quartz. Schumann, Lyman,

* In the autumn of 1925 the discovery of even shorter wave-lengths was made by electrical measurements and the use of captive balloons and aeroplanes in the extremely rarefied atmosphere of the regions of the upper air. They have a penetrative power higher than the shortest rays hitherto known to science. Prof. Millikan, their discoverer, said, in November, 1925, that these new rays, of the order of 0.0004 Angström units, are able to penetrate 6 feet of lead as against the 8 cms. of penetration by the short gamma rays of radium. *Whether they can be harnessed to man's use is* not yet known. These rays are believed to emanate from the nucleus of the spiral nebulae remote in space, since they are shot out in all directions through the ether, and they correspond to those associated with the change of hydrogen into helium, or the capture of a single electron by a positive nucleus. The new discovery leaves a gap to be filled between the short gamma rays of radium and the much shorter new ray found by Professor Millikan.

Richardson and Bazzoni, using vacuum spectroscopes and hydrogen and helium atmospheres, have explored territories ranging from 1,850 Angström units down to the shorter wave-length of 420, beyond which is an unknown region which the mysterious and wonderful change from light to Röntgen or X-radiation takes place. We are only on the threshold of tremendous achievements and man's coming control of vast cosmic forces which will make pale all science has done in the past. Will such control be used for war or peace, for the lasting happiness of the human race or its misery and destruction?

In passing one may note the latest development in the use of the germ-killing rays: the invention in November, 1925 (by Dr. W. D. Coolidge, a well-known Röntgen ray expert), of an apparatus by which the Cathode rays, usually produced only within vacuum tubes when a powerful electric current is passed through, can now be generated in the air, and in strength stated to be enough to kill insects and microbes.

The most striking effects of Dr. Coolidge's invention are obtained on living things.

" Bacteria," he says, " have been rayed, and an exposure of a tenth of a second has been found sufficient to kill even highly resistant bacterial spores.

" Fruit flies, upon being rayed for a small fraction of a second, instantly showed almost complete collapse, and in a few hours were dead."

This may lead to the application of the rays as a powerful germicide and insecticide, but their promiscuous use on higher forms of life would, in the present stage of the development of the apparatus, be dangerous.

With a potential as high as 250,000 volts, and a current of several thousandths of an ampère, the rays travel as far as 18 inches from the tube and produced a purplish glowing of the air in front of it.

To return to the subject of the invisible ultra-violet ray therapy, we see that the first physician to use the ultra-violet ray was a Dane, Niel Finsen, of Copenhagen, who, finding natural sunlight too slow a method of treatment, devised an artificial sun-bath formed by a powerful carbon arc lamp in which, after successive exposures, the whole body can be bathed. Then the amazing sight of consumptive children, clad only in a loincloth and tramping or playing on the dazzling, white snow of the High Alps in the depths of winter was seen in Switzerland.

There, Dr. Rollier took into his Preventorium at Leysin, sick and weakly children suffering from bone diseases, tuberculosis, rickets, let them bath in the sun and walk about in the snow wearing only snow shoes and a girdle. Marvellous cures were obtained, for the sunshine, "best of masseurs," healed all disease and touched into free and bounding life children who stood face to face with death. Snow, it may be noted, reflects the ultra-violet rays of sunshine, to a great degree, so that sun-bathers get the benefit of both direct and reflected light.

Rollier's treatment is gradual, starting with a few minutes' daily exposure of the patient's feet to the sunlight, until, clad in a loin-cloth, the patient's whole body is bathed in the sunrays for hours daily, both in winter and summer. Fair people react more intensely and quickly than dark people, and the degree of sun-burn or tan is a measure of the rate of progress towards cure.

The bodies of sun-bathers in high, mountainous regions are both warmed and stimulated by the direct rays of the sun in a degree which could not be endured at lower altitudes or in tropical lands, where excess of heat or infra-red rays largely destroy the good effect of the ultra-violet or invisible, and the luminous or visible rays. This explains why sun-bathing is best practised in the early morning; but, all the same, ultra-violet rays act more quickly when the irradiated object is warm than when it is cold.

Ordinary woollen clothing, we noted, absorbs what little of the ultra-violet rays manage to get to us through the double screen of smoke-clouds over our cities or, in rural areas in the lower altitudes at which most of us are forced to live, through the dust and clouds in the upper regions of the air. Cotton clothing, which would permit the rays to penetrate to our bodies, is, of course, impossible to wear in temperate climates, other than in the rare and short midsummer weather. To meet this need, an English manufacturer has invented a silky, transparent material, transparent to ultra-violet rays, known as Celanese, which, it is claimed, will allow people to obtain all the advantages of a sun-cure, without going to Switzerland. Artificial silk, if light and loose in texture, will let pass through 90 per cent of the ultra-violet rays, said Dr. Wingrave, of Lyme Regis, Dorset, in June, 1925.

Sun-bathing in the natural rays of the sunshine, except in the clear pellucid atmosphere of mountain regions, allows only the middle ultra-violet rays to reach our skin, but they can penetrate only one-tenth the diameter of a small pin's head into the layer of living cells forming the inner boundary of the scarf-skin or epidermis, where they produce sunburn. The most powerful ultra-violet rays reaching us from the sun are only 25 millionths of an inch in wave-length, and although possessing the greatest curative force, cannot even penetrate the thickness of one microbe, which means that one layer of microbes would screen from lethal action another below it. As we said, however, they are cut off from us by rain and fog and in the upper regions of the air, so we have to substitute artificial sun-baths from powerful arc and incandescent electric lamps to obtain these beneficent actinic rays, which are those producing photographs on sensitised plates as well as bringing us health and strength.

Electric light has properties very similar to those of sunlight, and a fair proportion of ultra-violet rays. One type of artificial sun-bath consists of 48 incandescent lamps, mounted in rows, and controlled by switches inside a cabinet lined with opal glass. The patient takes off all his clothes, and sits on an adjustable stool, his head lying just outside the cabinet. This light bath has almost superseded Turkish baths.

Dr. Axel Reyn, of Copenhagen, has just invented a powerful carbon arc light in which, after successive exposures, the patient can bath his whole body. High ampèrage and low ampèrage baths are used, and can cure six to eight people simultaneously, or successfully treat two recumbent patients at once. But this method is very costly.

There is the Mercury-vapour lamp, with quartz or silica tubes, of 220 volts and using three ampères of current, which can sterilise 132,000 gallons of clear water in 24 hours. This sheds a warm light over infants' cots, and cures children's anæmia and rickets, the latter disease due to a deficiency of calcium and phosphates (bone-forming material) in the blood, which is raised to normal by the ultra-violet rays. The mercury lamp is powerful in ultra-violet rays, but quite cold.

For children's ailments, Dr. Professor Leonard Hill, the well-known English specialist in ultra-violet ray treatment, is starting sunlight lamps in public baths in London, so that children in lightest possible clothing can dance in a circle upon which the lamps shed their radiance.

Shall we live, in the future, in houses of glass constructed so as to let the sunshine pass through with its healthful, actinic rays?

Mr. F. E. Lamplough, late Fellow of Trinity College, Cambridge, has invented a new type of glass, called "vita-glass," which, like quartz and unlike ordinary glass, lets ultra-violet rays pass through, so that patients in a hospital with windows of vita-glass derive as much benefit as if they were outside in the life-giving sunshine. The vita-glass costs from about 3/- to 4/- a square foot, whereas quartz lamps, for indoor treatment, are very expensive.

"Artificial Mountain Sun" is the poetic name of another ultra-violet ray treatment, in which air-cooled mercury vapour lamps are used. A column of mercury in a quartz tube forms the electrodes of the arc, whose heat-rays are moved by an electric fan, whilst the ultra-violet rays are directed through quartz lenses on to the sufferer's skin.

An electrical engineer, who was investigating the nature of rare ores, found that the hands of his workmen, suffering from eczema, were healed if they were exposed to the radiations from heated tungsten. This was the origin of the tungsten arc lamp, of which a scientist recently told the Röntgen Society the most intense and richest source of ultra-violet rays were arcs of tungsten electrodes. A metal shield reflects the light of the arc on to the patient, and protects the operator, and its effects are intensified by a concave, nickel-coated mirror, reflecting heat as well as light rays. Patients' and operator's eyes are protected by goggles, and the lamp moved from time to time to lessen the heat.

Functional complaints, nervous debility and neurasthenia, caused by the sick hurry of modern life in large cities can be cured by exposing the body to the rays of the tungsten arc, for two or three minutes, twice a week. This treatment is combined with the use of the "Condenser Couch" upon which the patient lies clothed and grasping a bar electrode in his hand, his body thus acting as one of the plates of an electrical condenser.

Finally, the Eidonow-Hall long flame arcs of carbon and aluminium shed their ultra-violet rays on persons, sitting around, stripped to the waist.

X-rays and ultra-violet rays, according to the latest researches, do not directly affect the causes of disease, but stimulate the healthy cells to eat up the unhealthy cells. At first, the patient feels no effect, when exposed to the ultra-violet rays. Then, from four to eight hours later, his skin flushes, and after further exposures, it pigments or tans and presently, the natural defensive power of his body is stimulated to fight disease. Yet, it must be remembered that artificial sunlight requires much training in its use, since an inexperienced operator may endanger the patient's health.

The ultra-violet rays played a romantic but very little known part in combating the submarine menace to Anglo-American commerce during the Great War. Ship convoys had, by some means, to be guided in line across the Atlantic by lights invisible to the lurking U-boat. This was done by passing ultra-violet rays through a black glass impervious to all other or visible light.

On the stern of each convoyed ship, lights were set behind the black screen, but the illuminant was invisible to outside observers. The next ship in line focussed on the screen a telescope containing a small fluorescent screen very much like that used to make X-ray pictures visible to the eye. The fluorescent telescopic screen picked up the ultra-violet rays projected from the vessel in front, and thus knew if it were in alignment.

This very interesting war-time experiment was recently reproduced by a Japanese scientist in Tokyo who succeeded in taking photographs in the dark by the use of the invisible rays. In this way, Professor Wright, of the famous Lick Observatory, in California, photographed a grove of redwood trees on the slopes of the Sierras 150 miles away from the observatory wherein the professor was sitting with his camera. Every detail of the leaves and branches of the big trees came out clearly in the photograph. He used a quartz lens thickly coated with silver to shut out visible light, and the same apparatus was made to photograph far distant stars.

This ultra-violet ray lens can be turned on in an aeroplane hidden behind dense clouds or in fog so that people on the earth cannot see it, and by this means an enemy aviator can take a photograph of a concentration of troops without the knowledge of the foe. Clouds offer no obstacle to the passage of the rays.

The human eye is sensitive to the presence of these rays although it cannot see them, and when a beam of ultra-violet light is directed on the eye a strange sensation of blinding light arises. The sensation suddenly disappears when the head is drawn out of the path of the light, and the eye feels as if a nerve had been severed. No wonder, then, that goggles have to be used to protect the eyes from these unseen rays. It is a curious fact that, under these unseen rays artificial teeth can at once be detected, since they do not respond with a fluorescent glow as do the natural teeth. Fog and rainy day effects are obtained in the case of pictures taken out of doors by the aid of the ultra-violet light, but in the case of the infra-red, invisible rays at the other end of the spectrum, photographs of green vegetation give remarkable effects of snow-laden branches in high June.

The uses of the ultra-violet rays, for purposes of every-day life and industry, are limited by reason of the fact that the shorter the wave-length the more it is absorbed by the optical medium through which it passes. Quartz lenses cease to be transparent to the ultra-violet rays above a length of 1,200 Angströms, and when the note, so to speak, becomes sharper still, moving up the octave, the physicist is forced to work in a vacuum if he would use the shorter wave-length. The use of the ultra-violet light is thus restricted, in practice, to a region close to that filled in the spectrum by visible light, and accordingly the wave-length most used is that of Wood (3,650 Angströms), near to the extreme limit of the visible violet light.

The germicidal action of ultra-violet light was tested before the Great War in purifying the waters of the river La Meurthe, at Luneville, near Nancy. They were infected with colibacilli to the extent of 30,000 colonies per cubic metre. The treatment was successful, in this instance, but it must be said that the great difficulty in the use of ultra-violet light in purifying water is that impurities held in suspension in the liquid act as screens opaque to the passage of the rays. Chlorination, or purification of water by the use of active chlorine in minute quantities, is preferred as a much less costly and quite as effective method of sterilisation. Milk, however, is a more profitable liquid to sterilise by the ultra-violet rays, which is done by passing the liquid through coils made of quartz, and radiating the invisible light.

Scientists have now succeeded in working out a scale showing the amount of resistance offered to ultra-violet light by different micro-organisms or germs. This scale, as ultra-violet light becomes cheaper to use, will be invaluable in treating the mildews and pests which attack plants and trees, and in the production of nitrates and ammoniacal salts for fertilisation, as is now naturally done from the air by certain microbes.

Many other remarkable uses have been found for ultra-violet rays and the other constituents of sunlight. It is well-known that green plants make sugar by a process of photo-synthesis in which solar rays falling on the plant's chlorophyll are caused to extract carbon from the air. This carbon is added by the plant to water absorbed by its roots, and converted into formaldehyde from which sugar is ultimately obtained.

It is this reducing and actinic action of the sun's rays in the higher altitudes of the air which rots aeroplanes' wings unless a dope is applied, and may explain how a flying man who started out on a round-the-world flight with a bald head, came back with a fine crop of hair. Warm sunlight, acting on the scalp, causes a rush of blood and nourishes the starved roots of the hair—and do not beauty specialists advise women, who desire long and beautiful hair, to dry it in the sunshine or walk without head-covering in the pure air of sunny lanes?

Drury Lane Theatre, London, has recently installed mercury-vapour lamps as a source of ultra-violet light to rejuvenate the energies of actors, actresses, scene-shifters, dressers, clerks, door-keepers and all employed about the theatre. This artificial sunlight is intended to rout colds, headaches and depression.

Inaccessible parts of the body that are infected, as in pyorrhea and bone tuberculosis can now be got at by means of curved, quartz tubes or water-cooled lamps introduced inside the bones. Two doctors of the Yale Medical School have found out that cod-liver oil cures rickets in children because it actually generates ultra-violet light in the intestines. This, it is said, explains why Eskimo babies in the land of 24 hours' winter night do not suffer from rickets. They eat blubber and fish diets rich in oils. Such oils are known to acquire thereby Vitamin A, which acts as a tonic in the blood.

The sun is being harnessed to cause food to absorb ultra-violet rays. We shall soon be "eating sunshine," for wheat, grown in the dark, after a two minutes' exposure to ultra-violet light has been found by Dr. A. F. Hess, of New York, to prevent weakness in bone. Some day the seas of the world may no longer supply us with codfish and its oil. If this happens, the same physician has found out a way of making cotton seed and linseed oil absorb ultra-violet rays.

Plant growth is stimulated by ultra-violet rays. It is known that plants can see sun-rays invisible to the human eye. In Hawaii, ultra-violet radiation was tried on sugarcane, pineapples, and bananas. The fruits ripened more quickly when exposed to the rays, and it was estimated that sugar-cane could be harvested at the end of 12 months, were ultra-violet rays used, instead of the 20 months normally required to reach maturity.

Animals kept in receptacles exposed to continuous sunlight, even though they themselves are kept in darkness, thrive because the wood radiates "tonic air," or light absorbed by the wood from the sun!

Poultry producers have been watching with interest the experiments made by two Kansas doctors who exposed hens once a day for 10 minutes to an electric-lamp source of ultra-violet light, and caused them to lay four times as many eggs as other birds, and twice as many of the eggs hatched. Pedigreed chickens, at Williamstown, Mass., are to have a sun-porch to shed light on them on dull days. It was found in experiments at the University of Maine and Harvard University that young chickens given artificial sun-baths weighed five times as much as others. Wisconsin University also demonstrated that eggs radiated with the light produced better and healthier chicks than those not irradiated.

Automobile makers are using ultra-violet light to test body fabrics and finishes. A few hours of exposure of upholstery fabrics, top materials, and paints under ultra-violet rays were found equal to many months of natural weathering.

The rays have also the power of ageing painting, and ultra-violet light tests enable paint manufacturers to tell how long colour schemes will last. The light penetrates water, and can be used to test paint and varnish immersed in a bath.

The leather maker has found that the very best glaze on tanned leather can be got by oxydation under the ultra-violet rays. He radiates the light on linseed oil, well aerated, which rusts and thickens into a kind of linoleum. In a similar way, it has been discovered that rubber can be vulcanised *without the action of heat* by mixing sulphur and rubber and radiating the invisible light upon the mixture.

It is known that certain Government laboratories at Porton, in Hampshire, are now engaged on experiments with gases to be used in the next war, if we are so insanely minded as to indulge in a next war. Among these gases is *phosgene*, which is "good for suffocation." During the last war, the ultra-violet light was used to concoct this gas by causing the gas chlorine and carbon oxide to unite, which they do not readily do without its aid as a "catalyser."

It is easy to give rein to the imagination and to foresee vast food manufactories wherein mercury vapour lamps will function as do plants in the order of nature and make our food out of the air. A beginning on these lines was recently made in Liverpool University where the well-known physicist, Professor Baly, succeeded in making synthetic sugar.

The phenomenon of fluorescence is noticeable when an invisible, short wave of ultra-violet light falls on certain substances and is reflected back as a coloured light of longer wave length, the colour varying according to the nature of the substance on which the invisible ultra-violet or Röntgen ray falls. This fluorescence is made use of in a variety of ingenious and interesting ways. In Paris, there is a Department of the Prefecture of Police, known as "La Service de l'Identité Judicaire," and to it are sent by judges and magistrates all pictures, documents and banknotes of whose authenticity there is any doubt. Here, under the hands and eyes of M. Fabre, the ultra-violet rays become policemen. A painting which connoisseurs thought was the genuine work of an old master is unmasked by the inexorable and invisible light, which falls on forged signatures, makes them fade away, disclosing the true painter's name, attesting or disproving the genuineness of the pigments used, demonstrating the true brush strokes of the master, and, with the aid of the X-rays, the skilled radiographer can tell the age of a picture and clearly show all the damage and restoration a painting may have experienced, even though the cleverest of forgers has retouched it. Clearly, too, the cheque forger's work is made much easier of detection by these invisible rays, which have been pressed into the service of Customs' officers who suspect fraud or smuggling, and of chemists called on to detect adulterations in articles of food. Here, it may be stated, every species of grain and flour has a characteristic fluorescence under the ultra-violet light, and this revelation of characteristic fluorescence may also be used by the scientist to measure the intensity of the unseen radiation in the like manner in which we contrast the intensity of illuminations with that of the candle.

A curious sidelight on the effect of ultra-violet radiation of an excessive character is thrown by the latest theory on the reason for the existence of pygmy races in the equatorial regions of Africa. It is supposed that these dwarf people develop and reach maturity much quicker than people living in temperate climes, because they are exposed to an intense ultra-violet radiation from the blazing sunshine of the tropics, causing their bones to grow too quickly and hence dwarfing them.

Baboons and other animals in the London Zoological Gardens, derived great benefits in 1925-6 from the radiations of mercury vapour lamps installed in their cages, where, by warming the floors, it has been found possible to dispense with hot air, and ventilate with cold air, with advantage to the health of the animals receiving this ultra-violet ray treatment.

Using the ultra-violet rays, Dr. Barnard, whose wonderful microscopy made possible the discovery of what is believed to be the cancer germ, has been able to photograph down to one-tenth of a micron (1-250,000th of an inch). The virus of cancer is so small that it has hitherto evaded the researches of bacteriologists by passing through their finest filters, and it will be remembered that, in 1925, Dr. Barnard, in collaboration with Dr. Gye of the National Institute for Medical Research, devised a remarkable ultra-microscope which allows the observer to see the reflection of the invisible bacteria. As the scientist looks through the eye-piece of the microscope at an intense beam of light passing across a liquid film containing the microbe, he sees a faintly luminous appearance moving on the dark background of the lens. This faint luminosity is caused by the deflection of the invisible particles of bacteria meeting the light rays. Mr. Barnard found that the green line in the spectrum of mercury in the vapour lamp used for the production of ultra-violet light best enabled him to see this invisible cancer germ. He is devising a new vacuum microscope, in conjunction with which he hopes to use a shorter wave-length, which will enable him to see microbes smaller still, and so carry farther the great war of humanity on disease.

There are other colour cures in sunlight, which can be used to fight disease. The visible violet rays are applied to the curative treatment of hemorrhoids or piles. Green rays can influence favourably the awful malady of African sleeping sickness, by the use of green lamp-shades in the sick room. Green light will also bring refreshing sleep to the sufferer from insomnia, whilst yellow and red in the spectrum are said to make active the brain and banish sleep. Wounds exposed to red light are now known to heal more quickly.

We are fast nearing the sunlit day when we may take sun-baths every fall to prepare for the gloom of winter; pour floods of ultra-violet rays on our gardens of vegetables, orchards of fruit and fields of corn to make them more quickly ripen and abound; live in glass houses through whose windows the ultra-violet light will pass bringing health and strength; eat and drink sunshine in the form of synthetic food and strengthening drink, and cure disease of body, nerve and brain, functional and even organic, by directing the rays on our bodies as we sleep. We shall at last regain the glory of the beautiful mind in the beautiful body which vanished from the world when barbarian and religious fanaticism overwhelmed the sunlit cities of Greece and Old Rome.

CHAPTER IV

FAR NORTH WITH THE SEAL HUNTERS

THE CRY IN THE NIGHT—AEROPLANING ABOVE ICEBERGS—STEAMER RAMS THE FLOES—BERGS HEAVING LIKE DANCING FLOORS—BLOOD AND IRON—COUNTING THE BABY SEALS—WIRELESSING NEWS OF THE KILL—LOST ON LONE ICE FIELDS—DANGER AND SUDDEN DEATH —FICKLE FORTUNE RIDES THE FLOES—HOODS AND HARPS IN ARCTIC SEAS—UNCLE SAM'S FUR SEALS

SMASHING and grinding her perilous way along a narrow lane of water, fissured in the ice floes, creeps a steamship whose rigging and ratlines are powdered and pointed with glittering frost and icicles. The trailing smoke from her stack and her blunt-nosed, rounded hull are sharply silhouetted against the fields of blinding white, sparkling and glittering like diamonds under the rays flung down in spears of gleaming light by the slanting, Northern sun.

For days, the steamship—a heart-of-oak, Newfoundland sealer, manned by a hardy, Viking crew—has been nosing her rounded bows, in the teeth of a tough Nor'Easter, into the fastnesses of the wilderness of virgin ice floated down 2,000 miles from the Arctic circle on the bosom of the Labrador current. Somewhere in the recesses of these vast ice floes, hundreds of miles wide, are hidden the great herds of "harps" (seals) returning Northward after a circular tour of thousands of miles from far Baffins Bay to the Grand Banks. The "scunner" (look-out man) has been vainly seeking these wary hounds of the sea, since the steamship butted her way out of the broken ice in St. *John's harbour and headed out into the frozen Atlantic.*

Last night, the look-out on her decks, watching under the cold, intense light of the stars, heard coming from far over the lone ice fields a great wailing and weeping like that of motherless babies who cannot be comforted. The wonderful lights of the aurora borealis softly flamed and streamed in glowing waves up from the horizon to the zenith, shot with the white, ghostly loom of the ice blink.

"Whitecoats to stabburd," shouted the look-out. He knew that the wailing betokened that somewhere near lay a "patch" of seals, perhaps 50,000 in number, and, crying for their mothers, the whitecoat baby seals, the special object of the steamer's quest.

The droning of an internal combustion engine rises on the air, and up from the deck of the steamer soars a baby, Avro aeroplane, her propellors cleaving the wind above the frozen masthead. The aeroplane skims across the frozen solitudes and is soon lost to view in the grey distance behind the glittering pinnacles of a distant berg. Forty minutes pass and then the ship hears the humming of the returning plane. The pilot announces that he has spotted a "patch" of "harps," 80,000 strong, lying on the ice about five miles to the nor'west of the ship.

Instantly, all is bustle and excitement on board the steamer. The captain shouts to the helmsman on the bridge, and the telegraph rings to go astern. A lane has to be opened by main force through the ice encompassing the ship.

"Astern it is!" Round spins the wheel, and the three helmsmen *hold on to the spokes with strong grasp, since* if the rudder hits an ice pan and wrenches the wheel out of their hands, the whirling spokes will easily break their limbs. The steamer backs to gather way for a charge on the floes. The telegraph rings for full speed ahead, and the iron-sheathed bows of the steamer drive crashing on to the floes, shivering and splintering the ice into pieces which rocket up to the mastheads.

She shudders as her hull hits the ice, which cracks into fissures rapidly spreading outward into the floes. A lead opens up, and the steamer shoots forward until stopped by an impregnable ice pan or hummock. Aloft, the scunner in his crow's nest, is bawling directions. Then, way for the bombers!

The ice, for once, and not by any means the last time, is too thick to be battered by the steamer. Men fix blasting charges and fuses to long poles, and drive the poles into the ice by the side of the ship. A red-hot iron bar is touched to the end of the fuses, and spluttering and fizzling the bomb is caught up and thrust far under the ice by the holes near the ship. There comes a crashing explosion. Blocks of ice shoot up as high as the masthead, and the way is once more clear.

Half an hour later, the scunner in the crow's nest sights a herd of thousands of seals lying asleep on the ice, in a wide bay lit up by the rare sunshine. Steam is shut off, and the ship, so that the sound of the engines and the churning of the propeller may not frighten the basking seals, creeps stealthily towards them. A grey mist, characteristic of these far northern latitudes, is beginning to come over the ice. Way on the ship is stopped.

Men swarm down ladders and ropes from the ship's decks on to the ice, some carrying gaffs, others keen "sculping" knives wherewith to skin and cut up their prey, and still others bear rifles. Behind each gunner walks an assistant carefully holding a bag of ammunition in his hand so he may avoid collisions by a fall on the ice which would cause death by explosion. Some men carry torches, others carry bread in case they lose sight of the ship in the mist. They leap from floe to floe of an ice field which heaves and falls as though it were the deck of a ship rocked by a heavy swell. No easy task this, and one in which Newfoundland sealers are peculiarly adept!

On crawl the men over the ice, and now the sharpshooters take up position hehind hummocks. Before the mist came up, you might see the cherubic, baby white-coat seal, round-eyed and lissom as a furry Persian kitten, basking in the clear, sparkling sunshine, or suckled by the mother seal. Old seals plunged under the ice, flashing their stream-lined bodies like a streak of lightning through the water.

A shot rings out on the frosty air, and an old sentinel seal, who has been looking round suspiciously falls flat on the white ice, which the blood spurting out of his head dyes a vivid scarlet. A fusillade cracks along the line of riflemen, seal after seal falls, and there is a general, panic-stricken rush of the herd to the "bobbing holes" in which they shelter and rear their young below the surface of the floes. Strangely, the mother harp seals join the rest in the mad rush and leave their helpless infants to fate and the sealers' gaffs. With a dip of their flippers, they plunge tail first into the bobbing holes passing far under the floe, like a grey flash of light.

If a sharp frost has frozen over the bobbing holes so that they cannot hurl their sleek, lithe bodies through, the hunted seals race to a weak spot on the ice which their combined weights suddenly fracture letting them through to deep water and safety.

Again, men, with sheath knives in their belts, armed with six foot long "bats" (gaffs) jump from pan to pan of the ice. They attack and kill a seal by clouting it on the head with the gaff. A bull seal, especially if it is a "hood seal," will show his teeth when hit with a gaff, and has been known to bite off one of the sealer's limbs. Soon the pure, white mantle of the glittering ice field is red with blood and carnage. Out come the sculping knives, and the fat or blubber of the innocent young white-coat is flensed. It is rolled over, its pelt skilfully and neatly removed, and its "fippers," or fore paws, cut off to be later turned into a very appetising dish. The pelts, or "sculps," are piled up in a pan, and each pan of skins is buoyed with a red flag, in the day time, or a torch at night. Many miles of the ice floes are covered by the sealers after jumping off from their ship. A torchlight pan may be too far from the ship for its load to be hauled back, and the steamer will have laboriously to force a passage through the ice to collect the sculps from each pan lit up by its torch spluttering under the cold, clear starlight, or looming redly through the fog on these desolate fields of ice.

Swept by gales, the floes may drift and carry away the skins which are then either lost or picked up by other ships. The sealers, with their reeking gaffs, remind one oddly of the spear-armed savages who repelled Captain Cook when he attempted to land on a certain island in the South Seas. The misty light of the ice floes contributes to this illusion, and it is, of course, only an illusion.

The men who carry the ammunition bags cut off the tails of the seals to tally up the kill. Then these sturdy, red-cheeked giants, their faces seamed and bitten by the sharp frosts and terrific gales of many years in ice-bound seas, tie the pelts to a line, and tow them over the icy trail towards the ship taking extreme care not to damage the skins, since such tears lessen their commercial value. On board ship, you may hear the winches churning and rattling, clouds of steam hissing in preparation for what is to follow.

The tow lines are hitched to the winch and the sculps and " fat " (blubber) are hauled on deck from the ice below. The blubber is run into steaming tanks, and the sculps are stowed in the hold, tally being kept by the truly mediæval method of notched sticks. Now the " pans " of pelts and fat are safely in the hold and the tanks. The officers have told the captain in his stove-warmed cabin the tale of the seals taken. " Sparks," from the radio cabin, has flashed to the land station in code the tale of the kill for the benefit of the waiting owners and the relatives and friends of the captain and crew. Once more, it is " Full speed ahead ! " The steamer again butts and crashes her way into the ice to force a lane, and hear the surges thunder on the bergs.

The Newfoundland sealer, it is obvious, must be of a hardy and heroic breed, and need be so to endure his months of peril on the ice floes. Once he is on the floes, the sealer, on peril of his life, must never forget that the ice is ever on the move, drifted along on the polar current flowing southwards to the Grand Banks. At any moment, a raging Arctic blizzard may rush upon the floes, and, hundreds of miles from land men may be caught far from their ships. When the barometer is low or falling, the man who gets out of sight of his ship and is caught by the insidious fog creeping up over the floes, may easily find Death lying in wait for him round the corner. If he is picked up, he may perish of frost bite, or, months later, his body may be found frozen and stiff.

The ship is always on the watch for fog, and at the first sign out shrieks the siren and a flag is run up to the truck to warn the men on the ice. Torches are lit on deck and a light burns on the masthead when the sealers are delayed or lost on the ice fields. Indeed, all night long, whatever the weather, lights burn in the cabin and fo'c'sle, since, at any moment, in the black Arctic night, gales may spring up and roar and shriek through the frozen rigging and ratlines, and the ship be pinched in a jam of ice blocks.

One such steamer, caught in the ice between two enormous pans of ice, had her bottom cut clean out, and when the ice opened up she sank in the seething waters. The crew were rescued by other steamers of the sealing fleet. Lucky to be saved! Another wooden steamer was nipped amidships and so badly squeezed that her rigging became quite slack. As soon as the pressure was eased, the ship resumed her former shape and girth. A few years back, 77 sealers perished in a blizzard on the ice not very far from their ship, which they were utterly unable to reach in the blinding storm. Again, an ice hummock may shift under a man, as he jumps across the floes, fling him into the icy water, and allow him to save himself from drowning only by hitching his gun to a berg. Snow blindness is not uncommon, and goggles have to be worn to shield the eyes from the glare of the ice.

Bursting boilers is another ever present danger. Twenty men were instantly killed when the s.s. "Tigress's" boilers blew up on the ice. The terrific strain of forcing

SEALERS WRECKED ON THE ICE. (BLACK SPOT ON RIGHT MARKS A "PAN" OF "SCULPS" OR DEAD SEALS.)
Photo by courtesy of High Commissioner for Canada, London, S.W.1.

"HAREM" OF FUR SEALS ON PRIBILOFF ISLANDS, ALASKA. (See page 84.)
Photo by courtesy of U.S. Bureau of Fisheries, [redacted]

To face page 78.

her way through the ice may open the ship's seams or burst her steam pipes, or her cargo may shift under the sudden impact of a hurricane, as in the case of a loaded Newfoundland steamer which went down with 173 men on board and a full load of seals. To prevent the cargo of sealskins and fat shifting at sea, the steamers' holds are partitioned into "pounds." Added to all these risks, propellers may be carried away by the ice and the rudder smashed clean off, leaving the vessel to drift helplessly at the mercy of wind and wave.

After all these hardships and dangers have been passed comes the division of the spoils when the steamships go home to port. The owner takes two-thirds of the catch, and the crew share the remaining one-third. The average earnings of a member of a Newfoundland crew seem to be about an average of 60 dollars for four weeks' work; in a bumper year, he may get as much as 150 dollars for the season. Even with a fipper supper thrown in, the remuneration is not an extravagant one for facing the icy tornados of frozen seas where frost bursts rocks, knife-edged gales whistle and howl through the rigging and drift hills of snow and ice against the steamer's hull, or freezing fogs enwrap the vessel, icing the deck, masts and ratlines and freezing the clothing of the men. The record remuneration of a sealing steamer captain in Newfoundland for 20 days' work is 5,433 dollars 94 cents. But this amount is exceptional. "A man will go for seals," they say in Newfoundland, "where gold won't draw him." The record kill on one trip to the ice-floes is 42,242 seals by Captain Balmford, off s.s. "Neptune."

Seal oil, to-day, fetches about 500 dollars a ton, and seal sculps about four dollars each.

Iron-clad ships break their way through the ice better than wooden vessels, and at the beginning of the Great War, Newfoundland possessed a powerful fleet of iron steamships. All of them, however, were sold, and, at the moment, all the island's steamships engaged in the sealing industry are wooden boats. In 1925, eight of these wooden steamships landed some 130,000 seals in Newfoundland.

On shore at St. John's, the blubber of the baby white-coat seals is run into tanks, ground up by passing under great steel teeth and stewed and refined in steam vats. It is finally bleached by the sun in glass-covered tanks, and converted into a pure, sweet, colourless oil which is used as a safe illuminant in mines, an ingredient in olive oil soap, a lubricating oil, margarine and in perfumes. There is an opportunity for an inventor to make a fortune by devising some more important application for seal oil. The seal sculps are steeped in brine, and sent to England where they are made into very high grade leather used in the manufacture of dainty bags. The local Chinese are said to make good brushes out of bristles plucked from the seal's sculps.

Sealing is marked by the same element of chance as characterises other fisheries. Winds have been known to drift ice floes, ridden by thousands of seals, on shore into quiet bays where landsmen have reaped a rich harvest, whilst, out at sea, within sight of these landsmen, steamships, jammed in a wilderness of floes, have vainly sought white-coats. Even so landsmen must beware the sudden gales, which, before now, have lost the lives of men by drifting them out to sea on the ice. Nets are set on the sea bottom to trap and entangle the body and head of a seal seeking food on the sea bed.

Strict laws govern the industry, and seals can be taken only between March 16th and April 16th, by steamers who are allowed to make one trip only. Moreover, seals may not be killed on a Sunday.

The Newfoundland seal is a hair seal, quite distinct from the fur seal of the Pribiloff Islands. Its home is in the Arctic circle, though it spends only three months of the year there, and is migrating for the rest of the time. At the end of the short Arctic summer, they congregate in separate herds on the vast fields of ice thousands of square miles in extent, which break off from the coast of Greenland and far Baffin's Bay. The fierce, pugnacious *Hood* or Bladder nose (so called from a bag which it puffs up to cover its head, nose and face, when fighting) floats down on the ice from the east coast of Greenland.

The Hood seals begin the 2,000 miles journey to the Grand Banks about the end of September. Off Baffin's Land, they meet the *Harps*, liquid-eyed, graceful seals, with a marking resembling an Irish harp on the shoulders. Riding on the ice in patches, the Hoods and Harps travel 900 miles along the coast of Labrador to the straits of Belle Isle; but, for some unknown reason, the fierce Hoods always keep to the eastward of the docile Harps. Both are thin and emaciated, but though the fighting Hood keeps offshore where food is less plentiful, he never invades the feeding grounds of the placid harp, whom he seems to respect as an aristocrat among seals.

The migrating herds reach and pass the northern extremity of Newfoundland about New Year's Day, and then they apparently vanish off the ice swimming southward to the Grand Banks, where they fatten themselves eating hugely of codfish, herrings, shrimps, white fish. Indeed, it is reckoned that they each devour four codfish a day, or altogether, consume 14 times as many codfish as are caught by all the Newfoundland fisheries!

About February 1st, the herds of seals, 1,000,000 and more strong, in fine fettle, quit the Banks and start north to meet the great Arctic floes coming south on the bosom of the Labrador current. They swim side by side to the straits of Belle Isle at the north end of Newfoundland. Just before reaching the ice, the mother harp gives birth to the baby white-coat seal, in mid-ocean 500 miles from land. On the floes, the harps bore holes in the ice which they claw from underneath, and rotate their bodies by means of their hind flippers, using their claws as a kind of drill until the hole is large enough for them to come up daily, spend all day on a fishing excursion, and return at night to suckle the little ones.

In the absence of the mother seal, the baby cries like a human infant, and the old seals bark like dogs, keeping up a constant howling all night long, on the floes. During her absence from the bobbing-hole, as it is called, the floe will drift some miles, yet the seal can find her own baby and bobbing-hole among thousands of others, and is not deceived even if the sealers have changed the location of the infant seal.

No food is seen on the ice for the reason that seals generally eat under water. Besides bobbing-holes, the seals construct blow-holes through which they can take in air, since like the whale, the seal must come up to breathe every half hour.

The Hood seals seek out hummocky ice on which to lay their young and they pick out ice some 30 miles north-east of where the Harps are rearing their families. They do not bore holes, and, unlike the Harps, live in families, scattered on the ice, and not in big herds. Both species are fast swimmers and can catch the swift salmon.

The baby white-coats grow 40 pounds a day, and acquire a layer of fat 2½ inches thick. As soon as they take to the water, the mother seal leaves them, which she does two days after they can swim. The young seal at once points its head northward, develops into a "Bedlamer" (a corruption of the French phrase, *bête de mer* or sea beast), and sometimes acts as a sentinel when the old seals ride the ice. Fog, cold, and ice these animals revel in, but water warmed up ever so slightly by the sun scalds them. The old seals are drilled like soldiers under command, but they have no control over the Bedlamers.

Uncle Sam's seals are the *fur* seals of the Pribiloff Islands and they comprise 90 per cent of the world's fur seals. The management of these herds is entirely in the hands of the United States Government, a monopoly made necessary by the unrestricted "pelagic" sealing, prior to 1910, when so many mother seals were killed in the water and their pups starved on land that the Pacific fur seals seemed doomed to extinction.

Every late summer and early fall, the U.S. Bureau of Fisheries takes a census of the fur seals on the St. George and St. Paul Islands in the Bering Sea. In 1925 there were 723,050 seals, compared with 132,000 in the year 1910 when the U.S. took over control.

When spring opens, in the Far North, the sleek and silken seals move towards the rocky, fog-hung shores where they were born. They come back from their annual migrations for battle, courtship, life and death. After the census is taken, and the polar ice comes down, they leave again for the Bering Sea. It is a mystery where they go for the winter after proceeding through the passes of the chain of Aleutian Islands, and out to sea.

The seals move south in a great arc, after the breeding season, fattening on candlefish as they go. They wander, some of them, as far south as California, over 1,200 miles away to return to the rookeries for the next pupping season. Not only adults, but the immature animals do this. As many as 70 females mate with one bull seal, and the bull seal weighs more than five times as much as the female. The only place where the fur seal herd ever comes ashore is on the Pribilof Islands. By a treaty with England, Japan and Russia, the U.S. shares the fur profits with these countries, in return for the prohibition of open sealing.

The pelts of the seals are cured by steeping in brine, after which they are packed in barrels and shipped to the States, where they are sold at public auction. Before selling, they are prepared for making into garments by being dressed and dyed.

The possession of a fur seal coat is the cherished ambition of many ladies, and so durable and rich are these furs that they will wear and look well for 25 years. Infinite care and skill go to the dressing of seal skins, more than one hundred distinct and secret trade processes being involved, and at least 60 days needed to produce their matured and exquisite charm and delicacy.

CHAPTER V

WONDERS OF WIRES AND WIRELESS

RADIO BEACONS—DIRECTION FINDERS FOR NAVIGATORS—MARCONI'S BEAM SYSTEM—SEEING BY WIRELESS—PHOTOS BY TELEPHONE—SELENIUM PHOTO CELLS AND NEW LIGHT VALVES—RADIO SLEUTH FINDING CONCEALED TRANSMITTING STATIONS—STORM WARNINGS BY WIRELESS—RADIO-PHOTO-PHONES IN ENGLAND AND AMERICA—THE PROBLEM OF TELEVISION—RADIO TYPEWRITER AND THIEF DETECTOR—SHIPWRECKED CREWS AND THE RADIO LIFEBOAT—"STATIC" RIDDLE SOLVED?

RADIO, which is probably destined to make life infinitely more complex than it has been, is really as yet only in its infancy, despite the astounding transformations it has already effected in the mechanics of life on land, sea and in the air. Let us glance at the revolution radio is silently bringing to pass on the sea.

"Lighthouses without lights atop" may be the fate of the towering beacons of navigation after their centuries of service on rock-bound coasts, since radio is already displacing these lanterns of wind-swept seas and revolutionising the lighting system round our coasts. St. Agnes's light on the southernmost rock of the Scillies is an example of what is happening to lighthouses of the Eddystone and St. Catherine's Point type. It was recently converted into a holiday home by the Earl of Onslow, because its original purpose of lighting mariners on storm-tossed seas has fallen into desuetude, and has let the radio compass and radio lighthouse into their own.

Another disused lighthouse, now employed as a summer residence, stands seventy feet high on the cliffs at the edge of the Sussex downs, near Beachy Head. This is the old Belle Toute Lighthouse, well-known to holiday-makers at Eastbourne.

Let us imagine ourselves on board a great trans-Atlantic liner groping her blind way in dense fog up the Mersey towards Liverpool harbour. The pilot stands, all nerves and anxiety, on the bridge, burdened with the responsibility for the safety of the ship and the many valuable lives and much property on board. Forward, the look-out man is telephoning his observations from the crow's-nest. Time, more than ever to-day, is money and the great ship cannot drop her anchor and wait for the fog to roll away from the skyline. She is steaming ahead with the speed of a railway train. The pilot now fastens a headpiece over his ears, grasps the wheel of the helm, and fixes his eyes on the compass.

A faint sound is heard in the receiver. Miles away, a land station is flashing a radio message to the ship's bridge, across the curtain of wreathed fog and the blind waste of waters outside the fairway. On top of the bridge-house stands a small antenna, shaped like a square frame, wound round with coils of wire, and pivoted to turn in any desired direction. A vertical rod connects the antenna with an arrow swung by wires above the face of the compass, and on the rod itself is set a small wheel which turns the antenna. The pilot now gently revolves the wheel on the rod until the sound in the telephone is sharp and distinct, which is when the wires of the antenna are in the same plane with the transmitting station ashore.

Simultaneously, the arrow over the compass moves until it shows the direction from which the signals are coming. They are continuous signals, not to be confused with messages sent by other radio stations on land. The pilot takes signals from three stations, and plots three lines on a chart of the fairway and harbour, running from the radio stations in the directions indicated by the compass readings. The point of intersection of the three lines shows the position of the ship which steams confidently ahead.

True or magnetic bearings are essential to the navigator, but the direction-finder furnishes relative bearings referring to the direction of the ship's keel line and not to north and south compass points. The action of the direction-finder, or radio compass, is dependent upon the exact position of its special aerial loops, and great care is taken to keep them rigid and constant in position once that position and the size of the loops have been accurately adjusted.

How, then, is the essential, true or magnetic bearing of the ship obtained? The answer is that if the ship has a gyro compass,* it is necessary only to mount a repeater card beside the direction-finder and the true bearing is obtained by direct observation.†

On the Borkum Riff lightship, maintained by Germany in the North Sea, the latest fog warning device takes the form of a submarine sound-broadcaster sending out the letters BR in Morse code eight times in four minutes,

* *For an explanation of the gyro compass see Chapter IX of this book.*

† It may not be generally known that as soon as a liner reaches a British port she is immediately in direct telephonic communication with any part of the British Isles and Continent. The first cable thrown ashore as the ship is about to berth contains a telephone lead which is promptly fitted into a socket on the quay, establishing immediate communication between the liner's state rooms and any place on land.

and beginning six and a half seconds after every fourth minute of the hour. Simultaneously, the wireless apparatus on the lightship broadcasts the same letters, but sends them out in four minute periods, beginning at the twentieth, thirty-sixth and fifty-second minute of each hour. A very ingenious system of timing is used.

The first dash of the Morse signal flashed by the submarine sounder is transmitted simultaneously with the final dot of the radio signal, but the wireless broadcast is then followed by a series of 15 dots. The reader will recall the fact that sound waves travelling under water speed at the rate of 4,900 feet a second, as we said earlier in this chapter, while the radio waves flash through space with a speed about equal to that of light, 186,300 miles a second.

Now the ship approaching land is acquainted with this system of timing, and the operator listening in the radio cabin aboard counts the number of dots received by air before the first dash of the submarine signal arrives by water. The dot on which the two coincide gives the number of miles between the approaching steamer and the lightship. The time taken by each of the fifteen dots and its interval in travelling through space on the radio waves is 1.253 seconds, which is about equal to the time required by sound waves to travel a mile under water. Thus the ship can find its distance from the lightship up to 15 miles by simply counting the dots, but the submarine signals alone will give the ship's bearings in relation to the lightship only with the supplementary aid of the radio compass or direction-finder.

A revolving radio lighthouse is a recent British aid to safer navigation. On a rocky headland, in sight of liners inward and outward bound to and from London, the

Empire, the Continent and America, the Marconi Corporation has installed a rotating radio beam of great use to navigators in storm, fog, and crowded waters and approaches to harbours.

A valve transmitter, operated on a 6.09 metre wave and fed by a current of 280 watts, is housed in a small hut at the base of the ordinary lighthouse, on the South Foreland, Kent. High frequency power is led from the valve transmitter, through insulated wires in an earthed, metal conduit, to the revolving vertical aerials, which are supported on steel towers. The radio aerials are continuously rotated and send out signals showing the direction in which an aerial is pointed at a given moment. Inside the radio cabin on land is a chart on which are marked lines radiated from the lighthouse, and when the aerial is pointing midway between any two of these lines the sign marked on the chart is being sént.

As the structure revolves, a number of plates, bearing Morse characters, move round with it on a large ring. The Morse plates operate a contact mechanism controlling the working of the transmitter, and ensure that the signal transmitted is sent in the direction in which the aerial is pointing.

Away out in mid-channel, the officer in the chart cabin on the wheel-house of the ocean-going steamship switches on the receiver and listens in to the radio signals telling him where his ship is. Every two or three minutes he hears a series of five or more Morse letters as the beam slowly sweeps past the ship. He glances at a chart and locates the ship's exact bearing, which corresponds to the middle letter of the Morse letters heard in the receiver. Even small tugs and fishing trawlers can use this beam system of signals, since the cost is not great.

This revolving radio lighthouse has a range of 100 miles over the sea, and can also transmit radio-bearing signals over land to other waters and harbour approaches. On board ship, the radio receiver used to pick up the signals from the revolving aerials is independent of other installations in the radio cabin.

The latest work of wireless wizards has been directed towards finding methods of transmitting radio messages so secretly and exclusively that only the person or station for whom the messages are intended will receive them. Continually increasing efficiency in the use of shorter and shorter wave lengths is aimed at, as well as "cold emission" and the use of hot valves sending out electrons more violently.

Senator Marconi has sought to secure this purpose by the development of what is called the "beam system" of transmission by short waves giving long distance communication hitherto obtained only by the use of great wireless stations flashing long radio waves to all the world from their gigantic antennæ, but offering no exclusive reception. The beam system acts like the reflector of a searchlight in projecting a narrow beam of intense energy towards a distant receiver, but it does not permit receivers, outside the direction of the beam, to pick up the messages, not syntonised or tuned to them. The ordinary long distance radio operates on wave lengths of 10,000 mètres and more, but reflectors concentrating these long waves on a definite station would have to be miles in height and length, and are therefore impracticable.

After very lengthy experiments, Marconi succeeded in designing a new transmitter, which he set up at Poldhu, Cornwall, which can absorb power up to 21 kilowatts. In conjunction with this transmitter, he used a reflector made of a number of vertical wires spaced around a parabolic curve. These wires were tuned to the wave length used in transmission, and the beam messages were flashed into space from an antenna placed at a point on the curve of the reflector. Using a wave of 92 mètres' length, Marconi, in May, 1924, sent 28 kilowatts of electricity through oil-cooled transmitter tubes and heard a voice speaking in Australia. The reflector was not used on this occasion.

Recent improvements have made it possible to send out beam messages of 50 kilowatts, using short waves, and in this way, at far less expense, the power of transmission hitherto peculiar to big long-wave radio stations can now be concentrated in new stations costing far less to build.

We may also shortly see in use an apparatus invented by one of the Marconi family which, it is claimed, will enable people who own valve sets to do without batteries and accumulators, and, by merely inserting a plug into an electric light bracket supplying the ordinary current for domestic use from the main, reduce that current to the voltage needed by a valve set for radio reception.

At the same time experiments were going forward in America with the object of finding a method by which radio messages, eight or more in number, could be simultaneously sent out from one radio transmitter with the secrecy characterising the short wave beam system of Marconi. In October, 1925, Mr. John Hays Hammond demonstrated before experts of the American Navy Department the working of an invention comparable in the field of radio to the multiplex system in land telegraphy. He broadcasted eight telegraphic code messages from one radio transmitting tube, simultaneously, on the same wave-length, and receiving them all on one receiving set.

A ten-mètre wave was used in the experiment, which is said to have been the first sending of multiplex messages ever accomplished on a low wave length. According to Mr. Hammond, his device ensures selective secret transmission.

It must be borne in mind that a high power station which has a capacity for generating say 5,000 watts does not actually flash into the air from its antennæ this amount of power. Heat radiation causes the loss by wastage of more than one-half of this current, so that what, in practice, does reach the air from the antenna of one 5,000 watt set is an equivalent of about three horse power.

Our decade of the twentieth century, in the light of the foregoing, may be called the dawn of the age of electricity, when all that has gone before, wonderful as it is, will pale in what is to come. Space and time are beginning to lose their ancient dominion over the faculties of the human mind, and the day may not be so far distant when man may, by the aid of this form of the life-force, solve the riddle of existence on other planets, and, perchance, listen in by cosmic radio to expressions of the thought of other ex-terrestrial intelligences. The fantasy of the popular novelist of 1925 may be the commonplace of mechanistic experience in 2025. Vast generating stations may then have been set up on the polar coal-fields and electric energy radiated into the polar air may travel through the higher layers of atmosphere, passing through its "static" belts as through a vast aerial conduit, to be picked up by receiving stations far to the south and east or west.

That is the electricians' vision of the future. Meantime, a marvel of electrical science has brought this vision a stage nearer actualisation by projecting on a film the image of the speaking countenance, the passing of ships on a tideway, the light and shade of great public buildings in cities many hundreds of miles away from the spectator. Not very long ago, some excellent photographs of prominent personages, snapshots of street scenes of a tug-boat speeding under the towering girders of a great railway bridge at Cleveland, were sent over a telephone wire and received in New York, more than 500 miles away.

As one would expect in our age of mechanism and scientific specialism and collaboration, this electrical marvel was achieved not by the work of individual genius, but by years of concentration by the best brains in science and engineering. Dramatists and novelists often find that their best plots and epigrams have been anticipated, so that it is not surprising, except to the layman, to learn that, in another sphere, the idea of transmitting visual images by wire is not new. One of the first attempts at photo-electric transmission dates back to 1847, when two synchronously revolving metal cylinders—one at each end of a telegraph line—were used for this purpose. Above each cylinder a metal style traced a spiral path similar to that of the needle on a phonograph record. A sheet of tinfoil was placed upon one cylinder, with the sketch drawn in ink made with shellac, and on the receiving drum was placed a sheet of paper, chemically treated, so that on passing an electric current through it, a chemical mark or stain was made. Here, then, was a basis for future experiments.

At a later date, the attempts made to transmit photographs over electric wires fall into two categories—one system requiring synchronism between revolving cylinders at the sending and receiving ends, and using rotating prisms or vibrating mirrors; another adopting a code and translating the transmitted photograph into that code, thus furnishing information necessary in order to reconstruct the photograph at the receiving end of the line. The principle adopted was to divide the photograph into unit areas of light and shade, and transmit over the wire electrical impulses corresponding to the light and shade shown in the unit areas.

The method used by the American Telephone and Telegraph Company, in its successful experiment at Cleveland, is a very simple one based upon the researches of its laboratories and those of the Western Electric Company. Photographs five inches by seven inches can be transmitted in a little more than four minutes, and received in such a form that they are ready for newspapers and magazines to reproduce. Images of line drawings, hand-written copy, cheques, deeds, wills and printing can all be transmitted by this method over the telephone wires, and there is no need to wait for the films to dry before use, since they may actually be inserted into the transmitter while wet.

How does the photo-electric transmission work? The film upon which a picture has been transferred is inserted in the transmitter by rolling it up in cylindrical form. Then that remarkable electrical "eye," the selenium photo-cell, brings its uncannily human-like powers into play. Selenium, it may be recalled, is a non-metallic element discovered in 1817 by the famous Swedish chemist, Baron Berzelius, whilst he was examining a deposit in his sulphuric acid chambers. It has the peculiar property of varying its powers of resistance to the passage of electricity in accordance with the amount of light thrown on it—a property which is made use of in the photo-electric cell of the "photophone" for "hearing by light," or transmitting sound waves on a "carrier" beam of light whose waves measure only one-millionth of a mètre. Light instantaneously affects selenium, and the effects of exposure disappear only slowly in the dark. A selenium cell can be used to turn on lights, and help the blind to read by sound.

When the film is inserted in the transmitter, a very small and intense beam of light shines through the film on to the photo-electric cell within the instrument. The film is rotated at a uniform speed and by means of a screw mechanism is made to advance parallel to the axis of the cylinder. The motion of the light, relative to the cylinder is, thus, analogous to that of a phonograph needle on a cylindrical record. Each minute portion of the photograph to be transmitted affects in its turn the intensity of the light reaching the photo-electric cell. The variation in the amount of light striking the sensitive surface of the cell gives rise to a current which, through the medium of a vacuum tube amplifier and modulator, controls the current flowing over the telephone wire.

At the receiving end, an unexposed photographic film is similarly rotated under a beam of light, and revolves at exactly the same speed as the transmitter. A new device, known as a "light valve," worked by the electric impulses starting from the transmitting photo-electric cell, controls the amount of light reaching the film at the receiving end of the line.

The vital part played by the light valve is to take the fluctuating currents from the telephone line and transform them into corresponding variations of light. As the film rotates at the transmitting station, the amount of light passing through it constantly increases or diminishes in accordance with the dark or light areas composing the photograph. At the dark spots of the film, the light is reduced, and the current as well, but where the film is transparent, the light passes through with little loss and causes a correspondingly strong current from the photoelectric cell.

In the receiving mechanism, the fluctuating currents record themselves finally in the width of the lines on the reproduced photograph. The reproduced photograph, it will thus be seen, is a combination of thick and thin lines, giving the effect of a complete visual image. At each revolution of the film, in the transmitting station, the beam of light or "carrier" photographs a line of varying thickness. In a photograph, for example, whose size is five inches by seven inches, there is a total of 455 such lines, spirally arranged like the threads of a screw, when the film is rolled up in cylindrical form; but when the film is unrolled and flattened, the traces of the spot of light form lines parallel to one another. Only four and a half minutes are required to finish the reproduction of the photograph, and the chiaroscuro and details are brought out faithfully and clearly. For newspaper purposes, 65 lines to an inch are allowed more for finer screen work.

Attempts attended by success have been made by the American inventor, Mr. Francis Jenkins, to transmit photographs by wireless, but the efforts have been hampered by the difficulty of securing the proper atmospheric conditions, so that steady transmission and freedom from interference can be assured. We shall describe Mr. Jenkins's experiment later on in this chapter.

The best time for wirelessing pictures is, of course, the "small hours," when the air is freer from electrical disturbances

The effects of this new photo-transmission are likely to be very far reaching and touch widely sundered departments of our modern world of commerce and communication. Some time hence, it is possible that our newspapers will reproduce pictures of striking events in foreign countries on the day of their occurrence. Criminals will find life made harder for them by the photo-electric transmission of finger-prints, as, indeed, was recently done at Chicago, where a well-known pickpocket was identified two minutes after the reception of a photo-electric print wired from New York. An hour after a murderer has made his escape it will presently be possible to have his photograph posted up on public places and in trains, tramway-cars, motors, or boats on which he may be trying to escape. A business man in London will be able to effect a sale in Paris or New York by wiring pictures of his goods or machinery; while banks will be able to have signatures on cheques photo-electrically transmitted, and even court proceedings may be expedited by telegraphing reproductions of wills, deeds, depositions and the like.*

The American Navy made striking use of the wired and radio photography in May, 1925, when the fleet manœuvred off Honolulu. Pictures of the operations were sent by wireless and wire to San Francisco and New York in twenty minutes, and good reproductions of the photos were made. Three lines of land telegraphs were used in transmitting the pictures, and two stages of the journey were covered by wireless.

* See C. Francis Jenkins's radio typewriter, p. 109. Radio pictures of new Parisian fashions in women's dress, London scenes in the "general strike," Browning MS. verses, and a cheque payable by a New York bank, were all flashed to New York from London in 1926, when the American Ambassador sent the first "photoradiogram" by wireless from the Marconi Radio House. All documents, before transmission as radio pictures, are photographed on celluloid.

Aerial photography, in fact, has now become the "eye" of the American navy. When, a short time ago, the battle fleet anchored off San Pedro, a flying-boat took a photograph of the lines of the fleet, as seen from the air, immediately developed the negatives, and in a few minutes had actually dropped the completed photographic prints at the feet of the commander on board the battleship "California"!

The commander at once knew the disposition of every ship in the battle fleet, and the advantage of this under war conditions is obviously immense. An admiral would immediately have under his eyes in his cabin the strength, location and disposition of the enemy's battle fleet. Each ship of the fleet could be furnished with these air pictures, rushed by a swift launch, and the admiral could then radio his orders knowing that every one of his officers had before him a map of the enemy fleet. Every successive movement of the enemy could be shown by further photographs taken from the air at short intervals.

Unless the enemy fleet were very quick in emitting a smoke screen, the main details of his armament would be vividly shown, since astonishingly clear aerial photographs can be taken from the great height, even, of 20,000 feet.

Railways controlled by radio are also within sight. The radio department of the Westinghouse Electric Company of America are now developing a wireless system whereby, they say, trains may be worked, points and signals controlled, and passengers spoken to directly from a central office. The system is called "the carrier current signalling and communication," and is a development of the principle that the wireless waves, if propelled in a certain way, will follow substantially the course of wires and will not leave them.

Probably the reader, especially if he or she is a radio enthusiast, may have wondered how the authorities can track down out of empty space, figuratively speaking, the unspeakable people whose "howls" disturb the reception of broadcast concerts, or those daring amateurs who may choose to set up a wireless transmitting station without troubling to go through the formality of a preliminary consultation with the Postmaster-General. This work of detection belongs to a fascinating department of the science known as "radiogoniometry."

The French military and police authorities, as well as radio fans, were recently baffled by the presence of a number of mysterious radio transmitters in private houses who sent out messages on wave-lengths interfering with the broadcast transmission of concert programmes. One such unknown threatened to send out false news of a political or financial character and the authorities set themselves to track down the house or houses in the quarter of Paris from which these threats emanated.

They first summoned to their aid the radiogoniometer by which the direction from which radio messages are coming is approximately located by a spiral frame of aluminium indicating the angle at which the Hertzian waves strike the receiver. When this spiral rod is turned in the direction of the unknown transmitter a sharp sound is heard by a person listening in on a telephone. The closer the radio-frame approximates to the direction from which the waves are travelling, the sharper the sound in the 'phone. If, however, the spiral frame is turned in a direction perpendicular to that from which the waves are coming the 'phone is silent.

The working of this apparatus is based upon the well-known fact that a magnetised bar radiates a magnetic field which can be made visible to the eye by sprinkling iron filings upon a piece of glass, laid upon the poles of the magnet. In the same way, an electric current circulating in the antenna of a radio transmitter, radiates an electro-magnetic field whose lines of force travel across space at a speed equal to that of light. When the electro-magnetic field meets the frame of radiogoniometer, pointing in the same direction as the antenna from which it is radiated, it induces an electric current which is heard in the telephone. If, however, the frame is pointing in a direction at right angles to the line of propagation of the electro-magnetic field, the lines of force are parallel to and thus do not cut the plane of the receiver, and induce a current of electricity.

It was found that the radiogoniometer required to be supplemented by a more delicate instrument and detector if it were to be able to locate accurately the direction of propagation of short waves which set up an unstable magnetic field.

A French engineer, M. Guy du Bourg de Bozas, has just invented a "microradiogoniometer," taking the form of a series of screens adjustable in all directions and angles relative to the horizon and the zenith. The microrad., as we may call it, accurately locates the direction, not merely of short, average and greater wave lengths, but of eddies of the frequently reflected Hertzian waves whose line of travel is hardest to find.

Three radio posts are set up to locate the quarter of the city from which the unknown radio transmitter is operating. It is found that two posts are not enough to give clues. Paris has recently been surrounded with a network of these posts for police and military purposes.

As soon as an unknown radio transmitter is heard in a given area of the city, one of the three posts telephones to the other two asking them to find the unknown's direction and the wave-length he is using. These two posts then set to work to plot three lines which should intersect in an apex exactly marking the locality of the unknown transmitter. In practice, however, the intersecting lines form a little triangle bounding and delimiting a block of houses.

Now, a motor-car, which looks like an ordinary pleasure or business vehicle, sets out towards the area marked out on the plan of the city. The motorist carries a portable instrument case containing accumulators and wires, and mounted on a graduated plate revolving on ball-bearings. This is the microrad. and it has no antenna or other frame. The coils in the box suffice, since the motor-car is going near to the transmitter.

Soon, the motor-car reaches the suspected location of the post, and stops at a point close to one of the apices of the triangle plotted by the two stations. The motorist revolves the microrad. on its graduated base, and takes a measurement, which he plots on a large scale street map of the district. He takes two other observations at two other points, which he marks on his plan, and the three lines intersect in a point which represents the house or site of the concealed radio transmitter. The police do the rest.

The day when a man sitting in his office or a woman by her drawing-room fire may press a button and see instantly projected on a screen events and life and movement in great cities or country scenes in lands on the opposite side of the globe has been brought nearer by the remarkable invention of a quiet, unassuming man working with a staff of young people in a laboratory at Washington, D.C.

In his play "Back to Methusaleh" George Bernard Shaw sketched a diverting episode in which a philandering, elderly Prime Minister, talking over a telephone of some thousand years hence, with a dusky Society beauty, sees her at the intimacies of her toilette in the speaking likeness projected on the screen at his side, and is abruptly switched off from visual communication with the lady. And no doubt seeing by radio-phone in 2300 will have its terrors as well as its compensations.

Mr. C. Francis Jenkins, the inventor of the remarkable ring prism for transmitting "motion pictures by radio," has not exactly achieved what Mr. Shaw has adumbrated in his play, but he has made possible the wireless transmission of cinema films and of news photographs to daily papers, synchronous with the setting-up of telegraphic news items. He enables clubs, hotels, theatres to display radio news photographs sooner than they can be reproduced in the daily newspapers, and has, *en revanche*, provided the newspaper with a method of reproducing its front pages in centres many hundreds of miles away sooner, it is claimed, than the newspaper-seller is able to cry his wares in the streets or at railway stations at the place of publication. An X-ray photograph can be wirelessed for medical diagnosis to a far-distant specialist, and international companies may use the service to issue stock prospectuses.

Radio-motion-pictures are really very simple in principle. If the reader places the reverse side of a penny under a piece of paper, and draws straight lines across the paper with a blunt pencil, the image of Britannia with the trident will appear on the paper. Radio photographs are reproduced in much the same way, except that, instead of lead pencil and white paper, lines are drawn with a pencil of light on a photo-negative.

The brain of the Jenkins's radio picture projector is a prismatic ring of optical glass and a light-sensitive, selenium cell. Selenium, as we previously said, is a non-metallic element which, when exposed to light, changes its resisting power to the passage of electricity. Cameras with ring-prisms can "slow-up" motion 1,000 times, so that one can see a high-explosive shell penetrating armour-plate.

What the ring-prisms do in the radio-motion-picture transmitter is to focus a moving spot or pencil of light, travelling line by line over the photograph, and project it on the selenium-cell. The revolving prismatic rings slice the projected image of the photograph into perpendicular strips, and line by line the moving pencil of light travels over the photograph. Lights, half-tones, shadows in the photograph are built up line by line, finally coalescing in the completed image.

The selenium-cell translates these light-values into electrical values, and they are transmitted on a radio-carrier wave through space to the receiving apparatus, hundreds of miles distant. In a word, the device corresponds to a long camera with miles instead of inches between lens and plate.

At the receiving station another pair of ring-prisms, running by motor in synchronism with the sending prisms, take the radio-impulse and pass it on to a light valve—a tube containing bi-sulphide of carbon, encased in a helix (or coil of wire). Variations in the electric impulse in the helix make the light valve able to convert the electric values of the incoming radio impulse into light values. The moving pencil of light, so produced, is caused to travel up and down the whole area of a sensitive photographic plate, each passage from top to bottom being equal in distance to its width from the previous moving point of light. About six minutes is required to transmit the radio-photograph from station to station. Prints can readily be made from the photo-negative.

Radio-moving-pictures are, of course, merely a succession of "still" pictures, rapidly revolved before the eye to create the illusion of life and movement. The one lens at the sending-station can transmit its photograph, picture, document, or printed matter to a thousand cities, and at distances limited only by the range of the broadcasting station.

One can now see, if not quite within reach, the time when events will be projected by radio as they happen; for the ordinary speed of the cinema projector is 16 photographs each second, whereas light and electricity travel through space at the rate of about 186,000 miles a second. Press messages can be sent by the radio prism at 100 words a minute, which Mr. Jenkins claims may shortly be increased to 1,000 words a minute.

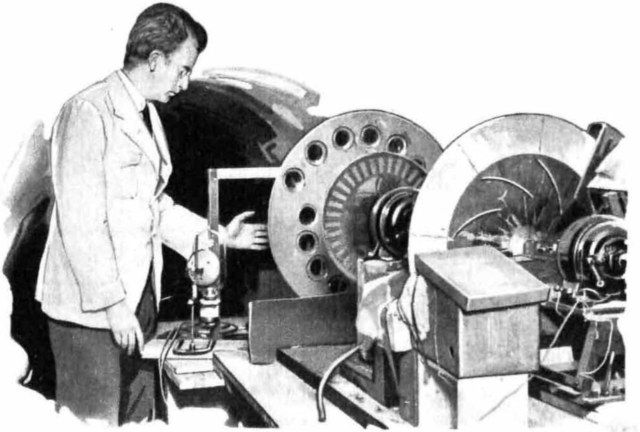
The transmission of radio-cinema pictures is accomplished by Mr. Jenkins with the revolving glass prism used by him to radio still photographs, a revolving wooden board about 18 inches wide having 48 separate camera lenses on its outer edge, and a cold light bulb. This bulb is the invention of an American professor, D. F. Moore, and is a gas-filled tube containing two plates of metal. When an electric current passes through the bulb, electrons are emitted from the outer surface of one of the metal plates, and they pass right round the inside surface of the bulb, following the path of least resistance, and reach the outer surface of the other metal electrode, where they emit a small but intense light. This light is cold, so that as the current waxes and wanes, the metal of the electrode does not glow or get heated, with the result that the bulb can be lighted and completely extinguished about half a million times a second. It sends the transmitted light impulses onward to another prism, at the receiving end of the line, thence to another rotating lens, after which a moving picture appears on a screen. Mr. Jenkins has recently put on the market in New York demonstration sets of an experimental type, with transmitters and receivers whereby amateurs may send and receive still photographs.

The problem of television by radio, that is to say, the simultaneous reproduction on a distant screen of the movements of a living object so that its variations of form may be visible to a far-away onlooker in the same way that the voice heard over the telephone is instantly audible to a listener, has been attacked with vigour in England and France as well as in America. In an optical sense, this problem largely resolves itself into impressing upon the retina of the human eye an impression generated in 1/250,000th of a second. To give an illusion of life and movement, it is essential the series of "points" or impressions each generated in this minute interval of time must be transmitted and registered on the retina in not more than 1/10th of a second. These series of points, of course, together constitute the image transmitted by the radio waves.

Some very remarkable experiments on this line have been made in Paris by the well-known inventor, M.

Edouard Belin, but, of course, it must be borne in mind that television, whether in England, France or America, is still in the laboratory stage. In the French experiments actual television, in the sense stated above, has not, so far as is known, been accomplished. But M. Belin has devised an apparatus consisting of an arc lamp, condenser and picture slide placed in the inside of a lantern. A series of points of light are projected by a pencil of electric light falling on the picture whose image is reflected on to a diaphragm. This pencil of reflected light is shot by a rapidly-moving series of mirrors on a drum rotated by an electric motor. The whole picture is explored by the moving point of light in 1/10th of a second, each point, as we said, lasting for 1/250,000th of a second. A photo-electric cell converts the light impulses into electric impulses transmitted by radio waves.

Mr. C. F. Jenkins, the Washington inventor previously mentioned, has now succeeded in carrying forward his experiments from the radio transmission of cinema pictures to television proper. He has invented a special type of lamp by which, if a person is placed in front of a cinema camera, his likeness is transmitted by the unseen radio waves to a far distant receiver. The transmission of the reflection of light from living persons or subjects in action is brought about by speeding up the transmission from one photograph in 5—6 minutes, in the case of "still" pictures, to 16 photographs in one second. A "cold light" lamp transforms the electrical impulses into photographs to be projected on a screen at the receiving end of the line. At the transmitting station, the combination of lens, prismatic rings and selenium cell is used as in the case of the radio cinema pictures previously referred to in this chapter. Similarly, the apparatus at the receiv-



ENGLISH INVENTOR SENDING THE IMAGE OF HIS HAND BY RADIO.

To face page 107.

Photo by courtesy of Mr. J. L. Baird, inventor of "Televisor."

ing station is the same. The mysterious lamp used in the transmission of the living image is the secret of Mr. Jenkins.

An Englishman has also succeeded in projecting by wireless the actual image of a living head or hand. Working in a quiet house off a West-End thoroughfare in London, he has perfected a radio apparatus by which he has transmitted the image of an actual hand or head, as distinct from a photograph or picture. This apparatus does not involve the use of prepared photographs but allows the observer at the receiving end to see what the instrument at the transmitting end is "looking at," at a given moment. The hand, head, or other living or inanimate object to be transmitted is focussed by lenses, whirling round on a disc at 5,000 revolutions a minute, on a sensitive, colloidal cell, invented by the creator of this radio-apparatus, Mr. H. L. Baird. The colloidal cell varies its resistance according to the intensity of the light falling upon it.

The lenses are arranged in spiral form, and as the disc rapidly revolves, each lens causes a single strip of the image to traverse the cell. Before reaching the cell, the light is interrupted at high frequency by the serrated disc. This interrupted light causes a pulsating current to flow through the cell circuit, and this current is transmitted through an aerial to another aerial at the receiving station, where it is amplified and lights a Neon lamp behind a disc, which is similar to the transmitting disc. The light from this lamp next passes through the lenses of another revolving disc, rotating in synchronism with the transmitting disc, and then traverses a ground glass screen on which the image is reproduced in a series of fine strips of varying light and shade.

Isochronism (equality in time of operation at sending and receiving ends) is obtained by coupling an alternating generator to the transmitter and sending an alternating current to the receiver, where, after amplification, it controls the speed of the motor driving the lens disc. Two aerials are in use, one connected to the light-sensitive cell at the receiving end, the other to the generator of the transmitter. Synchronism in the working of the sending and receiving ends of the apparatus is secured by rotating the driving mechanism about the spindle of the receiving machine until the image comes correctly into view.

An ordinary valve set is used at the receiving end to receive the varying current from the colloidal cell, and there is a filter circuit to separate the synchronising current from that transmitting the image.

A hand, reproduced, appears as a blurred outline; a man's face, looking at the transmitter, is reproduced on the receiving screen as a white oval with dark patches for eyes and mouth; but the apparatus has reached the stage when it is capable of transmitting a wink or showing on the receiving screen an opening and closing mouth.

In January, 1926, Mr. Baird gave a public demonstration of the working of his portable "Televisor," which can be attached to a valve set and receive and reproduce on a ground glass screen small pictures wirelessed from a broadcasting picture station which, it is stated, may presently be established in the West End of London. At the present stage of development, the pictures thus sent out and reproduced on the receiving screen by the Televisor resemble the flickering pictures seen on the early bioscope screens. Actual images with all their light and shade and the motions of the living subject are faithfully reproduced by the Televisor. A loud speaker is included with the rest of the receiving apparatus, if it is desired to reproduce the sound of the sender's voice.

By another device, using cylinders different from those employed by the American Telegraph and Telephone Company for the transmission of photographs by telephone wires (described in this chapter), Mr. Jenkins enables the business man to send by wireless a typewritten letter, signed with an autograph signature, all of which are faithfully reproduced. The next step will be to test the transmission of such radio-photo letters on the trans-oceanic radio routes. It is stated that these radio letters can be flashed at 100 words a minute, no special band of wave lengths requiring to be allocated to this service since what are called the audio-frequency bands used in ordinary broadcasting are not used.

The transmission by recording telegraphs of tape messages to newspaper offices and clubs, such as are sent out over land wires to subscribers by the Central News Agency and Reuters in this country, has recently been adapted to the radio by an American company. It is claimed that secrecy is secured by the use of a peculiar combination of codes which a listener would find it impossible to read by ear, or to decode, and by the synchronism of the motors at the sending and receiving stations which are made to run at the same speed. The listener who attempted to pirate a news message, for example, would have to know not only the right code, but also the right speed before his motor could take the message. A tuning fork is actually used to keep the printer motors of this radio machine running at the same speed.

Two strips of steel are attached to the prongs of the fork, with a tiny slot in one strip. As the fork is vibrated the slot is alternately exposed and concealed, the rate depending upon the known vibratory rate of the fork. On the governor of the printer motor a row of white dots is painted, and when the operator looks through his vibrating tuning fork the slot is exposed just often enough for the eye to see the dots, provided the motor speed is correct.

There is even a method of detecting and preventing, by wireless, thefts by men in workshops and factories !*

Two German scientists, members of the staff of a Leipzig engineering firm, have just invented a remarkable radio device which not only rings a telephone bell when a thief walks out through the workshop gate, but actually searches him as well ! The troublesome period of post-war inflation in Germany is stated to have led to an increase of petty thefts by workpeople, against which the usual methods of personal searches at the factory gates of home-going men proved distasteful and fruitless. At the time when paper marks fluctuated so wildly, metal was more stable in value.

Dr. Geffcken and Dr. Richter, the inventors of this device, have installed it at the factory gate of Messrs. Gebrüder Wetzel, of Leipzig-Plagwitz. The radio thief-detector, as made by this firm, consists of a door through which every worker leaving the factory must pass, and an iron case in which are mounted electrical instruments, including a telephone which signals the presence of metal concealed on a person.

The radio thief-detector does away with all personal searches. A generator inside the instrument-case creates electric oscillations, which are discharged by a transmitter into the space inside the door through which the worker

* Wireless fans will know that the capacity of their condensers is affected by the presence of a human body in the vicinity. A recent ingenious French invention uses this fact to signal the approach of a burglar to a safe. A mercury vapour transformer, two coil relays, etc., are in circuit with a loud siren in this radio-burglar-alarm.

must pass. Thus, in the doorway, the waves produce an electric field whose influence is felt in the surrounding space. If a man passes through the door with metal parts hidden on his body, the electric field undergoes a slight change, and, by the aid of a new type of sounder-amplifier, the slight changes in the electric field are made to ring a telephone "buzzer."

The electric oscillations form a "spool" round the door, and generate, in the metal parts passing through in a man's clothing, waves similar to those sent out from an ordinary radio antenna. In their turn, these waves re-act on the sending apparatus and give rise to a signal which is heard by an official listening-in on a telephone in the control room. If the "find" is a genuine one, he will hear a buzz on a high, level note. This thief-detector can be so arranged as not to signal the presence of a worker's personal property, such as a watch or key in his pocket, but in order not to hamper the telephonic signals larger metal bodies, such as thermos flasks or cooking utensils, may not be taken through the door by the worker. He has to deposit these on a table outside the range of the radio-finder.

When the telephone has signalled the presence of illicit metal on the clothing of a worker, the gate-keeper is not called on personally to search or undress the suspected man. A small electric "search spool" attached to the apparatus will at once locate the exciting cause of the signal, and it can be used at any distance from the man's body.

The spool is so accurate that it will indicate with certainty the location of a penny in a person's clothing, a needle in a coat, or even the gold-filling of a tooth, at the time of the search.

Then the "howling" or "atmospherics" in the head-phones of wireless sets have been ingeniously put to use.

When a sudden storm approaches a great city, cutting off the daylight, and shrouding in a dense blanket of greyish yellow vapour all buildings, houses and streets, myriads of lights flash out in all offices, workshops, factories and private dwellings. The demand on the electricity power stations and on the reserve of the gas company's gasometers is immensely increased.

The howling on the wireless has been made to sound an alarm bell to herald the approach of a storm. High up above the sky-scrapers of New York City, the New York Edison Company has installed an aerial or antenna, hanging between the smoke-stacks on their Waterside Generating Station, on First Avenue, New York City.

The storm, as it approaches, sends out radiations which are picked up by the aerial on the roof. These radiations or "howls" set up an oscillating current which travels to and from the ground, through the spark gap, coherer and condenser of a wireless receiver. Then the current rings a storm-bell in the operator's office, and it is the work of an instant for him to warn the power station of the coming storm.

We may fittingly close this chapter by a brief reference to that boon of shipwrecked passengers and crews—the radio lifeboat.

Shipwrecked crews and passengers adrift in open boats in the middle of the ocean will no longer voyage helplessly across thousands of miles of water, suffering the tortures of heat, cold or thirst, watching vainly for the smoke of a passing steamer on the horizon. Great trans-Atlantic liners bound from Liverpool to New York are now to be equipped with a self-contained radio-set, two and a half feet square at the base and four feet high, for use in the ship's lifeboats, so that hurrying ships can be directed to the scene of shipwreck and disaster. The ordeal of the crew of the s.s. "Trevessa," who not long ago spent 22 days rowing in open boats across 2,000 miles of the Indian Ocean, is to be made a thing of the past.

If the passengers and crew are forced to abandon a sinking liner, it will now be possible for the wireless operator to radio an S.O.S. message every ten minutes from the lifeboat. Any ship within 60 miles can pick up the message on a crystal receiver, and on a valve receiver within 100 miles. Then the operator can guide a rescuing ship to the lifeboat by a radio direction-finder, attached to the life-saving set, which is provided by the Marconi International Marine Communication Company, of London, England.

The riddle of the "static" or silent fields wherein radio-reception dies or fades, while, in belts adjoining, the reception of the wireless messages and broadcasted speech or music is puzzlingly clear, seems on the point of being solved. Naval investigators at the Navy Department, Washington, D.C., and physicists at the Carnegie Institution found, in 1925, that these dead areas of static are caused by the deflecting influence of the higher reaches of the atmosphere. This zone of the atmosphere is termed the "Heavyside-Kennelly layer," after the names of the British and American scientists who first conceived the idea of the existence of such a zone.

The radio waves shoot through space in horizontal and vertical directions. The horizontal waves are believed to follow the earth in somewhat the same manner as an electric current in the case of ordinary telegraphic land wires. They flash round the earth's surface until, finally, they may vanish at a tangent into the ether of space. On the other hand, so runs the theory, the vertical waves hit the ionised atmosphere in upper reaches of the dome of the sky, and are deflected back to earth, whence they are deflected upward to the sky. Zig-zagging from earth to sky in a series of gigantic trajectories, they encircle the globe. This is the explanation of the static or silent belts of radio, in which this peculiar zig-zag movement of the radio waves creates a hiatus in reception. There are, however, other causes of radio static belts, such as the influence of the iron which is so frequently found in the bottom of the ocean. It would, therefore, appear that it is the existence of such a layer in the upper atmosphere of the earth which alone makes wireless telegraphy and telephony possible.

The reception of messages by radio from Europe to America, to take one instance, is often considerably interfered with by these atmospheric influences, or "static." All European signals are picked up on one large antenna attached to the great trans-Atlantic receiving station at Riverhead, Long Island, but in the case of a sudden thunderstorm, a second powerful station at Maine, ten miles away, picks up the European radio signals and passes them into a short wave transmitter which flashes all these unsorted and jumbled messages to short wave receivers at the Long Island station. There they are sorted out in a battery of receiving sets, each tuned to a different wave length corresponding to different stations. This secondary receiving station acts in reserve to the main station when the latter is disabled by atmospheric disturbances.

CHAPTER VI

MARVELS OF MODERN EXCAVATION

DEAD CITIES SURVEYED FROM THE AIR—X RAYING THE EARTH FOR HIDDEN TOMBS—SUBMARINE CYLINDER TO LOCATE DROWNED CITIES—AMERICAN'S DISCOVERY OF LOST WORLD—CHAIN-GANGS OF OLD NILE—EXPLORING LABYRINTHS TO FIND TREASURE—MARVELS OF THE VALLEY OF MUMMIES—MYSTERY OF ISLAND TEMPLE—HIDDEN TUNNEL TOMB—WRITING ON A PRECIPICE TO BAFFLE DESERT-RAIDERS—GIANT'S CASTLE ON A MOUNTAIN—JEWEL HOARD OF SEVEN DEAD CITIES—RIDDLE OF KNOSSOS—TOWER OF BABEL AND UR OF THE SUMERIANS—HORROR OF DAWN SACRIFICES IN OLD MEXICO—STRANGE LOST CITIES OF THE UNKNOWN MATTO GROSSO—GOLD BUG OF AMERICAN GRAVES—THE CAVE MAN'S FOOT-BRIDGE—UNDERWATER CITY OF THE CASPIAN SEA

HIGH above the lone, level sands, stretching far away across the burning plains of Mesopotamia, drones an aeroplane, in which sits a keen-eyed observer, shading his eyes from the terrible glare of the almost vertical sun, and narrowly scanning the surface of the shifting sands. A little cluster of swarthy, bearded Arab tribesmen, below on the sands, look like ants to the airman sitting in his cockpit. They fall from their cream horses, and cast themselves prone on their faces, praying to Allah and the Prophet that they be not seen by the infidel on the devil-machine, humming overhead. But their fears are groundless.

His aerial reconnaissance is not for predatory, desert tribes, and Bedawin raiding from their black, felt tents the lonely outposts of white men, and then flying like the wind upon their spirited Arab horses away from the avenging bombs of punitive expeditions. The airman is watching for strange, surface markings on the sands of the desert, continuous lines of depressions or mounds, which, seen from the air by a trained archæologist tell him that buried cities of long-lost Asian civilisations, and buildings of rarer stone or hard-baked clay lie below.

Caravans of 3,000 years of grave, white-turbaned merchants bound to flourishing Eastern cities whose very names have been forgotten and buried in the sands of time have passed by these dead cities, and even the trained scientists of our own day have traversed the road without suspecting that anything lay beneath their feet. These dead and buried cities cannot be seen from the ground, but betray themselves at once to the airman.

The French air "ace," Peletier d'Oisy, a short time ago flew his machine above what are believed to be the ruins of the Carthage of Hannibal, which stretch for more than seven miles under sea off the coast of Tunis. Prince Waldeck, his passenger, took a film of the ruins, which he followed from 100 yards off shore. The sea wall of ancient Carthage was clearly traced for some eight miles, and huge columns could plainly be seen by both men gazing down at the sea bottom. The remains observed were of vast dimensions, stretching from Cap Carthage to Cap Kamart, a distance of at least 10 miles.

Then in April, 1925, the finger of Romance once more touched this part of the world. An Arab fisherman was gazing over the side of his boat on the look-out for rock fishes, off the lonely isle of Jerba, or the Isle of Lotus

Eaters,* on the coast of Tunis, when he saw what he took to be the ruins of a city deep down below at the bottom of the pellucid waters. He dived and came up with an unusual find. He showed it to an archæologist. The experts were thrilled by the strange find. Aeroplanes were used to survey the drowned city from the sea, and divers were sent down; but none are able to say what the mysterious city at the bottom of the ocean may be, though 300 miles away is the site of old Carthage where a party of American, British, and French archæologists have been for many months at work digging up the ruins of the Goddess Thainit.

A Greek galley, laden with treasure, was found lying across the streets of the drowned city, and Greek vases, at the date of writing, have been brought up by divers exploring the wreck. It is possible that the unknown city was contemporary with Knossos of Minoan Crete. At the moment, archæologists are disposed to place anterior to 10,000 B.C., the epoch when the onrushing waters of the Atlantic broke through the Pillars of Hercules and submerged the Mediterranean valley of the Neolithic Age.

Here, then, is a new aerial voyage of discovery which may unearth the libraries of forgotten cities and lands of 5,000 to 10,000 years ago, splendid jewels and fine gold and silver, tools and weapons recalling a past undreamt of by the historian. The American Archæological Institute (John Hopkins University, Baltimore) is planning such an aerial expedition to the deserts and solitary places of Egypt, Mesopotamia and Arabia as will put in the shade

* "Domdaniel," the fabled abode of wizards and evil genii, was supposed to lie "under the roots of ocean" somewhere off this coast. This bizarre name first appears in Chaves and Cazotte's "Continuation of the Arabian Nights" (1788-1793), and was used by Southey in "Thalaba," and by Carlyle as synonymous with a city of sin.

the magic carpet of the Bagdad of the Caliphs, and rival the time-machine fantasy of the novelist, H. G. Wells.

Science, in the guise of the submarine diving cylinder built by the well-known firm of Krupp and Essen, and now being used by Dr. Hartman in his deep sea expedition in the Mediterranean, is to be pressed into the service of the archæologist, trying to solve the riddles of the history of the ancient world. Subsidences of the land have huried beneath the waters of the Mediterranean numbers of famous cities and splendid palaces which were by-words in men's mouths when the galleys of Imperial Rome bore her legions to every quarter of the then known world. The Hartman cylinder, with its apparatus of under-sea cameras, has taken photographs of the ruins of ancient buildings in cities "half as old as time," but now lying deep in the sea off the coast of Italy. Drowned villas of rich senators and treasures of the Cæsars hurled over cliffs to escape the clutches of barbarian looters await these divers of 1926. They will try to clear up the mystery of the whereabouts of the Colossus of Rhodes, that wonderful statue of Apollo, which straddled the harbour of Rhodes in the ancient days, but has long ago vanished into the sea. And there are submarine enigmas in the shape of drowned ruins lying in the waters of the Carthage of the Punic wars, which the submarine diving cylinder may presently elucidate.

Up to the present, the methods of the excavators of ancient tombs and cities in the lands of the Nile or the Euphrates have been necessarily rather crude and toilsome, and are still so. Before he can drive a pick into the soil, the excavator has to survey the spot, carefully noticing irregularities in the ground. A small bank may show where wind has blown the dunes against a wall, until the sand has drifted over and buried it. A depression may tell him that he is on the site of a ruined building. The weather and climate do not count for so much, since, in Egypt, the everlasting sun and little rain preserve objects under a bright, serene atmosphere of vivid distinctness.

Aerial photos taken by the British Archæological section of the Ordnance Survey at a height of 5,000 feet, revealed in May, 1925, an old hill fort of Saxon origin at Longstock, Hants, England.*

Science has again come to the aid of the archæologist-excavator by giving him a mechanical device whereby he can see in the dark, or through opaque earth and rocks. It is the Eötvös, or torsion-balance,† worked by the gravity-force of the earth. This X-ray device for excavators is a balance-beam suspended by a fine and delicate wire, one-thousandth of one inch wide. A gold weight is attached to each end of the beam, one weight being nearer than the other to the earth. At night, when the instrument is unaffected by the action of the sunlight, a hole in the ground, a hollow tomb, or mineral desposits cause the balance of the beam to move. It twists the wire so that a spot of light is reflected by a mirror on a scale and shows the excavator that he has lit on a hidden burial place.

This is one of the wonders of modern science of which the ancient Egyptians with all their wisdom, knew no more than did Pharaoh Amenothes of the 18th Dynasty, of the electric light which sheds its rays upon his 3,500 years old mummy, gazed upon by British visitors in the Valley of Dead Kings, at Thebes.

Romance treads ever at the heels of the intrepid ex-

* A circle of poppies, growing thickly in an ancient ditch, showed on the photograph the site of the ancient fort, which could not be seen from the ground.

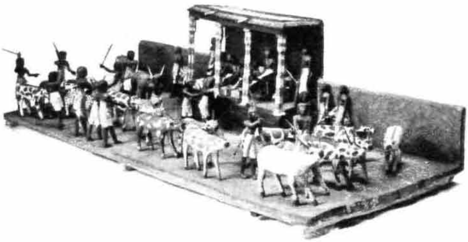
† A fuller account of the Eötvös torsion balance is given on pages 183-186, chapter IX.

cavator digging in the desert sands, or hewing at the rock tombs to find traces of the life and love of 5,000 years ago.

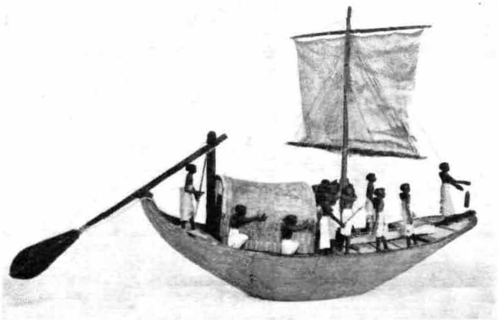
As the violet shadows of the evening creep over the deep, mountain gorges lit up by the silver glow of the powdery dust of the desert, the lumbering water buffaloes shamble up from the green banks of the Nile, driven by slim and graceful girls whose lissom figures are matched by those of the dancing maids painted on ancient papyri taken from Pharaohs' tombs. They pass by sepulchres yawning in the hillside, where kids frisk and bleat around their dams, and gossiping women, with bare and slender feet, brown-faced and robed in spotless white return at sundown from the river, balancing water jars on their heads.

This is the Valley of Dead Kings where the mummies of great Pharaohs lay in state in hidden, burial chambers, hewn out in the bowels of the mountain, some 3,500 years ago, and where Tutankhamen's tomb was found the other day.

Here for eight weeks American archæologists of the Metropolitan Museum of Art, New York, dug and dug in the Valley where Egypt's mighty dead had been found hidden by Maspero. By chance, they wandered into a big cliff-tomb, inside whose two yawning entrances hundreds of bats were clinging and squeaking. Great boulders of fallen rock blocked up the entrances. Other searchers had been there and unsuccesfully dug over the soil, and the Americans were about to abandon the tomb in despair, when the camera-man turned over a limestone block and found on its under-side a brilliantly-coloured and delicately-traced frieze pattern, 4,000 years old. Two expeditions had unsuccessfully dug in the tomb before the American discovery.



TOMB MODELS SHOWING OVERSEER COUNTING CATTLE (FOUND IN SEPULCHRE OF XI OR XIII EGYPTIAN DYNASTY.)
Photo by courtesy of Metropolitan Museum of Art, New York.



MODEL OF NILE TRADING BOAT (FOUND IN EGYPTIAN TOMB *circa* 3000 B.C.).
Photo by courtesy of Metropolitan Museum of Art, New York.

To face page 121

They dug, for another three weeks, watched keenly by an old, blear-eyed, Egyptian fellah, and sifted over a pile of rubbish, finding only the hammers and rollers left by some ancient quarry-man trying to obtain building stone from a smashed facade. Mr. H. E. Winlock, one of the excavators, then assistant curator of the Metropolitan Museum of New York, was about to give up in despair when one of the party caught sight of a yawning, black crack between the wall of the corridor and the rock floor.

Pushing an electric torch into the cavity, Mr. Winlock gasped with astonishment. The beam shone on a little world of 4,000 years ago. Exquisitely modelled figures of women were grinding flour; fishermen hauling seine nets between canoes; a gang of drovers with upraised sticks goaded on oxen; rowers were tugging at oars and a tall, slender Egyptian girl gazed straight at him and the light shining through the crack in the wall.

Workmen, clearing the cave-corridor, had noticed chips of rock, falling into a crack, behind which was a low chamber three yards square. A little pit, waist-deep in the cave, had been carefully filled in by the 4,000 years old builders, who had used chips of the rock it was cut in and had admirably deceived both ancient thieves and modern archæologists. The crack in the wall had been opened by a fall in the rock, and there was barely time to take photographs and remove the models when tons of rock fell in, burying the tomb from sight. Toiling hard for three days and nights under the desert stars, the Americans found that the tomb had been that of an Egyptian noble, buried in a gilded coffin and stone sarcophagus and placed in a mortuary cell deep down under the corridor. Ages before, thieves had destroyed everything, leaving only the secret closet with its wonderfully life-like little *ushabtiu* figures of carved and painted servants to tend the soul on its long wandering to the abode of Osiris, in the Land of Everlasting Life. Some of the models are now in the Metropolitan Museum, New York.

How did the Egyptians erect those towering monuments and vast monoliths, and those Pyramids which so amaze the twentieth century tourist as, dwarfed to the size of an ant, he gazes up at them from the desert-plain at their base? They had no such mechanical and engineering equipment as we possess to-day.

Let us turn the handle of the magic time-machine and flash on the screen a living picture of old Egypt and the banks of the Nile as they looked 5,600 years ago, in the time of the Fourth Dynasty of Pharaohs. It is the hour after dawn. Across the shimmering sands of the desert crawls a long line of men of all races and colours, brown-skinned and Semitic in appearance, Hittites and Assyrians taken in battle, Arabs and Bedawins captured by warlike Pharaohs, in raids on lands across the Red Sea. Up a wide, sloping causeway, they are dragging huge obelisks, hewn out in quarries in the limestone hills. Beetle-browed overseers, with heavy whips of elephant hide, keenly eye the miserable, conscripted workmen, some of whom are native Egyptians, pressed by the local governor, in the name of the Pharaoh. They detect a laggard, and the cruel lash falls whistling on a black, velvety skin. There is a loud shriek from an Ethiopian negro, whose body is bedewed with sweat and his lips with blood. He stumbles, slips from his yoke, and crashes on the stone pavement, apparently dead. The overseer rains down crashing blows with his flail-like whip, but the Ethiopian slave does not heed them. He is travelling the long road to

Elysium. On goes the cortège until it reaches the banks of the Nile, where the obelisks are hauled into barges.

Another set of men, plying banks of oars on the flat-bottomed boat swiftly urge it down-stream for the stone to be again hauled up a sloping embankment by slave-gangs straining at hide-ropes. Along a sloping road they go until they reach the end of the embankment, and the colossal hewn stone obelisk is projected over on to a bed of sand. Men then feverishly shovel away the sand under the base of the block until it sinks its vast length into the sand-bed, gradually swinging upright into the intended position.

Not far away, in other quarries, men can be seen scoring deep grooves in the rock face, drilling holes and ramming in wooden pegs. They pour water on the pegs, causing them to expand and fissure the rock face along the grooves. Yet other men daub with colours unit areas on the rock, and draw figures in each division for the sculptor to carve and cut out the finished statues from the living rock. These seem to have been the methods adopted by the ancient Egyptians in their vast engineering works five or six thousand years ago.

Between these towering stone monuments and the shifting sands of the desert an unceasing fight was waged. The encroaching sands would creep round the bases of the Pyramids and sweep over and bury them as the restless sea dashes and foams upon the shingly shore. One Pharaoh, when he came to the throne, would find that the monuments of his thousand-year-old predecessor were engulfed in the sand. He would give orders, as Pharaoh Thothmes IV did to his engineers in the case of the buried Sphinx, to have the sand removed from the stone and cast back on the desert. A few more seasons would wane and again the great stone guardians of the Nile had disappeared in the sands. The task was like that of Mrs. Partington endeavouring to sweep out the Atlantic with a broom. It resembled, too, the endless battle between the Pharaohs and the tomb-robbers.

Six thousand years ago, the Pharaohs of the fourth dynasty built labyrinths in stone and set their tombs in secret chambers so that tomb-robbers entering the Pyramids might wander for days without finding the way out again to the free air. High up on the face of a great Pyramid would be a cleverly-hidden door, swinging on a pivot, and imperceptible to the searcher on the outside of its walls. Even if he hit on the concealed door, which could be opened only by pressing a secret spring, he would find himself wandering only in a stone corridor. A long time would pass and he would enter a lofty hall, richly decorated with bas-reliefs and painted scenes of great beauty faced by the "speaking likenesses" of the men who made these halls of death.

But he was not in the treasure-chamber of the dead Pharaoh. He had still to find the craftily hidden entrance to the tunnel leading to the death chamber. It was hidden on one face of the hundreds of stone blocks lining the hall and all alike to the eye.

If, by some chance, the thief hit on the entrance in touching the spring on the hidden, stone face, he merely found himself in another gallery and before long came to a dead stop facing a number of colossal stones, shaped out of the hardest granite. He might blankly stare—his way was barred! The high priests had foreseen and prepared for his coming. These granite blocks had been placed in position in the tunnel, propped up by timbers, and after the burial ceremony, the vaults had re-echoed as the stones fell crashing down into carefully prepared grooves.

The idea of the Tomb-builders was to ensure for the "KA," or double (or dual spiritual entity), a future life, and the resurrection of the body, and to succour the wandering soul on its long journey to the Heaven of Osiris. Their subjects, so often conscripted to labour at the building of Pyramids, were sceptical of these religious beliefs and plundered the imperial tombs without scruple.

One Pharaoh built a strong burial chamber, which the thieves looted. Another Pharaoh, a thousand years later, made a secret mausoleum. The robbers found and plundered *that!* Then Queen Hatshepset of the 18th dynasty (about 3,500 years ago) built a temple for herself in the desolate, burning Valley of the Tomb of the Kings where rain seldom or never falls on the parched limestone cliffs and sandy soil. She was an ancient Egyptian Queen Elizabeth or Catherine the Great, who claimed to be the divine daughter of Amen-Ra, the King-God of Thebes, and wore male dress as depicted in the bas-reliefs on her temple at Der-al-Bahari, in Western Thebes.

The Queen-Pharaoh let it appear that her mummy was to be enshrined in the temple in a gorgeous sanctuary, but secretly dispatched a priest who hollowed out a tomb in the limestone rocks on the desert hills. The priests hid the entrance with very great care, and set obstacles to prevent anyone entering the tomb. Other Pharaohs of later dynasties followed her example, but the tomb-robbers broke in just as before.

They were not without some excuse, since the powerful priesthood of the 20th dynasty, in the time of Pharaoh Rameses, battened on the country and its wealth so that the poor people, groaning under the priests' exactions were driven to rob the tombs of the Pharaohs. One of the thieves was caught about 1250 B.C., turned king's evidence, and told how with the aid of the cemetery officials, he and his confederates had broken open coffins, taking jewels, gold and precious stones and vessels, and shared them out among eight of the spoilers. What happened to him and them is not known, but the tomb robberies went on, age after age.

Then the high priests of the god Amen-Ra, in desperation, went by night into the lonely hills of Western Thebes to find a hidden place to which in the dark hours they secretly conveyed all the mummies of the Pharaohs in their sacred charge. There, in the wastes of Der-al-Bahari, the Valley of Dead Kings, the great kings of the 18th, 19th and 20th dynasties slept undisturbed for 3,600 years, forgotten and unknown, until 44 years ago a famous Egyptologist, Gaston Maspero, stumbled on a beautifully illuminated hieroglyphic papyrus which some Arabs were offering for sale.

Maspero's mind flashed to the conclusion that these Arabs were tomb-thieves who had lit on a royal burial chamber. He rushed to Thebes and told the pasha, who arrested a suspected man, but without avail.

Baksheesh, however, won the day, and on a certain morning, two Arabs met Maspero at a solitary place in the desert, and led him across some boulders at the base of forbidding cliffs. Rounding a vast block of rock which seemed to have fallen from the cliff above and cunningly screened it, they saw a hole in the face of the precipice. They lowered themselves by ropes down a fifty-foot shaft, and groped their way in pitchy blackness along a tunnel, stooping to avoid knocking their heads against its roof.

Now, they turned a corner, climbing down a flight of rock-hewn steps deep into the bowels of the mountain.

Soon, they were entering a great chamber, and saw in excitement mummy cases piled up in confusion against the walls, and, on the floor, alabaster vases, ushabtiu statuettes and terra cotta figures. Along another corridor, they passed into the royal burial chamber with its gilded sarcophagi and admirably decorated mummy cases all round the walls. Here were the dead Pharaohs. One of them, a brave man who had fought against the hated Hyksos or Semitic shepherd kings, conquerors of Egypt, had his mummy unrolled, and was found to have a split skull, a tongue bitten through, a broken lower jaw-bone, a twisted neck and a dagger stab over one eye. He was Seqennra who had ended his life in battle.

Day and night, Maspero and his friends laboured, and one morning, the fellaheen, tilling their fields along the Nile, lifted up their eyes from the soil and saw a barge, carrying 22 royal mummies, kings and queens, passing down stream to Cairo, amid an outburst of wailing from Egyptian women, tearing their hair and running along the banks, and the cursing and weeping of men firing off guns. Their descendants were mourning the Pharaohs who died 3,000 or 4,000 years before, the most recently discovered of whom, Tutankhamen, was found in 1924, by Mr. Howard Carter, buried under the rubbish dumped thousands of years ago by the builders of Pharaoh Thothmes III's tomb, cut above it in the rock face. (N.B.) Tutankhamen's tomb, on opening, was found to have been looted of all movable gold and silver articles.

The image of the unfortunate young Pharaoh Tutankhamen survives in two statues now in the Cairo Museum. One of these statues was found in the rubbish of the

Theban temple of Ptah, at Karnak, and the wistful expression of the suffering young king impressed Maspero very vividly. He said he thought Tutankhamen had died of consumption, so haunting to the imagination were the lineaments of the king as expressed on the hard granite by some realist Egyptian sculptor. A second image was dug up from the débris of another temple where it had been smashed in pieces by a later orthodox Pharaoh, Rameses IV, to form building material, for his sanctuary. In November, 1925, after the removal of a dazzling collection of jewellery, sewn into the royal mummy, the mummy was lifted from the coffin and X-rayed by a Cairean doctor of anatomy, another doctor of the Egyptian Department of Antiquities undertaking at a later stage to analyse the internal organs of the long dead Pharaoh, sealed up in canopic jars and placed under the wings of Osiris in the vault—from whence doubtless originated the Hebraic phrase, "the Son of Man with healing in his wings."

Forty feet below the surface of the desert at Abydos, where was unearthed a stone tablet recording the names of Pharaohs, a band of British archæologists, sent out by the Egypt Exploration Society, are trying to pierce the mystery of the strange island hall of Osireion, or the temple of Osiris, god of the sun and of the nether regions into which the sun, according to ancient mythology, descended in the hours of darkness. They began the work in 1911, and resumed it after the war. By January, 1926, they had unearthed a great hall surrounded by a canal 12 feet wide, whose waters are replenished by an unknown source. No bridge crosses this canal, to which the approach in the time of Pharaoh Seti I, was by the sacred boat of Osiris, corresponding to the ferry of Charon across the Styx to the ghost land of Hades.

A vast grey hall, with 17 chambers hewn out of hard granite, has staircases leading down to the waters. It is supposed that the rites of Osiris, in his aspect of president of the infernal regions, were secretly performed by the priestly caste in this strange temple on the waters.

Then, in 1926, two excavators, led by Dr. Reisner of the Harvard-Boston Expedition, were clearing away rubbish in the shadow of the Great Pyramid at Gizeh, when they stumbled on a bed of gypsum in the granite rock. They broke it away with picks and shovels, and found a blind staircase. Suspecting that a shaft leading to a tomb lay somewhere hidden in the neighbourhood, they overhauled every inch of the locality, for days painfully scraping with steel implements the hard rock. Then one day, success rewarded their efforts. They lit on a cunningly hidden crack in the rock weathered and coloured to look exactly like the surroundings of natural limestone. Beneath lay a 100 foot shaft of a tunnel choked with blocks of limestone, which they laboriously hacked and hewed away, until their picks penetrated into a sepulchral chamber. The deep darkness of 6-7,000 years in which the tomb had lain forgotten since it was sealed by an unknown Pharaoh racking his wits how to baffle tomb riflers, was dispelled by the flash of an electric torch, and the excavators saw the light flash back in a dazzling sheen of gold! They were gazing on the gold sheets wrapping the sarcophagus of a Pharaoh who impressed the imagination of 5,000 years of Egyptians, as an Alexander the Great. More may be known to us when the present Egyptian Government removes its restrictions, conceived in a narrow spirit of nationalism, and permits the world to obtain freely news of work financed by money which is not furnished by the present Government of Egypt.

Across the screen of the time-machine now flashes a series of blurred pictures in which we dimly discern a welter of forgotten nations and empires battling for supremacy in Western Asia. Bearded and hook-nosed Semite goes down before the dark-hued Egyptian, and the mysterious Aegean or Minoan race is submerged by the Aryan wave of Mediterranean valley pirates pressing on to the sack of Troy, until the clash of arms resounds at the gates of Babylon and the Semitic-Assyrian, debauched by luxury and weakened by prolonged imperialistic militarism, is swept into the gulf of time by a hardy race of Aryan and Median mountaineers from the tablelands of Persia.

The dissolving views harden and coalesce and we see a perpendicular cliff, towering 300 feet above a scorched-up plain, beat upon by fierce sun-rays. We gaze on a land of caravans and thirsty plains, and the cliff-rock is Behistun, on the caravan road from Hamadan to Bagdad. "Grave, white-turbaned" merchants are watering their camels and themselves drinking at a well and hardly deigning to glance up at some remarkable rock-sculptures on a rock-platform high above on the cliff-face. For 2,500 years have these wonderful sculptures stood undisturbed, whilst the phalanxes and chariots of Macedonian and Roman have passed in successive waves across the eternal desert, whose "lone, level sands," stretch far away as those withered by the cold sneer of the head of sculptured Ozymandias, lying on the earth.

Darius the Mede, chose this wild site some 2,400 years ago, and 300 feet above the base cut away the sheer rock face so that no wandering Bedawin or other martial invader could climb up and smash the polished stone bas-reliefs showing King Darius gloating over a long strain of fettered war-captives, or destroy the 1,000 lines of cuneiform writing in Elamite, Persian and Assyrian.

Further to preserve his rock-carvings and inscriptions he brushed them over with a remarkably enduring brown varnish, traces of which remain on the stone even to-day.

The riddle of the stone and its writings went unsolved for 2,400 years, until in 1835, an Englishman, Henry Rawlinson, army commander in the Persian province of Kermanshah, climbed on hands and feet up the cliff to the narrow, rock platform on which the sculptures stood. He had a passion for the study of cuneiform inscriptions, and he perched a ladder dangerously against the face of the inscriptions in order to obtain copies by rubbing.

One morning, he was bridging a gulf with his ladder, and starting to walk across the chasm, when one end of the ladder broke clean away and left him dizzily swaying on the portion still attached to the cliff. He hung on by his eyebrows, so to speak. Inch by inch he climbed up the rungs to safety, making his way back much in the manner of a trapeze expert at a circus. He had to abandon the taking of inscriptions on *that* rock.

Nine years later, Rawlinson employed a Kurdish boy to climb the rock and take copies of the rock writings. Swinging in a cradle plugged in to the jutting rock-face, the boy for 10 days dabbed damp paper on the cuneiform writings, and took copies, his life hanging on a thread as he dangled in mid-air 500 feet above the desert. Rawlinson went back to his consulate at Bagdad, and in the intensely hot, summer days laboured at the inscriptions whilst sitting in a summer-house in his garden, a pet lion at his feet, and water from the Tigris pouring over his roof from a mill-wheel to keep him cool. He and others were successful in deciphering the cuneiform writing.

To stumble suddenly upon the vast ruins of a gigantic castle perched on towering cliffs, with walls 30 feet thick, approached by a colossal stairway climbing to a platform fronting a huge gate, and admitting one to a spacious court of honour dimmed by the shadows of many lofty pillars, sounds like a tale out of the "Arabian Nights"! One would expect to meet a genii who, with a wave of his wand, would people its immense solitudes with a jewelled Sultan sitting on a throne of peacock feathers, a grand vizier kneeling in obeisance before him, amid scenes of Oriental magnificence with bevies of dancing girls and crowds of richly apparelled courtiers filling the carpeted spaciousness illumined with glowing ruby-coloured lamps.

Yet this adventure befell the well-known Orientalist and explorer, Professor Ernst Herzfeld in 1925, wandering in the wilds of Southern Persia hard by Firuzabad, the abode of the Sassanadian king, Ardashir, whose descendants were expelled by Arab invaders and had to fly for refuge to the Emperor of China. This castle, lost for nearly 1,700 years, occupies a site the size of a town, and stands on a mountain some 6,000 feet high. It is probably the ancestor of Europe's mediæval castles. Such a discovery reminds us that romance is not dead even in our modern world of radio and coming television, since the country in which this mysterious ruin lies is quite unknown to the explorer.

A romantic tale of excavation which reads like an episode of the "Arabian Nights" is the adventure of the ex-grocer's boy, Heinrich Schliemann, of Neu Bockow, who, digging in the lonely hill of Hissarlik, near the Dardanelles, found buried in certain ruins no less than

90,000 articles, many of them magnificent gold cups and goblets shaped by goldsmiths or cast in gold. He identified one of these ruins as the site of Troy, of the *Iliad*, and found seven dead cities, built on top of each other, the fifth of which he said was Troy. Some of the gold cups weighed 3lbs., and jewels had been thrust into a town wall, perhaps to hide them from an onrush of an invading Hellenic or other Aryan army. A roaring fire in a far-back age seemed to have raged in one set of the ruins; for, taking up what he thought was fused copper wire, Schliemann found it break apart and a shower of golden and silver bracelets rolled on the ground. At Mycenae, he unearthed the bodies of ancient kings, masked and buried in golden armour. They are now in Athens Museum.

For more than 25 years, until to-day, unavailing efforts have been made to decipher the strange, hieroglyphic writing and pictographs left by the mysterious Minoan race who ruled the Mediterranean when Egypt was yet young and long before the prows of the Phœnician navigators had stemmed the waves east or west of the Pillars of Hercules or Gibraltar. This powerful nation was centred at Knossos in Crete, and had developed a very high degree of civilisation long ages before the Semitic peoples had erected Babylon and Nineveh. They seem to have been fond of bull-fighting and the dresses of their women are strangely modern in style, judging by ancient inscriptions on seals found in Crete. It is supposed that they were of the same race as the modern Basques, or an offshoot of the strange, Neolithic race which, 10,000-15,000 years ago, circled the globe with a chain of colossal dolmens or stone monuments from England right across Europe and Asia to the South Sea Islands and Mexico and Peru.

Great earthquakes and an internal rising in Minoan Crete appear to have brought about the ruin and demolition of the great Palace at Knossos, and that event took place at the epoch when the hated Hyksos or Semitic, Arabian desert rovers overran and subjugated Egypt. A new king was chosen, and the Minoans built the ruined sites at Knossos, only to be finally overwhelmed by Greek sea-raiders avenging the annual tribute of Hellenic youths and maidens exacted from them by Minos.

Sir Arthur Evans unearthed at Knossos, on the hill of Kephala overlooking the blue, Ægean Sea, many indecipherable pictographs, hieroglyphics and a strange linear writing of unknown significance. Ten or twelve feet below the soil, he found the ruins of a palace, with stone seats encircling the walls of a council chamber having a stone throne in the centre, and hollowed out to make a comfortable seat for the king. Here sat Minos with his council of Ministers. The throne had a back carved in a series of six curves, rising to a half circle at the top. Its front was carved into the shape of legs.

He also brought to light magazines of huge, stone jars and casellas, in which a man could stand upright as though he were one of Ali Baba's "Forty Thieves." These chests had contained oil, food and treasure, and after the palace had been burned down, it is evident that thieves had broken into the magazines and rifled their contents, leaving broken hammers behind them. In the domestic quarters of the palace he found remains of quite up-to-date sanitary convenience including water-closets with flushes—built by a mysterious race of men who lived some 3,500 years ago!

Below the ruins of the Knossian palace he finally unearthed the stone axes, flesh-scrapers, clay images of the men and women, and polished pottery implements of the Neolithic or later stone-age people.

Some of the Ægean pottery found in these ruins is painted or inscribed with concentric circles which are believed to be derived from the intercourse of these early Mediterranean civilisations with the miners of the Danube who used similar signs.

The tale of these early races and civilisations of the morning of the world has yet to be told. Quite recently, Mr. R. Campbell Thomson found on the site of a very ancient inland sea-port, Eridu, once connected by canal with the Persian Gulf, traces of Neolithic or later stone-age men who cut corn with baked-clay sickles and who painted pottery.

Another excavator, Mr. Woolley, found under an old Persian pavement at Ur, the shrine of the Moon-God, a Babylonian floor 2,500 years old, and heaps of beautiful gold statuettes of women, gems, lapis-lazuli, gold necklaces and so forth. Life-sized lions, cunningly carved, whose eyes blazed with red fire and whose scarlet tongues lolled out of their heads startled the gaze of Dr. Hall, digging in 1919 at Tel-el-Obeid, when he laid bare the site of an ancient Sumerian city, ruled over 4,000 years ago by King Hammurabi, celebrated for a code of laws found engraved on stone.

A vivid glimpse of life in and around the shrine of Nin-gal, wife of Ur the Moon-God, worshipped by Abraham, the Bedawin, more than 4,500 years ago, was flashed upon the screen of the time-machine in March, 1925, by the joint expedition of the Museum of the University of Pennsylvania and the British Museum. An ancient Babylonian king built a convent for his daughter, and modern Americans, digging in the "Ziggurat" (a vast tower of dried brick-clay) found schoolrooms, offices, dwelling houses, and store-rooms.

Copper watch-dogs, buried probably 5,000 years ag were under the house-floors, still on guard, and a grea hoard of clay tablets was unearthed recording the dail business of the priests and the temple. For every pint c oil, head of sheep, and pound of butter brought to the vas temple storehouses receipts were found, and merchant had left lists of hides, woollen thread, and gold, silver an copper coins deposited at the shrine. One can see, to how each worker was graded as to his capacity to tur raw wool into finished cloth, and what rations of grain an oil, as wages, he received. Every man, woman and chil employed in the temple workshops is mentioned in th steward's vouchers, and every farmer has his tithes pai to the priests duly recorded. Five thousand years ol kings had left their stamps on the walls, and drive through the joints of the brick-work were cones of bake clay, shaped like nails and patterning the wall. Thi little mystery is, at last, explained by the fact that th shafts of the cones are inscribed with the king's name and the dedication of his building to the Moon-God.

A beautifully-carved relief on a limestone slab, 15 fee high, was discovered, showing the features of King Ur Engur, who built the Moon-God's temple; depicting builders carrying mortar up ladders, on another facet and recording the list of canals* constructed by him fron this great Sumerian city of Ur, about 100 miles inlan from the Persian Gulf, with which the port of Ur wa connected.

A small black head, in diorite, was found in anothe

* Clay cones have been found recording the fact that some of thes canals were built "so that men might grow onions and other vegetables."

court of the temple, and is probably the statue of a priest of 4,000 years ago, one of the sacerdotal corporation of the two palace-temples who lived on the tribute paid by wealthy Sumerian merchants trading up the canals from the Arabian Gulf to the great port of Ur.

The searchers, continuing to turn over the rubbish of ages, then lighted on an exquisitely sculptured head of the Moon Goddess, in white marble, its eyes beautifully inlaid with lapis lazuli and shell. The contours of the face were round and full and the hair was elaborately coiffeured. Under the palace of Dungi, a Sumerian monarch who reigned about 4,000 years ago, they found in the grave of an official in the ancient law courts a set of tablets from which it appeared he had just added a single room to his town house, and had bought the necessary little plot of land for the modest equivalent of 17s. 6d.

Inside a wall built, 1,600 years later, by the ruler of the second empire of Babylon, Nebuchadnezzar, they laid bare some houses, where somewhere about 693 B.C., a person dropped on the floor a lot of inscribed clay tablets, some of which contained schoolboys' exercises and grammars and others, religious hymns and prayers. Under the floor of this house, they unearthed the cast-out contents of an ancient shrine, among which was a little grotesquely carved plaster plaque depicting a dweller of the people of the marsh, in a boat on the Tigris, with an arched cabin containing a pig and a goose, two fish hanging by the stern on a string. This reed boat of the morning of the ancient civilised world is remarkably like the goofah, or coracle one may still see rowing Arabs to the desert across the Tigris, from the Bagdad of 1926.

The shimmering sands of the desert and the lonely, silent places of Old World's dead civilisations now fade from the screen of the time-machine, and we see a picture of lofty, terraced steps leading up to a vast temple over which the sun is rising. Brown-skinned priests, smooth and beardless, stand on the platform at the base of a vast pyramid and tower-temples and altars carved with the emblem of the serpent are on either hand. War-captives fettered and in sacrificial white are grouped around the Maya priests. Suddenly, the deep booming of a gong reverberates from the temple steps and echoes over every part of the city spread out far below, and the people shudder as they listen, for it bodes the shedding of blood! A victim is haled by an attendant to the foot of a sloping green stone—the sacrificial altar of the war god—he is forced by the high priest on to the sloping stone, and his body inclines backward, his bare throat in readiness for the obsidian knife. The priest slashes open the victim's breast, tears out the quivering heart and holds it before the god. The body of the victim is then tumbled down the steps to the captors and their friends, waiting below, to take it home and cook it at the victory banquet. From other shrines and temples in the vast enclosure an infernal reek of burning human flesh goes up to the skies. Thousands of skulls are skewered on sticks and built into the temple walls. Other victims, armed with wooden weapons, are set to fight champions equipped with steel—the amphitheatre a round or spindle stone. This is old Mexico with his lunatic civilisation crying far back to the days when, 20,000 years ago, his ancestors were building Stonehenge, on Salisbury Plain, England, choosing like victims for sacrificial atonements, and harvest-propitiations, worshipping the serpent, and carving the serpent-emblem on their buildings.

Again, the scene changes, and we see a party of workmen in the month of January, 1922, engaged on building construction. The pickaxes are hard at work and the steam-digger is panting and churning when a man suddenly throws up his hands and disappears from view. Other men rush to his aid and find he has fallen into a deep pit. Ropes are lowered, the rescuers descend and are amazed to find themselves in the streets of an ancient town under modern Mexico City. They explore passageways, see very modern-looking tiled floors, and walls in perfect condition. Guarding an entrance, they come face to face with a vast stone-serpent, carved out of hard stone and extremely accurate in design and technique. This is one of the characteristic signs of the Neolithic peoples throughout the world.

Hard by is a baking-oven of dried adobe bricks, and a pile of thousands of hard stone nails stacked for constructional work. The labour expended in making these nails must have been prodigious, and the science of this ancient race is shown in the fact that, to forestall earthquakes, the stone walls were built to slope *backward!* About the same time, a finished boat was dug up under a San Francisco lot.

Is Brazil the ancient cradle of civilisation, from which, across the drowned continent of Atlantis, the torch was carried to the Mediterranean and the Nile Valley, and thence to the basin of the Euphrates?

Among the Indians of the vast forests of the Matto Grosso, that unknown region of two million square miles where perpetual twilight reigns under the boughs of labyrinthine, virgin woods, is a persistent tradition of a mysterious race of superior beings who inhabit the "white mountains of the interior." Geologists say that this area of South America constitutes that which first emerged from the primæval sea. It was then a vast island, but the cataclysmic upheaval resulting in the upthrust of the great cordillera of the Andes united the two areas. Immense marshes separated the cordillera from the plateau of the "Brazilian Isle," and they gradually drained away into the Amazon, on one side, and the Pacific, on the other.

Many are the expeditions which have sought to lift the veil from this land of perpetual twilight; few have returned. The famous trust of Krupp, of Essen, organised an expedition to penetrate into the heart of Brazil, but the difficulties of commissariat and the too great number of men forced an abandonment of the plan. In the archives of the National Library of Buenos Ayres is a MS. of absorbing interest relating the remarkable adventures of a group of Portuguese gold prospectors who penetrated into this strange land in the year 1753. Beyond the belt of forest, they found the gigantic ruins of a fortified city, destroyed by an earthquake, and abandoned in haste. A magnificent palace with a superb entrance hall, towering archways, the colossal statue of a man, standing erect, pointing to the north, and a temple delicately sculptured are among the glories of this once splendid city.

The surrounding country was a veritable "garden of Flora," flowers bloomed, rice grew luxuriantly in lakes, ducks swarmed on the crystal-clear waters of ponds. Near the opening of a mine, a bar of silver lay on the ground, as though abandoned in all haste by men flying for their lives. Unfortunately, the MS. has been badly gnawed by insects, but one may read across its mutilations a reference to nine men of the expedition who left the main party, and marched inland. At the end of nine days, they saw at a distance a boat, manned by two men, white-skinned, and dressed in European garb, their hair floating in the wind. "They fired a shot by way of signal . . . escape." Here the story is obliterated.

Colonel P. H. Fawcett, the famous explorer, his son, and another young Englishman, set off into the wilds of Brazil, in April, 1925, in an attempt to find this lost city. They expect to be wandering for two years in this land of twilight forests. The traditions of the Indian tribes are that vast buildings, lit by a strange light or ray that never goes out, shine in the darkness of these cities. "A great crystal on a pillar, shining so brightly as to dazzle the eyes."*

On the walls of these ruined Brazilian cities in the forests of the Matto Grosso are engraved characters which bear an astonishing resemblance to the letters A, K, υ, ε, ζ, θ, Δ, I, Λ, Ω, Z, Φ, in the Greek alphabet. Colonel Fawcett has with him a small radio receiver by which he hopes to find his longitude by daily time signal. At a later date, he plans to re-visit the forest interior by hydroplane, which he hopes to be able to use on one of the streams flowing from the Matto Grosso to the Amazon.

The lure of gold and treasure finds attracts many, quite unconcerned with archæological research, to the burial grounds of long-vanished races.

A chance seeker, wandering on a hill called the Cerro de Narrio, in the province of Canar, South Ecuador, picked up a gold object. The news spread like wildfire, and in a day or two, a horde of treasure seekers trekked many hundreds of miles on foot and in waggons and swarmed upon the hill, which is situated in a country noted for its many burial grounds of Maya origin, and the rich,

* *Vide* a telegram to the London "Daily News," from Cuyaba, on April 20, 1925.

archæological treasures of pottery and gilded ornaments dug up on the site.

Men feverishly dug, day and night, scarcely giving themselves time to eat or sleep. Provision booths magically sprang up on the slopes of the hill, but little was found to reward the riflers of ancestral graves, since most of the ornaments dug up were merely of gilded copper. A vast amount of valuable, archæological evidence was destroyed which would have thrown interesting light on the mysterious highland race living in Ecuador before the white man's ships and guns ground their keels on the beach and woke the echoes of the valleys.

It is said, however, that for more than 40 years past, great treasures of gold have been found in the graves and have vanished without a trace, 32 lawyers having formed a well-backed association of *haqueros* or grave-seekers to exploit the territory. A distinguished American archæologist, Dr. Max Uhle, who was on the spot, went round persuading the diggers not to destroy so much, and bought many of the finds. He says they were left by a race who knew not gold, but were more familiar with painted and engraved clay ornaments, crystal and bone objects, and also made copper-gilt vases, bells, nose ornaments, pins and tweezers, exquisitely worked.

Allied and German soldiers digging trenches wherein to hide from the deadly hail of shrapnel and bullets, during the European War, came on traces of dead civilisations and prehistoric life. Flint tunnels and tools of the New Stone Age were unearthed at Arras and Lille; skeletons on a gravel-bed, encompassed by timbers, and pottery, beautifully polished and 2,400 years old, were found at Soissons (they were the remains of the warriors of Brennas, the Celt, who warred on Rome, 2,400 years ago), whilst on the Eastern front in Russia, a Roman cemetery and traces of old Teutonic tribes were unearthed by prisoners clearing sites for camps.

Most people know that the men of the ice age, or the Palæolithic epoch, were gifted with artistic talent of a high order, as is manifest in the wonderful paintings of wild animals on the walls of caverns in the Pyrenees and in Southern France, but no one thinks of these remote ancestors in the light of engineers. A remarkable discovery of a footbridge, used by ice age man to cross a marshy river bed, was made in 1925 at Kaerde, near Dortmund. It makes us revise our opinions. A Swedish professor Gagel thinks the bridge is more than 50,000 years old, or ten times the age of the Pyramids. High technical skill was shown in the construction of this bridge which is 40 yards long, and is made of split planks of oak, carefully planed and fastened together by oak clamps at intervals of a stride. The mystery is how did the cave men build such a bridge by means of implements made of mammoths' teeth?

Heine, in a wistful and beautiful poem full of the imagery of the older childlike Germany, tells of the mysterious ringing of bells which may be heard on mystic midsummer evenings by lonely fishermen sailing homeward across the Baltic Sea. They come, so runs the legend, from drowned cities of a golden age sunk far beneath the waters by enchantment, potent as that which held Tannhauser imprisoned under the Venusberg. Some such haunting myth ought, one would imagine, to attach itself to the ancient submerged city, with its streets and buildings of archaic Eastern architecture, which a Russian Soviet ship, bound from Persia to Baku, and driven out of its course across the Caspian Sea, saw gleaming below the Shihova sandbank, on an evening in October, 1925. No one knows what this city may have been; for its very name is lost in the seas of time. In some long past day, a series of violent earthquakes sank it, and others, beneath the waters, and changed greatly the contours of the coast-line.

CHAPTER VII

CHARTING UNKNOWN SEAS TO-DAY

TYPHOON WARNINGS BY WIRELESS—HYDROGRAPHERS AND THEIR SURVEY SHIPS—WONDERS OF THE INSTRUMENT CABIN—LIGHT-KEEPERS' SUN STATIONS—WADING THROUGH TROPIC SWAMPS—DANGER ZONE SIGNS—BRITISH ADMIRALTY HYDROPHONE—WATCHING FOR ICEBERGS—NOVEL AMERICAN DEVICE FOR SAFER NAVIGATION—SONIC DEPTH FINDER AND RADIO-MICROMETER—HOW SALT AFFECTS OCEAN CURRENTS—"FARMING" AT SEA—RIDDLES OF THE OCEAN BED

THE tropic sun blazes out of the bluest of skies down on the sparkling waters of a Far Eastern sea where is placidly steaming a remarkable vessel whose deck is littered with buoys and ropes and studded with wonder-working instruments for tearing from old Ocean the secrets hidden in his bed of primeval slime.

Drifting listlessly over green waters which seem to slumber in the hot, white light, a passenger new to this sun-smitten world might imagine he had entered the realms of endless day. Not a cloud in the stainless blue—except for some curiously light gossamer tufts of fine hair-like streamers softly converging to a point on the horizon.

Suddenly, a hail comes from the bow to the bridge, and electrically the ship wakes into life, her decks humming with activity. The mirror-like placidity of the sea is slowly vanishing before a long heavy swell travelling from the horizon. Yet the sun still blazes down on the deck and the barometer is high.

A radio message flashes from the ship to a shore station fifty miles away, and in fifty harbours for one hundred miles around all movement now ceases. Vessels, riding at anchor, at once get up steam to strengthen their moorings, and other ships, too far away to run for port, first heave to for safety, then ascertain in what quadrant of the approaching circle of disturbance they are, and steam swiftly before the stórm. The dreaded typhoon is approaching, héralded by the radio flash of a British Admiralty survey-ship on duty in Far Eastern waters, and taking observations which may help to predict the path of the typhoon, tearing off iron roofs, uprooting telegraph poles and trees, and smashing steamships' propellers.

This is only one of its many fascinating activities. The safety of every ship sailing the seas depends upon the accuracy of the charts, the careful soundings of dangerous waters made by the officers of the British Navy's survey ships.

Life on board these hydrographers' steamships is strenuous and exciting. The brain of the ship is the chart-room, where expert hydrographers and land and marine surveyors daily record soundings of the sea-bed taken by various instruments, including a steam winch on the after-deck, a graded fathom line read by leadsmen, and electric machines for sounding depths of 100 fathoms or less. Ships' captains nowadays will take perilous short cuts and shave round capes in a dangerous manner in order to get from port to port in the quickest time and earn the greatest possible profit for their owners. Were it not for the great work of the survey-ship in revealing unsuspected dangers near coast lines, many more wrecks of valuable steamers and men would strew the rocks of the world.

Shoals often shift and alter the position of their mark-buoys; dangerous areas shown in old charts disappear or extend; or a rock pinnacle known to be in the fairway in 1926 has vanished in 1927. What is a safe passage for deep-draft ships one year may be highly dangerous the next.

If the reader glances at a marine chart he will see that hydrographical surveys are built up on a framework of triangles whose corners are the main points of the chart. Detailed marine surveys, showing the topography of adjacent coasts, are always urgently needed for the great trade routes on the sea-ways leading to busy ports and harbours. They are taken with carefully levelled theodolites of the latest scientific pattern, aided by trigonometrical calculations.

On a coast survey, the charting steamer finds out her position by steaming out to sea, picking out three fixed objects on shore for signals, and plotting the position with the aid of what are called "two-section angle instruments." But in narrow waters and shoaling channels, or in coral seas where the ship's bottom would be ripped out by one false move, the survey-ship uses the more accurate three-arm protractor for finding its position.

This instrument is a graduated circle with one fixed and two movable radial arms. To plot the ship's position, the officer uses the fixed arm as zero point, and observes the two angles, set by the instrument, between three selected objects on shore or sea. The protractor is then moved over the chart until its three bevelled edges pass through the three objects (shown on the chart). The centre of the instrument now marks on the chart the ship's position.

Ten miles out from land, the shore signals cannot be seen, and then the survey-ship steams past survey-buoys anchored three miles apart and parallel with the shore line. Fixing herself on these buoy-points, the ship can continue her work six miles beyond the limit of visibility of shore signals.

Whilst the ship is slowly steaming in a straight line, soundings are being taken, and officers mark on a chart a series of parallel lines, a quarter of a mile apart, and showing a depth of 10 to 15 fathoms. Beyond these depths deep-sea sounding instruments are used to obtain depths of water up to 100 fathoms.

All soundings are reduced to mean sea-level, and at the end of the season's survey are finally recorded upon a fair chart, which is dispatched by the ship to the hydrographical department of the Navy. The Favé tide-recording machine is laid in estuaries where the ship desires to obtain differences in the times and heights of tidal waves. Great risks were run by European survey-vessels engaged after the war in charting areas where mines still abounded.

The United States survey-ships of the Washington Coast and Geodetic Service in deep sea waters have on board the Sigsbee deep-sea sounding machine, in which is used a shot-weight, a specimen cup for obtaining specimens from the sea-bed, and a submarine thermometer. As soon as the 80lb. shot reaches the ocean-bed, it is automatically released, and the specimen cup and thermometer shot to the surface.

Made to stand enormous pressures, the submarine thermometer is enclosed in a metal jacket attached to a rotating vane. Temperatures on deep sea floors approach freezing point, since they are too far away to be affected by the sun's rays. When the sea-bed is reached, the vane whirls rapidly round, upsets the thermometer and breaks the column of mercury. As it shoots to the surface, reaching the higher water temperature, the excess of the expended mercury in the bulb is secured in a small reservoir. The sea-bed temperature is made known by reading off the length of the mercury column left in the bore.

So accurate is the British hydrographic survey that it is easily possible for a sea-farer, when making landfall, to sound at intervals of 12 minutes, and in an hour determine quite correctly the position of his ship.

The work of mapping coast-lines and taking soundings in the nearby waters is divided among expert surveyors, who first find a base line, and then fix by means of angles a series of positions, far apart, from and to which other angles are measured to fix other stations. These are the main stations or corners of the "triangulation," as it is called; and built upon this framework is a plot-work of secondary stations. Each surveyor plots these points on a field-board, from which they are later transferred to the finished chart.

The base-line is obtained in several ways. Two shore stations, visible from each other, are chosen, with the ship midway between them. At a given signal, a flag is mastheaded and dipped from the ship's truck, and observations of the ship's position are simultaneously made by theodolites and a micrometer or sextant at the shore stations. Another way is to fire guns alternately from both ends of the base line on shore when the ship dips her flags. Observers record the distance by counting the interval of seconds between flash and report.

Vigilant light-keepers flashing sun-signals across the

100—150 miles often separating observation stations are a striking feature of the U.S. Coast and Geodetic Surveys. They have to keep their lights directed towards the observers, for which purpose they carry heliotropes—mirrors reflecting the sun in any direction by day—and electric and acetylene lamps by night. High above trees and houses soar lofty towers to ensure for the observer a clear view of many miles across country. Watch has also to be kept on the vagaries of the earth itself, whose slight wobbling as it rotates on its axis causes variations of latitude in different places.

Some of the problems which face hydrographers in tropical waters would dumbfound a landsman. No survey-ship, for example, can land a crew on long stretches of the low, wooded coast-line of the negro republic of Liberia, for the purpose of choosing a "zero" or prominent object from which to measure all other angles. The problem to be solved was how to chart the coastal waters and shores from the ship. The British Admiralty hydrographers accomplished this by dropping floating beacons into the sea, so as to form equidistant triangles, and then selecting observation posts 60 miles away from the spot to be surveyed.

Farther south, towards the Equator, where the prevailing winds and currents threatened to smash the ship (if she tried to anchor) on a lee shore in a savage, inhospitable African region, a rapid survey of the coast was carried out by the ship under way, with three observers in her foretop. Four other observers with theodolites landed and toiled through the dense jungle to stations four miles apart, two of the stations being visible from each other. The ship steamed from point to point, whilst her foretop was "shot" by the theodolites ashore at successive stations.

At a first rapid survey of unknown regions abounding in volcanic peaks and islands, the same ship fixed two theodolite stations on low hills near the sea, and distant from each other. The angles to the distant peaks were measured from these, and the ship steamed from place to place in the group, fixing herself on these peaks, and obtaining third shots to third points. She also took observations of intermediate points for the purpose of laying down details of the islands and plotting soundings.

On foreign shores, the British nautical surveyor builds stone cairns on cliffs and headlands, sets up a tripod of stakes as a mark, or white-washed spots on capes. He may also tie canvas to the boughs of trees for the same purpose in the dense bush or mangrove swamps of equatorial coast lines. Many miles of waters off flat shores are sounded by boats' crews, who use as a marker a flagstaff flying neutral emblems. Flags of national significance, when flown by survey-ships engaged on this duty, have been known to cause trouble.

Meanwhile, a shore party is landed for the purpose of making a topographic survey. The surveyors ashore have to walk over every inch of land, and use a boat only to round cliffs and headlands or make stations from which to "shoot" up the ship or coast by theodolites. One of the shore party has to wade through swamps and find out, by questioning the natives, if the marshes in the rainy season break their bounds and to what extent.

In savage lands, too thick with bush and jungle to walk over, the country is sketched from the ship, stations being made on board, and sketches drawn at each station. Angles are then measured from the ship to hill-spurs, peaks and ravines, while the officer who has to map the coast-line, sketches river entrances.

Here, the heliostat or sun-signal-mirror, mounted on *gimbals, plays a great part.* Small beacons are set up ashore, and an officer at a theodolite station, hidden behind foliage, or on the side of a hill, flashes the mirror towards the observer, who can detect the flash from a long distance, and has to take angles to its position. Galton's *sun-signal, used for this purpose by modern survey-ships,* is fitted with a telescope by looking through which and adjusting the mirror, a dim image of the sun is seen covering the object to which the flash is directed.

Soundings and surveys of currents and tides are a very difficult part of the ship's work. A nautical surveyor must have a keen eye to read the signs of danger on the face of waters. A ripple on the surface of a tideway in calm weather is a warning of the presence of a dangerous submerged rock upstream quite close to the nucleus of the ripple. Birds hovering over the water, fish suddenly springing into the air, or discoloured patches of sea, tell the mariner of neighbouring shoals on which his ship may unwittingly drive. Kelp, too, grows on nearly every rocky bottom, and no ship will pass it by until the sea has been sounded, and if the kelp streams level with the water, showing that it is growing attached to the rock, the ship gives a wide berth to the danger zone. In the ship's foretop, stands a man on the watch for reefs which are prolonged under water by narrow, shoal ridges. On the chart itself, these obstructions are called "Vigias." All rocky points likely to be rounded by a ship are narrowly examined, and breakers are steamed round as closely as prudent, so as to discover the danger-line beyond which no ship must pass. If the coast is unknown and of certain geological formations, the survey-ship has to sound long and oft before it can be sure that no stray rocks have been missed. Divers even may have to be sent down to examine the floor of the ocean.

In the brilliant sunshine of tropical seas, where coral banks abound, the survey-ship has constantly to test the reputation of channels alleged to be safe for deep-draft ships, since, though under-water coral shines in strong light, a steamer may pass within a mile and with only three fathoms of water under her keel and not detect the coral from her masthead.

A "submarine sentry," towed at 40 fathoms depth, may save many hours of hunting by revealing unsuspected banks and shoals. The submarine sentry is merely a sinker (or sentry) attached to a stout wire. If it strikes the bottom, owing to the water becoming shallower, it at once frees itself and rises to the surface, sounding an alarm on board the survey-ship. It was recently used by British survey-ships for discovering safe channels inside the Great Barrier reef off the coast of Queensland, Australia.

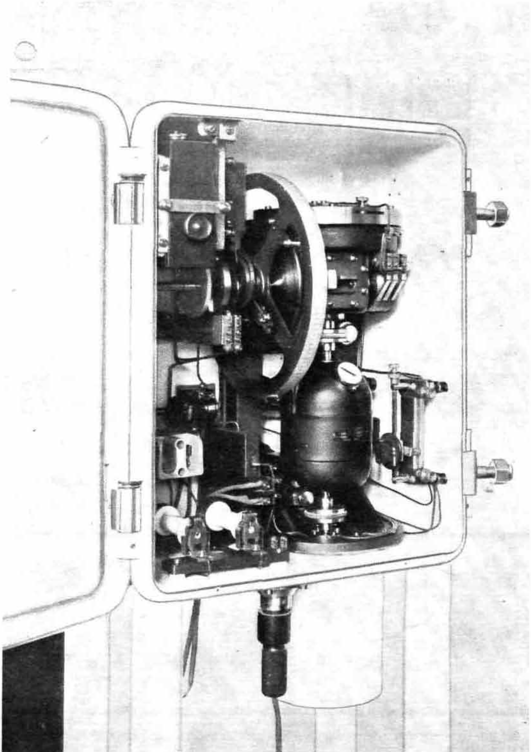
The U.S. Coast and Geodetic Survey uses the "wire drag" in searching for submerged ledges and pinnacle rocks in dangerous waters. The drag is suspended horizontally, in any desired depth of water, by vertical wires leading up to buoys on the surface. It may vary in length from 200 feet to nearly five miles, and is towed through the sea by launches which sweep an area of water at the depth to which the drag is set. If a rock, sand-bar, or wreck hits the drag as it is towed along, a horizontal wire catches the obstruction and a buoy bobs up from the water to show the danger zone.

A remarkable war-invention which may revolutionise deep-sea surveying is the hydrophone. During the bombardment of the German batteries mounted on the Belgian coast, the British monitors made use of the hydrophone to warn shore authorities of their own position. All they did was to drop a depth-charge and their position could be fixed in the darkest night or densest fog, by means of the sub-aqueous sound-waves transmitted to the shore through the hydrophone. Explosions caused by mines, torpedoes and submarines, far out at sea, were thus instantly located and an armed ship sent to investigate the cause.

The sound of the explosion travelling through the water reached a number of hydrophones whose position was known, and the difference between the times at which the shock arrived at the hydrophones was recorded photographically by a shore galvanometer connected by cable to the hydrophones. Sound travels at 4,900 feet per second through water, and about 1,100 feet per second through air, so that even the swiftest current of water does not greatly divert the sound.

A ship approaching land in thick fog may similarly ascertain her position by throwing a grenade into the sea and sending out a radio message. A recorder at the shore receiving-station immediately registers the radio signal, and next receives the sound-wave of the explosion. If two receiving-stations are on shore, their respective distances enables the pilot to determine the exact position of his ship, since radiogoniometric measurements and wireless directional finders are found to vary in accuracy by day and night, and according to wave-length emitted.

The hydrophone and sound transmitter for deep-sea surveying, as used by the British Admiralty, measures the depth of water under the ship by the time a sound-wave takes to travel from ship to sea-bottom and return as an echo. A blow from a spring-driven hammer on a



BRITISH ADMIRALTY HYDROPHONE FOR SOUNDING DEEP SEAS.
(OPEN DOOR OF RECEIVER.)

Photo by courtesy of the Secretary to the Admiralty, S.W.1.

To face page 155.

metal diaphragm in contact with the water spreads the sound-wave. The hammer is set moving by an electrical transmitter switch, which causes it to strike the diaphragm three times per second.

A man with a telephone receiver strapped to his head listens for the returning echo, which is picked up by the hydrophone fixed on the ship's hull opposite to the transmitter. The hydrophone itself is simply a diaphragm and microphone which are set in vibration by the echoes, and the depth of water is read off on a circular scale, whose hand is controlled by a rotating telephone switch.

Nautical surveyors to-day find they can fix the position of buoys out of sight of land more quickly and accurately by using the hydrophone than by taking observations of the star-dome. These buoys may be part of a peace-time survey or in war may be used for the accurate laying of minefields. In foreign seas, the hydrographical ship of the modern navy now carries a portable sound-ranging set, a dozen small hydrophones and 30 miles of light cable.

Day and night along the great trans-Atlantic steamship lanes, U.S. coastguard cutters, attached to the International Hydrographical Service, keep watch for icebergs and icefields drifted southwards by the Labrador current in April, May and June. They send out daily by radio warnings of the whereabouts and limits of the dreaded floes which have sent the "Titanic" and many another liner to their doom. At night-time, their three anti-collision lights of green and white gleaming from the masthead, signal "all's well" to the navigator on the bridge of the liner passing westward along the fairway to Sandy Hook Lighthouse.

Let the reader picture to himself and herself what the phrase "visibility is bad"—so familiar to airmen on

Channel crossings—means to the navigator on the Atlantic steam lane at certain times of the year, and he or she will then gain a vivid impression of the value of the work quietly done by these coastguard survey cutters.

A mournful wail, muffled in a blinding, white fog, which has closed down on the deep waters, drones from the syren of the magnificent Atlantic liner, groping her way at dead slow speed along the great steam "lane." Half an hour ago, a myriad electric rays glittered fairy-like from her many port-holes across the foam of the night waters sleeping untroubled under the calm, clear light of the eternal stars. Then, the liner ran into a belt of mist which wiped out the stars and left the anxious look-out on her bridge to strain his tired, red-rimmed eyes into the bank of fog ahead of her bows. His brain and nerves are on the alert for a terrible danger.

The wail of the syren drifts into and is lost in the fog, and the look-out relaxes his tense grip on the handle of the ship's telegraph, when suddenly the warning drone of the syren is strangely echoed from a spot seemingly a few hundred yards ahead in the blinding vapour. The steersman's face is electric in its response, he moves a handle frantically, and far down in the bowels of the great ship a gong clangs out its imperative signal to the engineer to reverse the engines.

The blades of the whirling screws stop their revolutions, then start again and churn up the water, the liner gliding slowly and now more rapidly astern from the direction of the echo. Saved from a repetition of the appalling disaster which, 13 years ago, sent the hapless "Titanic," with her many valuable lives and £1,250,000 worth of bullion and jewellery, to the bottom in over 4,000 fathoms of water!

The former liner had been warned by a wireless message, flashed by one of the little steamers attached to the International Ice Vigil and Patrol Service, to keep a sharp lookout for icebergs which had been seen in this part of the ocean. Two gallant little steamboats, the coastguard cutters "Tampa" and "Medoc," keep vigilant watch from March to the end of June for icebergs and field ice floating near the trans-Atlantic steamship lane. Their beneficent work, making the sea safer for ships, is regulated by the International Convention for the Safety of Life at Sea. The two patrolling steamers have to find out the southern, eastern and western limits of the ice, and wireless daily messages, in 75th meridian time, telling of the movements and whereabouts of bergs.

In April, May and June, when the polar ice sheets break up in the Arctic regions and are drifted south in great frozen expanses, sometimes from 10 to 40 miles wide, they enter the Labrador current and are floated further south into the Atlantic as vast icebergs, glittering in diamond pinnacles of splendour, should the rare sun-rays slant down on their fantastic summits. They may affect climate, appreciably, in the temperate regions of America, by altering the temperature of the ocean currents and the distribution of the atmospheric pressure. The fishermen's catch of fish, large or small, off the New England and Newfoundland coasts, may also be decided by the size or drift of the floating icebergs.

The ice-patrol radios its report of the movements and locality of the icebergs to the American Hydrographic Bureau at Washington, D.C., and the American naval authorities in their turn broadcast these warnings daily from five ports on the Eastern seaboard, whence they are picked up by incoming and outgoing trans-Atlantic steamers.

In 1925-6 a remarkable mechanical device, called the "Sonic Depth Finder," came into use on the U.S. patrol steamers to determine the presence of icebergs. The Sonic depth finder, of which a photograph is here reproduced showing it at work, is an electrical apparatus corresponding to our British Admiralty's hydrophone and echo-transmitter, exhibited at last year's British Empire Exhibition. It finds the depth of the sea at any particular spot by measuring the time taken for a sound to travel from the ship's keel to the bottom of the ocean and then return as an echo, which is heard on a telephone in the operators' room.

It seems a paradox to say that *heat* radiated from icebergs in mid-Atlantic is also used to warn ships of their proximity; yet it is a fact that a new device, known as the "radio-micrometer," not only enables a liner to detect the insidious approach of this danger to life and navigation, but even indicates the size and distance of the berg.

On the approaching ship, a thermopile (or electric battery for registering small quantities of radiant heat), enclosed in a vacuum tube and placed in the focus of a reflector, picks up the waves of radiant energy coming from the iceberg. These heat waves are registered upon a galvanometer of extreme delicacy, and by the strength of the current you may know both the size and nearness of the iceberg to the ship. It is stated that tests have shown that this sensitive apparatus can detect heat radiations from the funnels of a liner six or seven miles away.

It has been left to an American scientist, Dr. George W. Littlehales, hydrographic engineer, of the U.S.

Hydrographic Office, Navy Department, Washington, D.C., to make a remarkable discovery in aid of safer navigation. "H.O. No. 203. The Summer Line of Position furnished ready to Lay Down upon the Chart by means of Simultaneous Hour Angle and Azimuth Celestial Bodies," is its cryptic description in the American naval archives. The doctor made over a million calculations before he perfected this wonderful device which enables the sailor to find his reckoning at sea with a single calculation in three minutes, where a page of figures and half an hour's hard work would usually be needed.

Every U.S. survey-ship is now equipped with the Sonic Depth Finder of Dr. Harvey C. Hayes, the U.S. Navy's research physicist. A few months ago, a War Department cable ship steamed into New York harbour with a thousand miles of cable on board. She reported that, with the help of two U.S. destroyers, who made surveys, she laid a cable over a submarine mountain 4,500 feet high in ocean bottoms whose every hollow had been sounded by the Sonic depth finder. This had been done at a greatly reduced cost by halving the amount of slack or loose cable paid out to lessen tension on the sea-bed.

The Sonic depth finder is built to stand rough sea-wear. Its sounder emits an electrically regulated sound which penetrates the ocean, and the operator regulates the time between each impulse and its successor so as to accord exactly with the time of the returning echo. The human ear can detect a time difference of one-two hundred thousandth of a second, and the Sonic depth finder has a possible error of only four feet in a mile of water. Research is being made to perfect a practical automatic recorder for this instrument, but, at present, any discrepancy in time between the repeated sound and the returning echo is corrected by a re-echo of the original sound, which enlarges the time-gap and finds and corrects the error.

Some other noteworthy devices operated by the U.S. Coast and Hydrographic Survey include a portable automatic tide gauge, ten inches square, and equal to larger instruments in speed and accuracy; an automatic current meter, which for two weeks without attention photographs half-hourly records of ocean currents at a depth of 400 meters or less; and the Wenner apparatus used on board the U.S. ice patrol cutter "Tampa," for finding the salinity of sea-water by measuring its electrical conductivity.

The landsman will be surprised to hear that scientists to-day hold the opinion that currents are caused, not by the wind so much as by differences in weight, temperature and salinity of ocean waters. The U.S. Bureau of Standards is said to have perfected an electrical salinometer which measures saltness to the fourth decimal place as the meter is dragged through the water in the ship's wake. Another proposed thermometer will automatically record depth and temperature on a chart.

When Jason and his band of heroes and demi-gods sailed the Argo across the Ægean main to capture the Golden Fleece hung on an oak-tree in the grove of Mars, he sowed the dragon's teeth from which sprang war and armed men. But when the British and American Governments send out oceanographical expeditions they are in the cause of peace and the welfare of all the nations of the world. The man in crowded city or on the farm is as vitally concerned in these deep-sea quests as the skipper of a fishing trawler or the navigator of a trans-oceanic liner.

"Farming on the land," recently said Dr. Slosson, U.S. Director of Science Service, "is limited to one single surface. You have in the ocean farms piled on farms, 500 feet of them," like skyscrapers. Some day, when the populations on land outgrow the food capacity of the fields and farms, an intensive cultivation of the sea may save the human race. At present we use only a few sea fishes for food and we know very little of them.

Here are some of the riddles which the up-to-date survey and oceanographical expeditionary ship will try to solve. They have baffled the wisest oceanographers for years past.

How do the contours of the ocean-bottoms affect weather cycles?

Where are the centres of submarine volcanism which cause great earthquakes on land, and produce vanishing islands sending out tidal waves? What really governs the movements of fish, causing abundance one year or shutting fish factories down the next year, and how can fishing be made less a gamble with the unknown? Why does the wind, when one ascends, blow faster at a certain area of the atmosphere than either above or below that area? Does that happen on the ocean; if so, is it conditioned differently in varying latitudes? Does the great quantity of mud yearly deposited by the Mississippi in the Gulf of Mexico cause earthquakes from Mexico to Costa Rica by overweighting the sea-floor and so disturbing the equilibrium of the land? What are the facts about the fields of static* (radio-silent areas) throughout the

* See Chapter V for theory of origin of "static" in radio.

world and over the oceans which interfere with the propagation of radio-magnetic waves, and what causes interference between radio high-powered stations?

CHAPTER VIII

HUMAN FLASHLIGHTS UNDERGROUND AND A CONTRAST

THE "DEADMAN'S HANDLE" IN THE ELECTRIC TUNNEL—FLYING JUNCTIONS—THE BRAIN OF THE UNDERGROUND—MINIATURE BUT VERY REAL—ROMAN ROAD ENGINEERING DEVICE—LITTLE LOCOMOTIVES AND HEAVY GRADIENTS—MODERN RAILWAY MARVELS

DEEP down under the streets of a great city there is a roaring of air and a clanging of steel doors, and the lurid glare of electric lamps lights up the white faces and grimy overalls of men who are crawling under the rings of a tunnel to the shaft-head of new workings. They enter the brilliantly illuminated interior of a great cylinder forming part of a remarkable mechanical device called the "Greathead Shield," after the name of its inventor, an English engineer. This shield has superseded the more costly system of timber supports, which characterises mining operations in loose ground. Hydraulic jacks are placed close to this cylinder or "skin" as it is styled, and parallel to the axis or line of the tunnel.

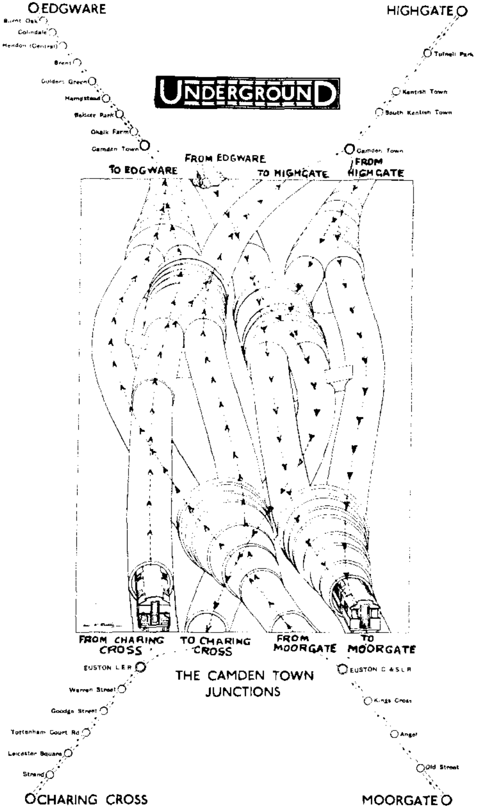
A strident, grinding noise comes to you from the front of the shield, where the resistless cutting-edges are boring through the earth. Men are here at work under an air pressure higher than that of the atmosphere above ground, since an inrush of water has to be held at bay and kept from flooding the tunnel. The shield has to cover the excavation made by its boring-edge until a permanent lining can be erected for the new tunnel.

Suddenly, an engineer, looking like Vulcan fresh from Etna, signals that a length ahead of the shield equal to the width of one ring of the tunnel has been excavated by the cutters. The powerful jacks come into play, pushing the shield forward; then the plungers recede into the cylinders and a clear space is left for the erection of a new lining in the tail of the shield. Thus, ring by ring, is a new tunnel built until completion.

Tunnelling in compressed air in the bowels of the earth is attended by the same dangers for the workers as diving in the depths of the sea to raise a sunken liner. In each case, nitrogen bubbles tend to form in the bodily tissues and to be absorbed into their fluids, and the danger of rupture or lesions can be overcome only by careful decompression in stages. No man working in compressed air, either in England or America, is allowed to go into the normal air until he has spent some time in successive locked chambers, for decompression. The first day underground for the novice is rather terrifying; the air roars past him, heavy steel doors clang behind him, and there is a disagreeable sensation of blocked ears and eyes. If, however, he takes the necessary precautions, he need not fear the dreaded compressed air sickness.

The whole system of compressed-air tunnelling depends upon the fact that every foot in the height of water exerts a pressure of 0.434lb. per square inch, and that the introduction of air underground or undersea at a pressure corresponding to that exerted by the water will hold it in check.

All this boring and delving in the bowels of London is



"FLYING" OR BURROWING JUNCTIONS ON "UNDERGROUND."

Photo by courtesy of London Underground Railways.

To face page 165.

directed towards modernising the oldest underground electric or "tube" railway in the world—the City and South London, dating from 1890—and linking it up to more up-to-date electric subway systems. Junctions had to be made with two other underground lines at Camden Town, London, and none of these lines could be crossed on the level because of the density of the traffic. Moreover, the intricate mechanical operations necessary were restricted to a dead period of four to five hours after midnight. The diagram reproduced shows how this was done by the device of "burrowing" or flying junctions which took 17 months to make.

* * * * * *

A horn sounds in the tunnel, and a flying train of electric coaches swings round a bend in the line, at a rate of 35 miles an hour. Inside the engineers' cabin a man grips a master-control lever as he sees a bright patch of light ahead along the tube, denoting the proximity of a station or dépôt. His face turns pale, there is a ringing in his ears and dizziness in his head. Nerveless hands slip from the control handle and he collapses in a faint on the floor of the cabin. No one is in control of the train, and death is at the head! Behind are swaying coaches crowded with business folk returning home from the day's work. A short section in front is another train equally crowded. One shudders as one visualises the appalling crash, and hears the screams of the injured, the groans of the dying below ground! Ah, there is a jar and a hissing under the bed of the train! A drum switch has come into operation, cutting off the current from the solenoids of the motor, and opening all the main contactors on the train. The air is exhausted from the Westinghouse brakes, and the train pulls up in safety—rescued by a wonderful device known as "the deadman's handle," *which no normal driver in motion must let go!*

* * * * * *

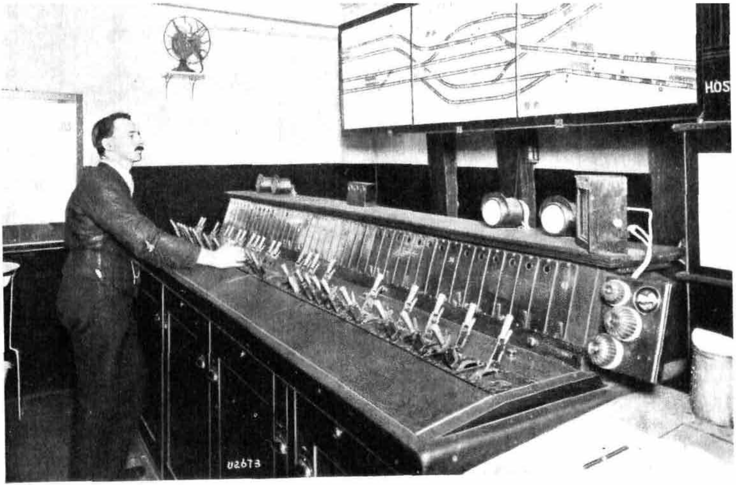
The brain of the underground electric system is its signal-box or cabin from which both switches and signals are controlled. Movable discs on an illuminated diagram (as in *the picture here reproduced) show the signalman the state* of the lines in his neighbourhood, and the destination of each train approaching his cabin. He can thus give it the required path, and he is in telephonic communication with the junctions should an accident occur or emergency require it.

* * * * * *

Contrast is the salt of realism, as it is of popular journalism, so our reader may care to put side by side with the nerve tension and perpetual comparative gloom of the life and labour of underground workers on London's electric railways, the quaintness and romance of the life of an engineer working on what is the world's smallest railway, high up in the wild hills of Cumberland.

Far away from the hurly-burly of crowded cities, in a romantic setting of wild and rugged moorland fells, and deep wooded ravines, or ghylls, down which foam musically rushing mountain streams where silvery salmon leap and flash in the pools, is this "world's smallest railroad"—*The Ravenglass and Eskdale,* of Cumberland, England.

It has a gauge of 15 inches, a length of 7.2 miles, and a picturesque history. Forty years ago, this miniature railroad had a much wider gauge, but failed to pay its way, and for a long time lay derelict, overgrown with grass and weed, its bridges and track falling in decay.



LUMINOUS TRACK CHART IN "UNDERGROUND" SIGNAL CABIN.

Photo by courtesy of London Underground Railways.

To face page 166.

The hematite iron ore which it had carried from mines in the Cumbrian mountains had lost place in favour of basic steel.

Then, in 1917, a company, known as The Narrow Gauge Railroad Ltd., took it over and put on its metals a number of miniature "Pacific" 15 inch gauge locomotives, shown in the accompanying photographs. Its popularity was assured, and from that day it has carried thousands of visitors to the Lake District.

There is a future before these miniature railroads, especially in view of the heavy wear and tear of the main roads by the smashing impact of motor vehicles, carrying loads fit only for a railroad track. It is possible that, in years to come, so far from the motor supplanting the steam locomotive, miniature railroads may be constructed to act as traffic feeders to the main roads and railroads.

The Romans, who built a magnificent scheme of military roads and causeways radiating all over the empire of the Cæsars, were not so foolish as to allow them to be smashed to pieces by unduly heavy traffic. On these roads, which are still in use in twentieth century England and march straight up hill and down dale, the Roman engineers laid sets of smooth stone blocks, dead in the centre, and parallel to the length of the causeway, so that great weights and burdens could be hauled with ease, and without fracturing the road surface. But to return to our midget railway——!

Thousands of sea-gulls, wailing and flashing their white wings in the sunlight across the estuary, speed the small train on its way from Ravenglass. This little port was established by the Romans as a point of embarkation for the stone used by the Emperor Hadrian when, 1800 years ago, he built the famous military wall whereby he vainly hoped to hold back hordes of bandit Picts and Scots from the rich country of Britain.

The Ravenglass and Eskdale Railroad runs along the river Mite, through Miterdale, and climbs the side of a granite range of hills, riven with deep, wooded ghylls and waterfalls, and flanked by precipitous "screes" of loose stones, falling a thousand feet sheer to the water. One is now deep in the heart of Wordsworth's country, with its lonely tarns, whose calm waters mirror blue skies, and its "shouting echoes."

It is not passengers, alone, who are borne up these dales and hills, for this little railroad taps quarries, and carries mails and coal to people living near its little stations, one of which is 200 feet above sea level. Its recent 15 inch "Pacific" type of locomotive (4—6—2) can haul a five ton train with ease up steep gradients and not require re-firing.

The grades of the line are severe and the work these model engines accomplish is much greater in proportion than that performed by the most powerful engines of the normal gauge. Trains upwards of five times the weight of the engine are hauled up grades of 1 in 37, whereas the heaviest load hauled on the main line in England is about five times the weight of the locomotive up a grade of 1 in 60.

The line rises over 200 feet from sea level, and the weight lifted in transit from Ravenglass to Dalegarth involves an expenditure of considerable horse power, in addition to the work done in hauling the train the seven mile journey.

* * * * * *

How many people know that a railway has actually been laid across an icebound lake for a distance of 30—40

"PACIFIC," MINIATURE PASSENGER ENGINE GETTING UP STEAM.
Photo by courtesy of Chief Engineer, Ravenglass and Eskdale Railway.

EXCURSION DAY AT RAVENGLASS.
Photo by courtesy of Chief Engineer, Ravenglass and Eskdale Railway.

To face page 168.

miles with no other support for the track than ice from 15 inches to a yard and a half thick?

This was done during the Russo-Japanese War, when a broad-gauge railroad was built across Lake Baikal in Central Siberia, for about 40 miles on the ice. In some places, volcanic springs bubbling beneath the yard thick ice caused the ice to thaw so much that several troop trains laden with stores and soldiers crashed through the thinned ice to the bottom. One of these engines was later salved from the bed of the lake and is now hauling trains between Leningrad and Sestroyeski. On its boiler it has a plate bearing its name, "Baikal," and telling of its adventures on the ice. It is considered by engineers that ice from 8—10 inches thick is capable of sustaining the weight of guns of ordinary calibre, or of a light railway. Indeed, at Leningrad, when the water at the mouth of the Neva freezes to a depth of 15 inches, in the winter, a line of rails is laid down for the city's tramcars to pass over.

* * * * * *

As these words are being written, trains are crawling through 34 tunnels, deep in the gorge of a famous pass in Northern India, where, not many years ago, camel trains bound for the highlands of Afghanistan and the plains of Persia, ran the gauntlet of a bloodthirsty and turbulent pack of tribesmen, who did not entertain all the respect one might have expected for the benefits of civilisation. Though it is said that these suspicious tribesmen have lost their ill-will towards the idea of the intrusion of a railway into their mountain fastnesses and have even lent labourers to help in the making of the line, yet the stations are so constructed that, at a pinch, they can be turned into fortresses bristling with guns.

This railway on the outpost of the British Empire ranks as one of the greatest feats in the history of railway engineering in India. It has taken five years to construct the Khyber Pass Railway with its 27 miles of metals, its 34 tunnels, 12 big girder bridges, 74 arch bridges of one span and three road bridges. The imagination is impressed by this railway crawling along the gutter of the roof of the world—one of the oldest trade routes of history, through which thundered Alexander's Macedonian legions rushing on to the conquest of the burning plains of Indus. The rugged spirit of the pass has taken its toll of the brawn and brain of the daring mechanical invaders of its sanctity—think what a tunnel to every mile meant in the making of this £2,000,000 railroad into the wilderness!

CHAPTER IX

MAKING THE EARTH WORK

THE GYROSCOPE AND TERRESTRIAL ICE AGES—WHAT IS THE GYROSCOPE AND HOW DOES IT WORK?—HOW THE GYROSCOPE HELPED TO WIN THE BATTLE OF THE FALKLAND ISLANDS—GYRO WARNS SHIPS OF DANGEROUSLY LOW DEPTHS—PROBABLE BIG GUNS AND SMALL GYRO NAVIES OF THE FUTURE—SAVING THE AVIATOR LOST IN A FOG—RUSSIAN SCIENTIST'S GYRO-TRAIN ON ONE RAIL—CYCLONES AND THE GYROSCOPE—STRANGE POWERS OF TORSION BALANCE—"X RAYING" THE EARTH TO FIND UNSEEN OIL AND MINERALS

THE child who watches a spinning top may not reflect on the fact that his rotating toy obeys a fundamental law of the universe which binds the turning earth to the sun, rules the motion of other universes on the confines of the star dome, and has a human-like perversity apparently in conflict with the Newtonian laws of motion.

If the theory of modern scientists is correct, the movements of electrons in infinitely small particles of matter consist of gyroscopic rotations much like those of the planets on their orbits round the sun. Light, too, is thrown on another terrestrial riddle. The great ice ages of the earth, whose origin has long baffled geologists, may have been largely due to gyroscopic "precessions" or changes in the direction of the axis of the rotating earth, causing it to "wobble" like a top slackening in its spin, and resulting in varying angular motion.

The simplest form of a gyroscope is a child's top. It is well known that if one takes a blunt tipped top and spins it, it is a difficult matter to make it wobble. If one tries to make it take a slanting position, when spinning, it quickly rises to the vertical position it had at the beginning of the spin. On the other hand, a sharp-pointed top, when spun, will wobble, if disturbed in its rotation, so that its upper part appears to trace a circle in the air.

One of the earliest uses of the gyroscope by a modern scientist was by the French academician Foucault, who in the middle of the nineteenth century devised a revolving ring or disc which he used to demonstrate the earth's daily rotation on its two axes, the north and south poles, by comparison with the stability in space of the direction in which the axle of the revolving disc pointed. He called the rotating disc a "gyro," a term derived from the Greek γῦρόω, "revolving in a circle."

The mechanical gyroscope, with which we are here concerned, is a high-speed rotating disc, which, when turning on an axle, allowing it to move freely in several directions, resists attempts to change the direction of its axis or spin. Its peculiar powers will cause a train to run at high speed on one rail across a gulf bridged by steel rope-rail; stabilise a rolling ship in a heavy sea; guide the sailor and aviator in fog and darkness; help the gunner on the turret of a modern battleship to train his ordnance on an elusive target. The true type of the gyroscope is the earth, which has been rotating on its axis ever since it was thrown off the sun countless ages ago.

A mechanical gyroscope is constructed as a two-frame or three-frame instrument, the frame consisting of gimbal rings which allow the rotating gyroscope two or three degrees of freedom, that is to say, leave it free to move in two or three ways. The axle of the gyroscope is attached to the innermost ring or gimbal, and when the gyroscope is spun, remarkable mechanical properties are displayed.

If we take such a swiftly moving and polished metal disc with the three gimbal rings, and spin the disc swiftly, the rotating disc, as we said above, has the peculiar property of maintaining the direction of its axis or spin, no matter how suddenly we change that of the handle by which we hold the disc and its attached rings. Let the rings be tapped, and the experimenter will notice a distinct resistance of both rings* to the pressure he exerts. If he puts a greater pressure on one of the rings he will at once see that the three-frame gyroscope has a mechanical system which seems to conflict with the second of the Newtonian laws of motion, since pressure on one of its gimbal rings does not move the ring forward in the line of direction of the pressure. The gyroscope resists the pressure and changes the direction of its spins; or, put in another way, it transfers its axis of rotation to a plane perpendicular to that in which it might be expected to rotate. We may say, then, that a spinning gyroscope tends to maintain its direction (or plane) of rotation immovable in space, and only pressure or friction will make it wobble or waver in its spinning. This peculiarity has important results when the gyroscope is applied to the working of the torpedo and military and naval gunnery.

* Both movable rings (or frames) of a three-framed gyroscope are *interdependent parts of the gyroscope's mechanism.* Pressure on the first ring moves the second or outer ring, in a direction at right angles to the line of pressure. Pressure on the second ring similarly moves the first ring.

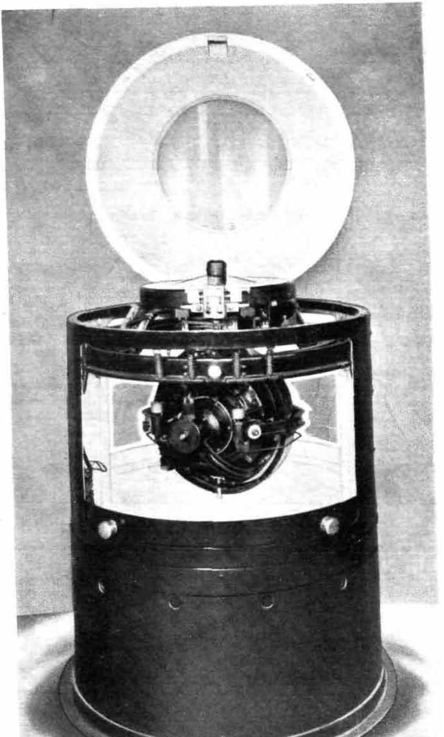
When Columbus sailed for the New World, he carried aboard his wooden flag-ship, the "Santa Maria," a magnetic compass which fairly accurately pointed to the magnetic north; but to-day the battleship or the trans-Atlantic liner, built of huge masses of steel and iron, cannot rely altogether on its magnetic compass, which is liable to deviation caused by the influence of the earth's magnetic field on the iron of the moving ship.

The modern navigator calls in to his aid the gyro-compass. This wonderful instrument is an application of the fact that a spinning gyroscope to which a weight is hung will, under the combined influences of gravity and the rotation of the earth, point to the *geographic* north-south, and spin in the same direction as the earth.

To-day, every officer who aspires to promotion in the British Navy and mercantile marine has to keep himself abreast of gyro-compass developments, and especially of that invented by Elmer A. Sperry, and first installed on the U.S. battleship "Delaware."

The nerve-centre of the Sperry gyro-compass is a master-compass, placed near the ship's centre line, where rolling is felt the least. Essentially, the Sperry gyro-compass is a three-frame gyroscope, the peculiarity of whose mechanical system is that it is not interfered with by the movement of the body (in this case, the ship) to which it is attached. A motor generator, worked by the ship's dynamos, runs the gyroscope in the master-compass, which is controlled from a switchboard.

A special electrical transmitter, controlled by the master-compass, shows on "repeater" compasses, placed in any part of the ship, the exact reading of the master-compass, in the same way that public clocks are synchronised from a central station. The dial of the repeater is lit by an



LINER'S MASTER GYRO COMPASS.

Photo by courtesy of Sperry Gyro Company.

To face page 174.

electric bulb, within its case. If the ship's dynamos should fail, storage batteries operate the gyroscope.

The gyro-compass also records the exact course steered by a vessel. This is done by a recording-compass connected to electrical circuits and following the movements of the master-compass. Radial lines drawn on a chart, shown, graphically record the ship's course, since the dial on which the chart is mounted revolves with the master-compass, bringing a marking-pointer into action, on the chart. Concentric circles on the chart represent five minutes by each small division, and one hour by each large division. The pointer starts at the inner edge of the chart, and is moved to the outer edge by clockwork.

The chart here shown records the interesting fact that a radio call was received from a burning oil tanker, to whose aid the ship at once proceeded, changing her course. A few minutes later, it will be noticed that the ship reverted to her original course, for another radio call came from the tanker notifying the putting-out of the fire.

By the recording compass it is also possible to tell how efficiently the helmsman handles the ship, and uses the steam steering gear.

Another remarkable type of gyro-compass is that invented by Dr. Anschütz Kaempfe, and used on German warships during the Great War. The Anschütz compass is a gyroscope with two degrees of freedom, which floats in mercury, and rotates in a bowl of hydrogen forced in under pressure.

It must be said that the axis of the gyro-compass points to the true geographic north only on the equator, and this is due to the fact that, although the earth rotates at a uniform speed, the angular velocity, or rate of rotation, at the equator is about 24,000 miles in 24 hours, but at latitude 60° only about 12,000 miles. This causes the gyroscope's axis to "precess" or wobble, like a spinning top. The consequent error in direction is compensated, in modern gyro-compass patterns, by a "lubber-line" which is automatically shifted, according to the ship's latitude, by two graduated dials set to correspond with the latitude and the ship's speed.

Empire over the waves of a heavy sea, and consequent sea-sickness, has been established by a gyroscope placed amidships. Here the waves themselves are made to stabilise the rolling and pitching ship. The axis of the Sperry gyro-stabiliser spins in a vertical plane, and when the waves hit the ship, the gyro tilts at right angles to the direction of the wave-force, thus neutralising its effect by passing it out at right angles as an equal but opposing force. A pilot gyro controls the main gyro, and sets it working in opposition immediately the beginning of a roll is felt. For stabilising the American steamship "Henderson," of 10,000 tons, a 30 ton gyro wheel was used.

An exceedingly interesting part was played by the gyro-compass in the Great War.

At the time of the battle of Coronel, on the west coast of South America, the British battleship "Invincible" was being overhauled at Devonport Dockyard. She was, by Lord Fisher, immediately ordered, with one other large British ship, to South American waters, under the command of Admiral Sturdee, to re-enforce the British fleet, and then to find and destroy the German ships which had defeated the British at the battle of Coronel. She was ready to leave the docks when it was planned to delay sailing until the ship could be swung and the magnetic compasses compensated. It was decided, however, that although the compasses were badly in need of adjustment, it was necessary to save every minute in order to reach South American waters before the German ships could find and destroy the British ships remaining in these waters.

The "Invincible," therefore, sailed without adjusting her magnetic compasses, and navigated entirely by the Sperry Gyro-Compass from Portsmouth to the Falkland Islands. An azimuth or astronomical observation of fixed, heavenly body and horizon was finally taken and the magnetic compass was found to be out about 22 degrees. The "Invincible" arrived at the Falkland Islands just in time to coal before the German fleet appeared.

Nearly every ship in action at the battle of Jutland was equipped with a gyro-compass, one of which, on the battleship "Lion," worked in a fire so hot that the lead sheathing on the electric cables fused and flowed like water.

During the Great War, attempts were made to launch aerial torpedoes and control them in their flight through the air by a gyroscope, exactly as the Whitehead torpedo is controlled and directed in the water, after being fired from the tube of a destroyer on a target or warship. These attempts were not successful, because the three framed gyroscope used precessed or "wobbled" as it spun, and so did not keep true the course of the aerial torpedo.

How is the torpedo, speeding at a rapid rate through the water towards a doomed ship, kept straight on the centre of its target, and deflection from its course by water currents and other disturbing influences prevented?

The answer is: "By the gyroscope." If, after being fired from the tube of a destroyer, the torpedo tends to leave its set direction corresponding to that decided for it by the rotating gyroscope, four contacts on the frame of the gyro come into action, and at once set special devices to work to steer the torpedo in the right direction.

One peril of uncharted or not recently charted seas is overcome for the navigator by the gyro-log and shoal-water alarm. The "log" is a rotator or revolving screw placed in a vertical tube projecting through the bottom near the centre-line of the ship. Valves are used for the withdrawal of the tube. When water enters the tube, a small propeller records its passage, and an electrical device transmits the measurement to the captain's bridge.

If the ship enters shoal water, a most ingenious alarm and automatic recorder come into play. The ship's propeller speed, as registered by the Sperry electric log, is shown by one of two dials on the bridge, the other dial showing the desired speed in knots. Cams (or toothed wheels) hold two electric contacts at a certain distance apart, under normal deep water conditions. When the ship reaches shallow water, the ratio of speed is changed, the electric contacts close and an alarm bell rings.

Gyroscopes will also show a ship's captain whether he is moving on a straight line or curved course. A two-frame gyroscope is here used, because such an instrument moves in unison with the body to which it is attached, whereas a three-frame gyroscope moves independently of the attached body, such as ship or train.

A telescope mounted on the axis of a gyroscope, placed on a ship's deck, will keep a target in sight however much the ship rolls. This is achieved by the "fixator" which prevents the gyroscope from "precessing," so long as the telescope points to the horizon. If friction in its fork causes the axis of the gyroscope to precess or waver, a slight pressure on the gyro's frames by a skilled observer brings the telescope back to the line of sight from which it has moved.

Naval guns may be trained by means of gyroscopes and stabilised against rolling. The firing and recoil of such guns interfere very little with the spinning of the gyroscope on its cradle pivots. Even on the roughest sea, the gunner can do his work quietly if his chair is fixed to the cradle of the gyro gun. The great difficulty, however, of naval gyro-searchlights and guns is the lack of an electrical steering system which will gyroscopically train the heavy guns and lights on their objectives. Small boats can be stabilised with gyroscopes so that instead of leaning over at an angle of 45° and violently oscillating after the recoil, they merely slighily heel over after firing and at once return to an upright keel.

One of the other wonderful powers of the gyroscope is that, by its aid, a modern artillerist can hit an object out of the direct line of fire, and round a corner miles away, just as surely as a gyroscopically directed torpedo can smash the hull of a doomed ship apparently sheltered by another.

The navies of the future may no longer consist of gigantic dreadnoughts. Their vast iron bulks may be modified by the gyroscope into small ships weaponed with the heaviest ordnance, stabilised and trained on the roughest seas by these swiftly revolving discs.

Commercial aviation is largely dependent on the perfection of the gyroscope. When white fog comes like a ghost upon sea or land, hiding the aviators' beacons and landmarks, he has the *gyro-orthoscope* to show him whether he flies straight or swerves. A pointer on a dial, standing at O, shows that the aeroplane is approximately on a straight course. Deviations of flight to right or left are indicated on a graduated scale, and the least angular movement of the aeroplane causes corresponding movements of the gyroscope.

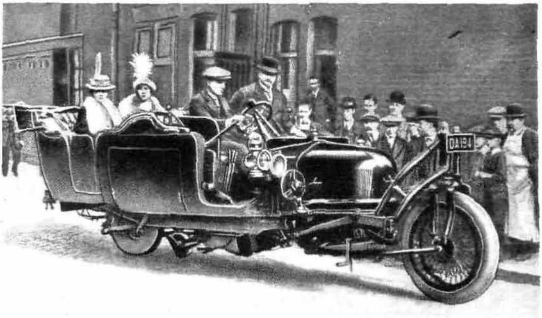
The railways of the future will be very different from those we know to-day. A citizen of a great city in the year 1970 may look up into the sky and see a train running at high speed, not on two rails along costly viaducts and permanent ways, but on a single rail, or even a steel rope spanning the gulfs of air between the sky-scrapers.

In this transformation, mechanism such as that perfected in 1924 by a distinguished Russian engineer, P. P. Schilovsky, may play a great part. He has invented a mono-rail car which is a single gyroscope mounted on a vertical axle, and rotating vertically. Dynamos and motors supply the power rotating the gyroscope. Besides this motion, the gyroscope has a sliding displacement, when the car leans. It causes a ratchet to engage with a rotating cog-wheel attached to the gyroscope's axle, and this restores the equilibrium of the car by hurrying the precession and returning to the vertical position of the gyroscope's axle. Special devices are used for easily rounding sharp curves in the line, and for maintaining equilibrium.

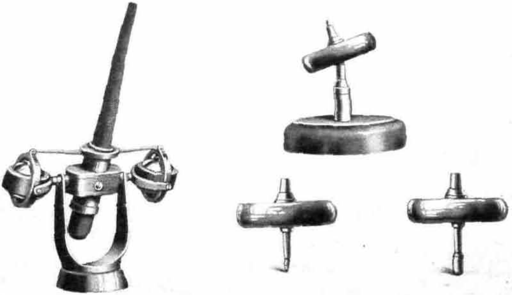
Mr. Schilovsky has evolved a complete system of mono-rail transport, comprising a novel permanent way, bridges built of a single girder carrying one rail, longitudinal sleepers and radio signalling devices.

The mono-rail system halves the length and weight of sleepers which would be needed on an ordinary railroad, and permits a speed of 120 miles an hour. Giant cars have been designed for main line and suburban railroad traffic, capable of carrying 400 people.

Gyro-railways would be useful in hilly districts, since



GYRO MOTOR CAR ON TWO WHEELS, RUNNING IN LONDON.
Photo by courtesy of M. P. P. Schilovsky, the Gyro Car Inventor.



GYRO GUN AND TYPES OF GYROSCOPES. (See pages 172 and 179.)
Photo by courtesy of M. P. P. Schilovsky.

To face page 180.

heavy embankments would not be required, and the cars, carrying double-flanged wheels, can ascend gradients of 1 in 8 as against a maximum of 1 in 20 on the ordinary railroads. As the car rounds a curve, an orthoscope comes into play, the axle of which is connected to a valve controlling a compressed air system. The compressed air enters pneumatic cylinders, and restores the equilibrium of the car.

Mr. Schilovsky, in 1921-2, supervised the construction of 20 miles of a gyro-railroad for the Russian Soviet Government, between Tsarskoe Selo and Petrograd. Seven miles of this mono-railway track were laid, when difficulties of finance and rolling stock temporarily put a stop to the project. The photographs here reproduced were loaned by the courtesy of Mr. Schilovsky.

Honour to whom honour is due, however, for it must not be forgotten that the first inventor of a gyro monorail car was a British citizen, Louis Brennan, an Irish inventor on the staff of the British Air Ministry. He devised a car running on one rail and carrying 40 people. It was shown in action at the Anglo-Japanese Exhibition, in 1913, when it attracted much attention from the lay public as well as from engineers. This heavy car was made to keep its balance, when travelling on a single rail, by two gyroscopes, coupled together, but spinning in opposite directions.

The centre of gravity of the car was placed above the level of the rail, and the car was kept safely balanced on the single rail by the two big swiftly revolving gyroscopes. In practice, however, it was found that the gyroscopes did not keep the car balanced for any length of time. They oscillated or "precessed," and finally overturned the car. Brennan then set to work and evolved an ingenious but complicated system of a liquid pressure valve and compressors to stop the oscillations of the giant tops and restore the wobbling axle to the position it had at the beginning of its revolutions. In the language of the gyroscope, this is technically styled "hurrying up the precession." The car then regained its equilibrium.

Experience showed that Mr. Brennan's gyro car was not perfect. The revolving gyroscopes got overheated owing to friction at their bearings, and the car did not automatically regain its balance on every occasion. The inventor had solved the problem of the gyro mono-railway in a brilliant fashion; but, in a world where everything proceeds by the method of trial and error, he had to give up further experiments because of lack of support from the Government or private individuals. Mr. Brennan found, as have hundreds of inventors before and since, that the English Departments of State prefer to let other nations spend their money on the experimental stages of mechanical inventions, and then, if at all, step in with assistance, like Dr. Johnson's patron, when the inventor has well and firmly established his invention—in the other fellow's country.

The gyroscope has recently been applied in a novel and interesting way to facilitate the continuous filming of an actress in a scene of a photo-play. The cinema operator can by this device dispense with the use of a tripod and can follow the action from room to room, taking a continuous film instead of the usual cuts from scene to scene. A British gyro camera is used and the operator moves about, as he takes the pictures, without imparting swaying and oscillating motions to the photographs. This is impossible with the ordinary cinema camera where the constant movement of the photographer makes his subjects seem to "jump about" the film. Electric batteries *work both the swift gyro, and simultaneously unwind* the film. A slight pressure on a switch starts or stops the working of this gyro camera.

How many thousands of lives and millions of property might be saved, yearly, if there were some means of foretelling the course of cyclones and hurricanes! An American meteorologist, Mr. F. J. Cordeiro, points out that cyclones, which are rotating masses of air whirling in the same direction as the earth's surface, north in the northern hemisphere and south in the southern, possess gyroscopic properties. Some day the gyroscopic laws of their motion will be applied to the prediction of the path of cyclones and tornados.

When the mining prospector of three centuries ago sought to find valuable minerals on the slopes of lonely mountains, he had to run the risk of being burned at the stake or tortured in some dungeon of the Inquisition as a necromancer or professor of the Black Art. He hazarded his life because he used a divining-rod made of forked hazel twig, which, apparently by occult means, twitched in his hand or violently recoiled as he passed over subterranean water or minerals.

But the modern mining engineer does not need to rely upon such uncertain devices of motor-automatism. Science has now placed in his hands a wonderful instrument which makes the earth itself disclose its secrets, even as the modern navigator has made the rotating globe provide the force steering the monster liner across rolling seas by the non-magnetic gyro-compass in the wheel-house.

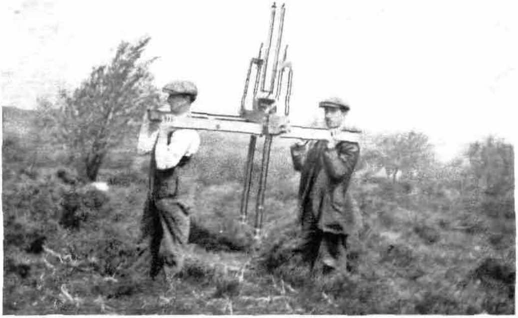
This device of modern science which, so to speak, X-rays the strata of the earth, is known as the Eötvös

Torsion balance, and was invented by Baron Roland von Eötvös, Professor of Physics at the University of Budapest, though the principle had been known and applied by eighteenth century scientific investigators. It is well known that an unusually heavy or an abnormally light body, either above or below the earth's surface, affects the gravitational field at all points of the surface in its neighbourhood.

Eötvös's instrument—a field apparatus capable of easy transportation in any part of the world—employs this property of the earth by measuring the very small differences between the gravitational pulls of adjacent bodies, on or below the surface of the earth. It is so sensitive that it can easily detect the change in gravity due to a ton of coal placed several yards from the instrument.

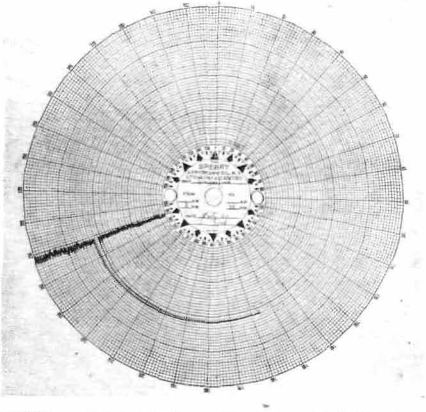
The Eötvös balance is very simple, consisting of a horizontal aluminium beam suspended by a very fine wire. At one end of the beam a weight of gold or platinum is fixed, while a second weight is hung some distance below the other end of the beam. The wire is made of platinum, alloyed with 20% iridium, and is usually a little over 1/1000th inch thick. To safeguard it against all disturbances, the balance is enclosed in a double or treble-walled metallic case, each case being thermally insulated from the others. The instrument is also worked in a double-walled tent to protect it against temperature influences caused by heat-radiation from the earth.

A mirror, mounted on the middle of the beam, enables its deflection, caused by mineral masses underground, to be observed, and this may be read either by means of a telescope or recorded photographically. In field-survey work, observations are generally made at night, since



OIL PROSPECTORS SEEKING PETROLEUM WITH EÖTVÖS TORSION BALANCE.

By courtesy of Messrs. L. Oertling, London.



GYRO CHART WITH INTERRUPTED RADIAL LINE SHOWING SHIP'S RESPONSE TO S.O.S. OF BURNING OIL TANKER IN MID-ATLANTIC. (See page 175.)

To face page 184. *Photo by courtesy of Sperry Gyro Company.*

disturbances by heat-radiation from the ground are less in the dark hours. The torsion balance, for this purpose, embodies two balance systems, side by side, enabling two observations to be simultaneously made; and in order to obtain correct results in the case of subterranean mineral or other masses, uninfluenced by surface irregularities, a survey is made of the area up to a radius of 100 yards from the station. The effects of any irregularities in this area are calculated, and suitable corrections introduced.

An interesting fact about these field surveys, prospecting for oil and minerals with the Eötvös torsion balance, is that the instrument is most affected over the edges of a mineral deposit, and very much less so, vertically, over the middle. This enables the approximate size and shape of the mineral or oil field to be traced out on the surface above it. The balance works best on level ground, but can be used in surveys of mountainous regions.

Baron Eötvös, himself, used his instrument largely to determine the formation of the lower stratum deep below the surface of the great Hungarian plain, that is for geophysical purposes. He was very successful by its aid in locating petroleum deposits—associated in nature with "domes" or anticlines of salt—and rich supplies of oil and gas were obtained from the resultant borings. The leading oil companies have adopted the Eötvös torsion balance, which has saved the cost of many test borings by determining the edges of an oil or mineral field. It can locate large deposits of iron ore, hundreds of feet below the surface, and can even furnish indirect information of the presence of much thinner lodes of more precious mineral ores.

Generally speaking, a comparatively large area can be surveyed by the Eötvös balance at the cost of a single 500 feet boring without its aid. It will also avoid the unfortunate experience by no means unknown to mining prospectors when a potentially rich minefield has been abandoned because a hole drilled within a few feet of a rich deposit has failed to indicate its presence.

Another method of detecting the presence of hidden metallic ores is that of the radio prospector. Germany has invented such a device, but has closely guarded the secret. On the other hand, Mr. D. Chilson, of the Bureau of Mines of the University of Arizona, has made available for the public a device which consists of a receiver, mounted in a tripod, and having a loop aerial, similar to the movable antenna of a ship's direction finder. The transmitting set is connected to the earth or is set up underground in a mining shaft so as to be nearer the lode of ore. In this way, the ore is made to function as a part of the transmitting antenna. The receiving set amplifies the radio impulses sent to it.

To take readings in prospecting unknown territory where it is suspected minerals may be found, the apparatus is set up with the loop in a vertical position, so the latter can be turned in an arc until the signals reach maximum intensity. This gives the "strike" or direction of the ore from the receiver. Without changing the strike, the loop is then "dipped" on its horizontal axis until maximum audibility is reached. This gives the dip angle. After the receiver has been set up in several locations and readings taken, the lines projected from the instrument give not only the location of the ore body, but its depth beneath the surface, which will be where the lines, prolonged, meet.

Experiments in the copper fields in Arizona are said to have been highly successful. An operator who knew nothing about mining or geology took several readings in territory outside the mining district, and generally considered barren, and found traces of ore at several points.

It may be here said, in passing, that the engineers in charge of oil fields and their plants are sworn to secrecy about the results of their experiences with ore locators of various types. For one thing, they are peculiarly liable to the attentions of people who have more or less occult devices which they wish to persuade others are infallible finders of hidden mineral wealth. It is admitted, privately, however, that oil prospectors have benefited by the use of these geophysical or radio devices.

CHAPTER X

THE CABLE-SHIP ON THE HIGH SEAS

SCIENTIFIC LABORATORIES AFLOAT—FINDING "ELECTRIC NEEDLES IN A HAYSTACK"—GRAPPLING THE OCEAN BED—RAISING A THIN WIRE THREE MILES IN THE SEA—WEIRD WATCHES AT SHORE STATIONS—THE FAULT FOUND!—LORD KELVIN'S WONDERFUL DEPTH GAUGE—MARVELS OF MAGNIFICATION—SINGULAR BEHAVIOUR OF CABLE CURRENT—PERMALLOY HUSTLES THE CABLES—THRILLING WAR TIME ADVENTURE

AMONG those who go down to the sea in ships, there are, perhaps, none of whom the public knows so little as the men of the wonderful cable-repair ships, year in year out grappling for the thin sheathed copper core lying three or four miles below on the ooze of the ocean-bed. The look-out on the bridge of a great Atlantic liner sees in the dead of night two red lights and one white flying vertically from the foremast of a ship right ahead in the ocean lane, and knows them to be the signal of a cable-ship, as enjoined by the maritime code. She has the right of way over other ships, for she cannot get out of their path when on repairs.

Down in the caves of ocean, across the green and glassy floors of waving marine vegetation, where lurk strange forms of life, and under submarine cliffs which may presently be rent in twain by titanic upheavals, run thousands

BRITISH OIL-DRIVEN DEEP SEA CABLESHIP FOR AMERICAN WATERS, TO-DAY.

To face page 189. *Photo by courtesy of Western Union Cable Company.*

of miles of thin copper strands carrying messages from the rush and roar of big cities over lost lands and primeval continents drowned deep in the seas of ages. Nothing can more vividly suggest the romance of the submarine cable than a week spent aboard a cable-ship on the high seas. It is a revelation of the magic of modern science and mechanism when applied to life and commerce at sea.

To-day, the cable-ship is a laboratory of complex and efficient scientific apparatus. The photograph here reproduced shows one of the most recently-built cable-ships, the "Cyrus W. Field,"* which is to be sent by her owners, the Western Union Telegraph Co. on service in the deep waters off Halifax, Nova Scotia. She is a twin-screw, oil-burning steamer, of 1,300 h.p., and has a bunker capacity which enables her to remain at sea for six weeks. In her tanks are coiled 170 miles of cable, and besides radio and gyro compasses, she is equipped with searchlights, an electric log or distance-indicator, and cable-gear combining the operations of picking-up and paying out in one machine.

The work of such a ship is, mainly, the finding and repairing of faults which develop in deep-sea cables.

"Fault," in the reader's mind, is a term which would probably call up a vision of a broken cable, fractured by some concussion on the ocean-bed which has completely severed communication, as would be the case were a telephone wire cut on land. In reality, however, "faults" in deep-sea cables are often of high resistance, which means that they may be very small and hard to detect,

* Named after a wealthy and far-seeing American who fostered the project of an Atlantic cable in 1857, at a time when a British Admiralty official had damped down an unfortunate inventor by saying that submarine telegraphs would never be required!

and would not be noticed were it not for their effect on the "duplex" or simultaneous dispatch of messages at high speed from two opposite stations separated by oceans.

Let us suppose that word has come to the head office of a cable company from its shore station of an interruption to an Atlantic cable four days steaming from the cable-hut, in south-west Ireland. Before the cable-ship leaves for the scene of operations, the shore stations at both ends test with various instruments for the purpose of finding with as little error as possible the position of the interruption. Deep-sea cables cost about £500 a mile to maintain, and the life of the cable is about 50 years, so that it is of great importance to the cable company that all possible delay may be avoided, and as much traffic as possible sent over the line. A single repair to such a cable may cost £100,000.

Four mornings later, if the weather is fair, the cable-ship reaches the probable position of the break, which is in the middle of the ocean lane where the west-bound liners follow the great circle to New York. She flies two great red globes enclosing a white diamond disc as a warning to the look-out of other vessels. The longitude of the position is taken, followed by a sounding, and then a one-ton steel "mark buoy" is heaved over the side of the ship to he moored approximately by the fault in the cable. A tremendously strong mushroom anchor holds the buoy firmly to the sea-bed, without chafing the cable.

Now, the ship begins the ticklish operation of grappling the sea-bed until the cable is hooked—a work demanding a very high degree of skill and experience from all concerned.

Lights are kept burning on the buoy at night-time, a boat being lowered for the purpose of illumination.

The cable-ship next steams out for a mile or so at right angles to the course of the cable, lowers a grapnel, and steams slowly back towards the buoy, passing and re-passing it until she has caught up the cable from the sea-bed. A look-out is kept for cable which may have been abandoned or lost on former expeditions, the ship going dead slow or drifting with wind and tide. Speed would only add to the difficulty of an always tedious operation.

The astounding depths at which the work of raising a submarine cable must be done—varying from five miles in certain places on the Commercial Cable Company's system from San Francisco to Shanghai, to a sounding of three miles off the Azores—imposes a great strain on the cable and may even cause it to break anew. Moreover, the pressure of the deep-sea water may range from two to three tons.

To ward off the danger of a new break and of too great a strain on the cable, clever engineers have designed grapnels which will simultaneously cut the cable and firmly grip the desired ends. A special type of grapnel signals by the ringing of a bell when the cable is hooked, or when the grapnel has entered deeper water and requires more rope paid out. It will also show whether, among a number of cables laid together, the right one has been hooked.

It may be here said that when cables are laid, a percentage of slack, varying according to the water's depth, is always paid out to facilitate the work of raising a damaged line.

If the strain on the grapnel rope is likely to break it in hauling the cable on board, the ship attaches the rope to a buoy, steams away for some distance, lowers another grapnel to cut the cable, and then hauls the severed portion aboard by connecting the second grapnel rope to a drum, but taking care not to pull against the buoy.

All this time on board ship, dynamometers near the bows have been recording the strain on the cable. These instruments are attached to the picking-up gear which is controlled by a powerful brake during grappling operations. The ship is at once stopped when a steady strain is shown.

At last the cable is raised above water, and two men climb down from the cable-ship's bows into boatswain's chairs, secure the cable with a chain and stoppers, saw it through on the grapnel, and heave one end on board. The cable is stripped of its sheathing, and the copper core connected up to the testing room.

A strenuous time now begins for the electricians. Day and night the work goes on, and the headquarters ashore are kept in constant touch with the ship's movements. It may take from two days to a week to repair the break; for the cable may be resting on a coral bed and repeatedly break, or the position of the fault may be still farther away.

Meantime, men inside the cable-hut ashore have been keeping a day and night watch on a mirror reflecting a beam of light thrown on to it by a lamp and lens. The mirror noiselessly signals the messages sent it from a similar instrument on board the cable-ship, and it is a weird experience in the night watches of the lonely cable-hut to see it at work linking up the land with a patch of ocean thousands of miles distant. The land-line from the cable-hut has been insulated from the head office, where careful observation is kept on the siphon-recorder.

The electrical brain of the cable-ship is the testing-room, a comfortable cabin with lounges and library on the main deck, where live the electricians surrounded by galvanometers, insulated tables, batteries, commutators, tools and other apparatus.

They signal the shore stations and ask them to free the ends of the cable. A current is passed through a marine galvanometer, and shows the fault by deflections of the instrument. The sound end of the cable is buoyed, and the ship steams off to the fault, warning those ashore to keep watch for signals arriving after an appointed date, which is the estimated time of the repair. Her engines moving easy ahead, the cable-ship begins picking up the cable towards the fault. She travels in a line parallel to the course of the cable in order to ease the strain. The picking-up gear starts its work, and a rotometer measures the cable as it is hauled aboard, in tropical seas covered with lovely marine growths. Finally, the cable is coiled into hollow tanks. The fault has been found!

Tests are made by the ship to prove the insulation after repairs, and the shore stations are again warned to free the cable for splicing and final trials.

A few words as to the remarkable apparatus used by the cable-ship may be of interest. "Logs," one of the most recent types of which is worked by electricity, are used to show the distance from point to point on the sea-bed travelled by the cable-ship, and to keep the cable clear of submarine banks or volcanic peaks.

For sounding the ocean depths, a wonderful instrument used by the ship is Lord Kelvin's compressed air depth-gauge and recorder. A thin glass tube, two feet long, and open at the bottom, is let down enclosed in a brass case attached to a sinker. Water rises in the tube, proportionately to the depth and pressure, and compresses the air in the tube. At the same time, the water washes away a red chemical smeared on the inside of the glass tube, thus recording the depth to which the Kelvin depth-gauge has been lowered. The gauge is hauled in, and with the aid of a table of figures, the record is translated into fathoms.

Searchlights and wireless direction finders are also part of the modern cable-ship's equipment, together with the Sperry gyro compass, instruction in the use of which was made in 1923 part of the training of a British naval officer.

Speed is, to-day, more than ever, the essence of modern cable-transmission, and this is attained by two ingenious devices—*Lord Kelvin's siphon-recorder* and the *Orling relay*. The siphon-recorder is a glass pen which moves over a paper tape, and whose tip is continuously lifted by an electro-magnetic vibrator. The line drawn on the tape by the ink-filled siphon pen is a series of dots, requiring less current and done at great speed. In the Orling relay, a falling jet of acidulated water is turned aside by the pressure of a quartz fibre moved almost invisibly against the jet. This quartz fibre is worked by a very feeble cable current, deflecting the jet of water to right or left. The relay magnifies these weak currents, and sends them to the siphon-recorder which gives out the message.

The next stage in the evolution of the submarine telegraph is the use of type-printing telegraphs, comparable to those of the land-lines, and transmitting hundreds of words a minute.

It may surprise the reader to learn that the modern deep-sea cable is often no more than 1¼ inches in diameter, sinking down to the ooze at the bottom of the sea-bed, where it lies in the darkness and stillness two, three or more miles below surface.

In shallower waters and inshore the cable is much thicker, and heavily armoured to protect it from shipping, but even so injury is frequently caused to it by trawlers. Galvanised wires give it great strength and power to bear several times its weight, when it is being raised from the sea-bed for repair.

The nerve of the cable is its copper conductor, sheathed in gutta-percha. A marine organism known as the "teredo" is so fond of gutta-percha that it has to be kept away from the insulation by brass tapes, which prevent it from boring into the cable. Care is taken when the cable route is surveyed to see that there is no chemical constituent present in the ooze of the ocean-bed which may corrode the sheathing of the cable. This is done by analysing specimens of the bottom soil.

Not only is the pressure high at the bottom of the ocean, but the temperature is low. It approaches freezing-point in the Atlantic, at 2,000 fathoms, where it is 36° F., and 34° to 35° F. in the Pacific. This low temperature is a factor of great importance in the successful working of a submarine telegraph, since it increases the conductivity of the copper-wire and the resistance of the insulating sheath.

The speed or velocity of transmission of electricity is theoretically equivalent to that of light,* but the behaviour of a submarine cable connected to an electric battery apparently conflicts with this theory. If one end of a cable is so connected to a battery the electric pressure or potential at the opposite end of the line does not suddenly rise, but very gradually changes, and when the battery is removed at the sending end, the current at the receiving end dies down slowly.

Some idea of the amazing volcanic convulsions to which the ocean bed is liable is suggested by the experience of

* Approximately 186,300 miles per second.

the Eastern Telegraph Company who in 1923 found that the bed of the Atlantic between Cape Town and St. Helena had been raised 2¾ miles in 24 years! The last sounding, made in 1899, when the cable was laid, showed a depth of three miles. Such a variation is of a very unusual character, for, in general, a rise or fall in the ocean-bed of a few fathoms only has been diclosed by soundings.

The competition with radio transmission has driven the cable companies to search for and adopt every device which is likely to increase the mechanical efficiency of the undersea wires. England has a monopoly of the making of electric cables since she was the first in the field and has invested a vast amount of capital in this industry. Thus, it is fitting that, recently, a well-known British cable and maintenance company should have contracted with big Atlantic cable companies to produce a cable made of a new alloy called "permalloy," which is said to have increased the speed of transmission from 300 to 2,500 letters a minute. Permalloy is an amalgam of 20% iron with 80% nickel, and it automatically increases the magnetic effect of the weak currents used, and sharpens the signals received.

A new cable, using the permalloy tape at its core, now runs on the Western Union Telegraph Company's route from New York to the Azores, and a second is to be laid this year (1926) from London to New York via Penzance and Newfoundland. It will cost about £1,500,000 to construct. The first permalloy trans-Atlantic cable was found capable of transmitting the enormous number of 1,700 letters a minute. The permalloy's special function is to prevent these messages, transmitted at such a high velocity, from getting mixed up, and it is wrapped round the central copper wire at the core of the cable which actually conducts the current. Permalloy, as wound round the copper core, is of the incredible dimensions of six thousandths of an inch thick, and one eighth of an inch wide, although it is made in "strips" 10,000 miles long!

Wonderful typewriting instruments are now in use at the cable offices in London and New York, at which skilled operators take off messages, coming over the permalloy cables, and simultaneously recorded by six machines. A new device will permit operators at the London receiving end to pick up several messages as they are being transmitted over one wire. This is done by eight men sitting before a whirling disc, each picking up words from a segment of the disc passing before him. These new devices correspond, in the sphere of the sea wires, to the wonderful Baudot and Murray type-printing telegraphs used on the land wires by our British Post Office.

Thrilling adventures befell some of the British cable stations during the war, and the story is not familiar to the public. It may be recalled that the first effect of the war was to double and quadruple the work thrown on the cable workers. Code messages were forbidden by the censorship and soon the news of disasters in the waters of many parts of the British Empire began to be flashed across the sea wires.

From 3-4,000 fathoms deep in the Pacific Ocean runs what is the greatest length of cable in the world. It stretches over a distance of 3,548 nautical miles from Bamfield on Vancouver Island, British Columbia, to the lonely Pacific atoll, Fanning Island. Palms wave in the breezes over the salt water lagoons of Fanning Island, and the heavy fronds of the coco-nut make cool and shady this island, "the place of the heavenly footstep," with its 11 miles of length and half as much width. Fanning Island is separated from the next island station of the British Pacific Cable by over 2,000 miles of salt water, and it is far away indeed from the sea lane of the great ocean liners and even of the tramp cargo steamer, so that, when one day in September, 1914, a steamer flying the French flag approached and signalled to the little harbour, the cable workers wondered what was her business in those lonely seas.

They were soon answered, a landing party came ashore, armed to the teeth, guns were run out from the steamship's sides, and a detachment from the German cruiser "Nürnberg" took possession of Fanning Island. They smashed the instruments, destroyed much valuable property, and generally made havoc on land whilst the cruiser hauled up the cable lines, cut both ends and dragged them out of position. Luckily, the shore party overlooked an artificial line. The operators were now isolated from the world, and the "Nürnberg" steamed away to meet destruction at the battle of the Falkland Islands. No early relief could be expected because the maintenance and survey ship of the Pacific Cable Board would not visit Fanning Island for many weeks to come. The plant and instruments ashore were a mass of wreckage, and there was no repair equipment on the island, nor a spare cable which might have been used to bridge the separated ends.

The operators set their wits to work. Some means must, by hook or crook, be found for letting the world know their plight. A message must be got to the station on Suva (Fiji Islands), 2,043 miles distant. The Germans had scarcely left the island before attempts were made to open up communications of a temporary character on the cable. I quote from the records of the Pacific Cable Board telling what was done.

"One of the operators, without the least previous experience in dealing with cable repair work, succeeded in partially raising the ends from the bed of the sea by adapting an ordinary pickaxe to the purposes of a grapnel. He then dived, and working under the sea (in a shark infested area) secured the ends by ropes, thus permitting them to be raised above the surface of the sea, where they were buoyed to platforms contrived from planks and barrels. A connection was then made between the ends by means of ordinary covered wire and the Fanning Island Staff were in communication with Suva, Fiji. The connection was, of course, precarious, and useless for public traffic, but it achieved its object of enabling the situation at Fanning Island to be known and the most appropriate measures to be taken.

"Much skilful mechanical work was also carried out by the staff in reconstructing instruments by piecing together serviceable parts from the debris of those damaged, and preparing the Station for the permanent reopening of communication. This resulted in the Station being in a position to handle traffic immediately the cables were repaired by the Board's Maintenance Steamer."

No less than 100 men with a team of five powerful horses were needed, in May, 1926, to haul ashore at Sennen Cove, Land's End, the shore end of the Western Union Telegraph Company's new cable to Newfoundland and New York. No ship could tow in-shore the three-mile end of this cable, which weighs 30 tons a mile, so heavily armoured is it to prevent wear and tear on the sea-bed. It was floated in on the tide, buoyed up on barrels, and the horses dragged it to the trenches on the beach, whence it was connected up with the land lines to London.

CHAPTER XI

SAFER AIRWAYS OF TO-DAY

HELICOPTER MAY REVOLUTIONISE AIR TRAVEL—THE "FLAPPING BIRD" PLANE—NEW LIGHTS FOR AERODROMES—NOVEL AERIAL WAR ON FOGS—AIRMEN'S SECURITY BULBS—"HONEYMOON EXPRESSES"—SEA-PLANE WITH SAILS—MOORING MAST IN THE DESERT—PICKING UP PASSENGERS IN MID-AIR—STEERING BY SUBMARINE CABLE—LATEST FRENCH STEERING INSTRUMENTS—NAVIGATING THE AIRWAYS—FIAMMA RADIO LAUNCH—RADIO AIR LINERS OF THE FUTURE—BRITISH "SELF-FLYING" MACHINE—A BRITISH "SAFETY-FIRST" FLYER—PUTTING OUT AEROPLANE FIRE IN FLIGHT—MOTOR-CAR-PLANE

THE man in the street and the man in the train have a lingering idea at the back of their brains that flying is still rather unsafe. Yet, as we hope to show the reader in this chapter, every passing month sees the invention or perfection of some aerial device or novel machine which will tend to make air travel as safe as railway travel in the very near future. A short time ago, an experienced pilot who has flown his machine some thousands of miles from Croydon air-port across the English Channel to France or Germany, was asked what it felt like to "take off" from the ground nearly every night in all weathers and states of the atmosphere, and speed through the air with nothing but a line of flickering lights to guide him onwards towards his destination.

"Oh," he said, with a smile, "I had rather have night flying than day flying, so far as ease of flying is concerned. You see, in the day you may find that fog or haze makes the task of picking up your landmarks a wearing one. At night, you can sit back in your seat in the cockpit, peer round the side of your machine and see the ground lights come pouring in over your wings. You have your radio signals from the land stations less liable to interruption from static or atmospheric disturbances, and over the sea, you can listen in for the warning sounds of the submarine leader cable telling you if you are on your right course. Better and better in every way!" He did not mention the fact that in three years of flying on the British and Dutch commercial airways there was only one passenger fatality for a period of 2,650,000 passenger miles flown.

One of the marvels of the future mechanics of aerial transport which will make for safer airways is the development and perfection of the helicopter. Using some such device, the aeroplane-airship of the future, starting from the centre of some great world-city, for a round-the-globe flight, will soar vertically up into the clouds from a vast trans-oceanic air port whose skyscraping glass dome will reflect the radiant morning sunlight.

It will not require, as now, lofty ascending towers with elevators or a wide stretch of turf and the spacious grounds of an aerodrome from which to "take off" and acquire the "flying speed" before the pilot can move the controls and tilt the main planes in order to climb into the air. This possibility of vertical flight is on the eve of being solved by the perfection of the helicopter, a heavier-than-air machine rotated by horizontal screws and vertical lifting-vanes which pull it straight up into the air from the aerodrome field.

What the helicopter, or "bird-wing" flying machine, will have to accomplish is shown by the very exacting conditions recently laid down by the British Air Ministry in the international contest for the prize of £50,000, offered for the best helicopter. It will have to be capable of rising from or alighting on any patch of ground of its own length and width, of hovering over any desired spot, and of maintaining itself by the vertical lift of its propellers. Flying straight up or down, its whirling screws have to cause the helicopter to reach a height of 2,000 feet, hover motionless for half an hour, fly a circle of twenty miles at 60 miles an hour, and descend into a small area, from a height of 500 feet, with the engine stopped.

Up to the present, the obstacle to the progress of the helicopter lies in the mechanical fact that the whirling blades of the spiral screws tend to interfere with each other's motions, and this mutual interference, or "cascade effect," may have a neutralising effect, when the machine is in the air, and so cause a crash.

Twenty or more of the best aviators in Britain, America, France, Spain, and Belgium have entered their machines in the last three years (from 1924-6), for this big prize, but no one of them has yet succeeded in "getting away" with the award.*

Britain possesses a helicopter machine constructed by the well-known Irish inventor, Louis Brennan (to whom we refer in the chapter on the gyroscope), but as the details of this helicopter remain a closely guarded secret of the Air Ministry, we can say nothing of it here, except that

* That is, at the date of writing, April, 1926. It is stated that the Air Ministry propose to withdraw the offer, after June, 1926.

it appears to be still in the experimental stage, and was reported in the London daily press, to have been capsized by a sudden gust of wind, in a secret trial held at the Royal Aircraft Establishment at Farnborough, in the late autumn of 1925.

America's helicopter inventors are Mr. Henry Berliner and Mr. de Bothezat. Berliner's helicopter is said to rise smoothly into the air under the pull of its lifting screws, and to fly at a low altitude, ascending and descending under control. Once in the air, it is said, the Berliner helicopter hovers motionlessly, then darts off at a high speed like an ordinary aeroplane, comes to a standstill and descends slowly, elevator-fashion, on any restricted spot. The pilot operates the machine by pushing switches and controls in his cabin. The de Bothezat helicopter, we are told, can lift the weight of its pilot and three passengers.

French air engineers have spent much time and money on the problem of the helicopter. M. Raoul de Pescara's helicopter has accomplished a record flight of 10-15 minutes, travelling on a circular path and returning to its starting-point. His helicopter described at Issy le Moulineaux (Paris), figures of eight, a closed circle, and travelled for three quarters of a mile before an over-heated motor forced a descent. Horizontally rotating traction screws lift Pescara's helicopter into the air, and when aloft, its screw-shafts are tilted downward, the resultant being a forward motion propelling the machine.

M. Oehmichen, another Frenchman, won a French prize of £1,490, flying seven minutes 40 seconds on a helicopter shaped like a cross-frame, and fitted with a lifting screw at each corner. Four other screws, have movable vanes to overcome any tendency of the machine to pitch, and to give lateral control and propulsion. He uses a gyroscope to counteract the tendency of the machine to spin under the influence of the lifting screws. M. Oehmichen lifted himself and a load of 200 kilogrammes on a recent trip, when his helicopter remained in the air for one minute.

The French Government are stated to have recently experimented with the fitting of rotors (see the account given of this latter invention in Chapter XIII of this book) to the helicopter, thus making use of the Flettner-Magnus principle of "sailing ships without sails." The rotors are fitted above the wings of the helicopter, and are driven by the engines working the propellers. The idea is to cause the rotors to lift the air flowing past the helicopter in its passage and so make it push the machine forward. What the result of this experiment has been has not been made public.

A strange aeroplane which can flap its wings in imitation of a bird's flight, rise and descend vertically in a confined space, and fly as fast as an ordinary aeroplane has been invented by a Spanish aviator, Señor Juan de la Cierva. It must be pointed out that this machine is not a helicopter although its behaviour in flight suggests helicopter peculiarities.

The "Autogiro," as it is called, is like an ordinary monoplane with the usual aeroplane body and motor, but has a peculiar feature in its construction which takes the form of a novel, metal pillar rising from the centre of the machine, just by the pilot's seat. On the top of this pillar are four wings or "vanes," crossing each other, and set horizontally. These wings rotate rapidly and are hinged so that they can be moved up and down as they spin.

This horizontal "lifting screw," as it really is, is driven by the "slip stream," or rotating current of air created by the propeller of the monoplane as it whirls round. To cause the machine to ascend, the pilot opens the throttle of the engine, and the whirling screw in front of the machine runs the plane along the ground. The current of air set up by the air screw spins the lifting vanes, whereupon the pilot alters the angle of the pillar supporting the vanes. These vanes now lift the machine through the air, and, flapping like a bird's wing in flight, automatically adjust themselves to the air pressure.

The lifting screw device makes the "Autogiro" immune from "stalling," or dashing to the ground, as an aeroplane does when its engine suddenly stops in mid-air. If this should happen to its engine, the vanes on the "Autogiro's" lifting screw continue to revolve, and float the machine gently to the ground, which it reaches at the speed of about five miles an hour.

At a special demonstration arranged by the Air Ministry who invited Señor Cierva to exhibit the powers of his remarkable machine at the Royal Aircraft Establishment at Farnborough, in 1925, he said that his invention meant that we are brought an important stage nearer the day when mail and passenger aircraft will be able to alight, safely, on stages raised above the centre of big cities.

"The 'Autogiro' will also be eminently suitable for launching from, or alighting on, the deck of a ship. For war purposes, owing to its ability to slow up in the air, it should be valuable as a scout; while its slow-flying properties should also make it useful as a bomb-dropper.

"I have worked out a calculation which shows that, developed in a racing type, and with a powerful motor, the 'Autogiro' should break all existing speed records, rushing through the air at a pace as great as 310 miles an hour."

Cierva caused his machine to stop suddenly in the air —which would have resulted in a fatal crash or stall in the case of an ordinary aeroplane—and then descend steeply to the ground which it reached with a gentle bump, doing no damage to the undercarriage and coming to a standstill a yard or so away. Early in 1926, the Señor was planning to establish an auto-giro mail service between Madrid and Paris, using high platforms above the roofs of large post offices in the capitals of Europe, from which to start on the air trip, and strong screens to ward off the force of gales and high winds, should such occur when the machines alighted.

The problem which has to be solved before the helicopter can become a perfect flying machine is how can it be prevented from falling should its engine suddenly fail while it is high in the air? We have seen how Señor Cierva solves this problem in his auto-giro. The helicopter, unlike the aeroplane, has no sustaining wings which would support it safely when the pilot seeks to glide earthwards with his engine out of action.

An Austrian device is to provide parachutes for the crew who are in a turret above the helicopter's screws. Another method is to attach long, thin-bladed metal screws above and below its body, and mounted on central revolving masts. When the helicopter rises these screws revolve at a high speed. If the engine fails, the pilot works a control in his cockpit which extends wings rigidly on each side of the hull, and inclines them at an angle which, as the machine is dipped forward, enables them to support it on a descending path, just as do the wings of an aeroplane.

In another new field of design several sets of whirling screws are, in the case of engine failure, made to operate with the effect of parachutes. When his engine stops the pilot declutches these screws, and, by an adjustment from his control-station, sets all their blades at a steep angle to the air.

Then, as the machine begins to fall, these freely revolving blades spin round at an increasing speed in the air-stream caused by the descent of the machine.

According to his theory, they would "grip" the air, as they whirl round, to such an extent that the fall of the machine would be checked until it was descending at not more than about 10 miles an hour—at which speed, by the use of special shock-absorbing alighting gear, it is reckoned that it could make a landing without injury either to its occupants or itself.

A new type of aeroplane, possessing a helicopter action, was recently tried on one of the aerodromes near Paris. It is the invention of M. Edouard Perrin who has had the aid of M. Henri Bouché, editor of the French journal, "L'Aeronautique," in perfecting the machine. The "Helicion," as it is called, has a trajectory or flight which, soon after rising from the ground, changes from the vertical to the horizontal. It joins to the qualities of a helicopter those of an aeroplane.

The last few years have seen some remarkable devices for making the airways safer for navigation in thick fog and bad weather on land and sea. Great aerodromes where continental expresses enter and leave for day and night journeys across thousands of miles of water and land have found that powerful Strontium beacons, showing high intensity red lights, penetrate mist better than white lights.

Neon tubes, placed on towers, serve as beacons to airmen 30 miles away, and penetrate fog. Such tubes are installed in the centre of large radio installations where flying is usual and warn airmen to keep clear of the radio masts.

An ingenious system of cone pilotage reflectors to serve as air-port indentification lights were recently installed at Croydon Air Port. A powerful beam with an intensity of 500,000 candles is here flashed vertically into the sky by a searchlight lens.

For the dispersal of fogs lying over aerodrome landing grounds, Dr. Francis Warren, of Harvard University, in 1925 devised a sand blast for hurling electrified sand from powerful projectors mounted on the engine-bodies of aeroplanes in flight. The idea is to blow away the accumulations of cloud overhanging fields and harbours. Small clouds are dispersed and larger clouds criss-crossed and pierced somewhat in the manner in which a mowing machine harvests a large hay-field. In a recent experiment, aviators climbed 13,000 feet to a stratum of massed clouds, and observers on the ground, watching through binoculars, saw the airmen cutting paths and ravines through the cloud mountains. They attacked projecting flanks of the clouds, cut them from the main body and dissipated them into air, then they dived into the wreathed vapours to war on a bank of thunder-storm clouds from which lightning flashed incessantly. The lightning ceased, and a fine rain began to fall, lasting for five-six hours. The experiment encourages the hope that a method has been found to disperse thick fogs overshadowing airports, or to clear a lane through which aeroplanes may be safely guided to the landing station. It is suggested that two large biplanes, equipped with this device, operating on the occasions when the London air is choked with fog, might save the city the daily loss of £1,500,000 which fog is said to entail.

A red, electric bulb is now used to catch the pilot's eye when the roar of the engine would drown the sound of a bell or gong warning him that he has reduced his speed below the margin of safety, prior to a forced landing in bad weather. In a fog, electric guiding cables, on the aerodrome below will cause a series of coloured lamps on the airman's instrument board in his cabin on the aeroplane, high overhead, to flash out their warning that he is near the air-port. They will tell him where he is, his height above ground, and will at once change colour if he misses the right path, by swerving his plane.

Investigations of aeroplane accidents have shown that a pilot, landing on unfamiliar ground, may be so engrossed in selecting a suitable place, that he may fail to keep his eye on the dial recording his speed. The wings cease to support the aeroplane in the air, and it falls and if the pilot is at a low altitude at the time, he may stall and strike the ground before he can regain control.

If aeronautical research work now going on in England passes the experimental stage, we may soon see the day when a pilot, who has accomplished his long trans-continental or trans-ocean voyage, will bring his machine within a certain distance of his home port. Should the weather be bad, he will hand over the control to a pilot seated on the aerodrome, who, by means of a wireless apparatus and very carefully adjusted instruments, will bring the machine to earth and steer it to the shed.

The time when flying will be as popular as the use of the automobile is now hastened by the development of the "light aeroplane" to which England in 1924, devoted much attention. The British Air Ministry organised a

MOTOR-CAR 'PLANES ON PARISIAN BOULEVARDS. (See page 229.)
Photo by courtesy of M. René Tampier, the Inventor.

ROHRBACH FLYING-YACHT ON WATER WITH MASTS IN POSITION AND SAILS SET.
Photo by courtesy of Rohrbach Aeroplan Co., Kjöbnhavn.

To face page 211.

the Cierva auto-giro adapted to the English light aeroplane. This should make flying safer for the amateur aviators and members of light aeroplane clubs. In Australia, aeroplanes are in common use as a means of communication between settlers on large ranches.

What is to be done when a sea-plane's engines give out miles away on the open sea? A German inventor and air expert, Dr. Rohrbach, answers the question by designing a new type of all-metal three-float seaplane.

It is a remarkable, all-metal flying boat—a veritable aeroplane-yacht—which flies at 180 miles an hour in the air, and speeds like a fast railroad engine across the sea. The crew of this novel flying boat are as much at home in the air as on the sea. Built of very strong but light-weight metal, the Rohrbach flying boat, with its gracefully tapering hull, is thoroughly seaworthy.

On its plated decks are ingenious telescopic masts which are invisible, when the craft is in the air. A fore sail, a main sail and a stay sail are set on these masts, built of duralumin (a very hard and durable alloy), and once the flying boat is on the water, the planes are drawn in, and, driven by a freshening breeze, the Rohrbach machine speeds gracefully across the waves, as though competing in a yacht race.

If the commander wishes to rise from the water into the air, he sets whirring and roaring two very powerful aero-engines installed under curved, outstretching wings of shining metal, mounted on either side of the flying-boat's hull. The wing-planes, which are of enormous length, are shot out from the sides of the hull, the sails are furled, the telescopic masts vanish into the hull, the sea water foams and hisses under her hull, like high-pressure steam ejected from a liner's boilers, and, driven by her rushing wing screws, the flying boat roars across the surface of the sea. Then the wind gathers in force under her vast, outstretching planes, and finally sweeps the aeroplane-yacht up into the air.

The Government has now added a fleet of these Rohrbach machines to our British air navy, and plans to build mammoth flying boats speeding as fast across the water as in the air. Marine engines are to be installed in their hulls to work under-water screws, and they are to be employed in cruising up rivers and in coastal waters. Their planes are to be stowed alongside their hulls, when not required for flying.

Sea-planes are now regularly called upon around the coasts of Great Britain to keep a watch for shoals of fish. One aerial observer, for example, located a dense shoal of herrings a mile or two off the Banffshire coast (Scotland). The news was at once sent to the local fishermen, and soon a number of boats were casting their nets at the spot. A few hours later they returned to port with good catches.

The French Bureau of Fisheries recently detailed a dirigible to aid the fishermen of La Rochelle, on the Bay of Biscay, to locate quickly the shifting shoals of herrings, sardines and tunny fish. Profiting by the experience of America, when aeroplanes were employed in the Californian fisheries in 1923-4, the French authorities decided that an ordinary aeroplane or heavier-than-air machine was unsuitable for the purpose of locating shoals of fish, since the noise of the whirring propellers frightened away the fish, or, when the shoals were detected, the aeroplane could not stop quickly enough to verify the position and radio the message ashore. A captive balloon was tried but found useless, because, when towed behind a fishing smack, it scared away the fish.

The airship leaves its base, at the port, on a fine morning when visibility is good, and it carries one of the fishermen as an observer. The probable location of the fish is decided on beforehand, and a chart is marked out with numbered squares representing the zone in which the fish are found.

Sailing slowly and methodically over the surface of the waters, an observer on the airship watches for signs of the fish. It is well-known that the bottom of the sea is plainly seen from an aeroplane or airship, the clearness of observation depending upon the altitude of the aircraft.

As soon as the observer spots a shoal of fish, he marks a square on the chart, corresponding to the position, notes the approximate direction in which the shoal is swimming, and at once radios to the port. The waiting fishing smacks immediately put out to sea, and are met and guided to the shoal by the airship; or the airship may remain in the air over the shoal and fly colours as a signal to the approaching fishermen. Once the shoal is being attacked, the airship leaves to find and spot new shoals.

An illuminated air-way of 10,000 miles is being planned by the British Air Ministry, and by 1928, or later, it is hoped that air-liners will leave London by night for Australia, accomplishing the journey in 100 hours. For the section of the route lying between Calcutta and Rangoon, a distance of about 900 miles, all-metal flying boats, proof against the ravages of tropical weather, will be used. The route then proceeds by way of Singapore to Port Darwin in Australia.

It has been found very necessary to outline the boundaries of aerodromes and landing-grounds in the hours of darkness if night-flying is to be practicable on international airways.

Another body, the International Commission for Air Navigation, has capped this project by devising a scheme for a round-the-world air journey also in 100 hours. Special machines have been designed to fly in thin air at immense altitudes where they profit by lessened resistance and attain average speeds as great as 200 miles an hour. Such machines are no longer speculative. They are already in design, while the route they will take has even been selected. Measuring just on 20,000 miles, it is from London, via New York, San Francisco, Peking, Moscow, and Berlin. Special apparatus is necessary to allow passengers and pilot to breathe at the altitude contemplated.

Then, on the edge of a sandy desert at Ismaila, Egypt, a lofty steel tower, 200 feet high, has been built as a mooring-place for the giant airships flying on the "all red route." An electric lift runs up the centre of this great tower, and as the air-liner comes to rest, passengers will step out of the ship and pass along a covered way to the lift, which will bear them to earth. At night, powerful searchlights will flash their rays over the desert as the other passengers leave railway trains at the foot of the tower and ascend in the lift to the giant air-liner, whose lighted cabins are blazing out over land and sea. Revolving turrets at the top of the tower act as berths for the air-liner, while she takes in hydrogen from a great tank at the base of the tower.

The recent successful experiment of launching an aeroplane from the body of a giant airship—the R33—2,000 feet high is a foretoken of a method by which safety in airship travel will be increased by the auxiliary aid of an aeroplane, should a long-distance airship be disabled from any cause. In this experiment it will be recalled that the pilot of the aeroplane descended to his seat in the cockpit of the plane which was riding under the hull of the great airship attached to a telescopic construction, equipped with buffers projecting from the airship.

An engineer, aboard the airship, opened the telescopic apparatus which left the aeroplane swaying in space some 60 feet below the mother ship. The pilot on the aeroplane next pulled the release lever, and his plane shot down until the engine acquired speed enough to check the way on the untrammelled plane, and made her ride freely in mid-air.

He now swung round in a wide curve, reduced his aeroplane's speed to that of the airship, and then headed the front of his plane straight towards the end of the telescopic apparatus on the airship. On the top of his plane is a coupling which at once hooked on to a bar on the telescopic apparatus, and then the aeroplane swung in the air, until, as soon as its momentum slackened, the engineer on the airship shut the concertina device and drew the aeroplane close against the hull of the airship, to its former position. The pilot then climbed up into the airship from the cockpit of his plane.

Following on this remarkable aerial feat, air experts are suggesting that it should be presently possible for air tenders to pick up passengers and transfer them to an airship on the coming all-red air route from London to Australia. A radio message would be flashed to the flying airship telling the captain that passengers and mail were waiting for him at the next aerodrome. The airship would release an air tender attached to her hull, and the latter would fly down, collect the passengers and mail, and then speed like a fast motor car after the airship, flying ahead. The passengers would climb a companion ladder into the airship.

Another device is being planned to allow air-mail planes to drop mail bags into confined areas on the ground, without reducing speed, in much the same way as an express railroad train drops mail as it sweeps through a junction. A combination of clockwork and parachute is to check the headlong fall of the bags earthward and land them gently. The new Italian liner, "Saturnia," running on the route Naples—New York, is to carry seaplanes, whose wings fold up and occupy a small space on the liner.

When the "Saturnia," on a voyage to America, is still about 1,000 miles from New York, one of the seaplanes will be launched with passengers and urgent mails. These passengers will be required to pay higher fares. The seaplane will be scheduled to cover the 1,000 miles between the liner and the shore in not more than about eight hours. A full use of these "air-accelerations" would mean a saving of two days on the voyage.

Experiments, it is said, are also to be made in sending out a seaplane with late-fee mails to overtake the "Saturnia" some time after she has started. The seaplane would then alight on the water, being raised by means of a special tackle.

A new British parachute enables a pilot to escape smoothly and successfully from a falling aeroplane. It consists really of three parachutes which rapidly open the one after the other when the aviator jumps out of his stalling machine. One of these parachutes recently saved a pilot's life when his machine suddenly spun and "nose-dived" in a deadly rush towards the earth where it smashed into fragments.

A very recent device for aiding the landing of aeroplanes in a restricted area consisted in the attachment of a form of brake to the wings. These brakes are worked by levers in the cockpit, and are said to reduce by about 12 *per cent* the *speed in landing. They are similar to the* ailerons, referred to in this chapter, and look like the emergency brake on a motor car. This braking device is made use of on monoplanes from which aerial photographs are being taken, and on which are installed dark rooms, camera cabins and tanks for washing and developing the photographic prints while the plane is in the air.

The insidious peril of the "air-spin," when the engine fails, and the aeroplane slips sideways and rotates as it falls is to be overcome by enlarging and altering the shape of the tail rudders, and by equipping the pilot with a parachute with which he can escape from a crash.

Steering an air-liner in a thick sea-fog is now accomplished in the English Channel from Boulogne to Folkestone by the construction of a Loth cable, (the invention of a young French engineer, M. William Loth, of Paris), to be laid on the sea-bed or along the ground inshore. Any route can be marked out by an insulated cable carrying an alternating current of a frequency of 4,000 to 5,000 cycles per second. This current creates a magnetic field which spreads outwards and influences loop aerials and valve amplifiers on the aeroplane. The pilot steers so as to make the cable signals sound at their sharpest and clearest in his telephone, which is only when his aeroplane is directly above the cable's leader gear on land or sea. At night time, separate aerodromes and stations along an air-route are indicated by sections of cable through which flow currents of distinctive frequencies.

The first section of an overhead cable for steering Paris to London air-expresses between Paris and Boulogne was completed in May, 1925.

M. Loth's device is equally applicable to steamships, where the signals from the submarine cable, sunk in the fairway, are picked up by a radio receiver on the bridge of the ship.

France has made remarkable progress in the invention of instruments of precision for safety in aerial navigation. The gyroclinometer (Bonneau, le Prieur and Derrien pattern), which has been adopted by the French Minister of War, helps the aviator to land safely at night or in fog, and shows him at any moment the exact angle of inclination or tilt of his machine, both cross-wise or in a longitudinal direction.

A gyroscopic top is the main feature of the gyroclinometer, which is spun by two jets of air, striking eccentrics on the surface of the gyro-disc. The air-jets are continuous and are induced by a vacuum which is automatically created, in the gyro-case, by the tube of a Venturi motor placed in the forced draught from the engine. A mirror is fixed on the flat upper surface of the gyroscope, perpendicular to the axis of rotation, and remains perfectly horizontal however much the aeroplane may pitch and roll.

An electric bulb in the gyro-case throws a light which is reflected by the mirror on to a transparent dial. The movements of this reflected spot of light show the pilot instantly the least change in the tilt or inclination of his aeroplane. During landing, the gyroscope can at once be put out of action by the touch of the pilot's finger upon a push, which shifts the gyroscope from its bearing. Current from a generator on board the aeroplane works the gyroscope.

If the pilot loses his sense of the horizontal when aloft lost in cloud, fog or darkness, he has only to press the push, which action couples the generator to the gyroscope, lights the electric bulb and spins the gyroscope. After two minutes, the gyroscope's reflecting surface is horizontal to the earth, and the spot of light on the dial enables the pilot to navigate his aeroplane correctly without a glimpse of anything outside the machine.

The danger of a bad landing in fog* or darkness is lessened by another instrument—a sounder called the *Sonde de Securité* (le Prieur). It consists of a steel wire, 39 feet long, weighted at one end of its length in order to set moving a dial under the pilot's eyes.

When the pilot wants to land or alight on the sea, he sets his plane at the correct angle, by the gyroclinometer, carefully watches the dial of the sounder and as soon as that indicates "as you were," under the sharp tension of the cable whose weighted end is touching water or earth, he changes the dip of the aeroplane so as to bring the luminous spot on the gyroclinometer to zero.

Another instrument, the *Tachometer* (Tachymètre) simultaneously registers on several dials at a distance, the number of revolutions or velocity of the aeroplane's motor. The single moving part of the mechanism works in oil.

An even more remarkable apparatus enabling a pilot of an aeroplane or dirigible on a long air-voyage of many hours to determine the force and direction of the wind and the lee-way of the aeroplane drifted by the wind blowing across sea or land is the French *Navigraphe* (le Prieur), exploited by "La Précision Moderne," of Paris.

* Dr. Behr, the German physicist, has applied a modified form of hydrophone, called the ecophone or *echolot*, to find the height of an airship or aeroplane above ground, in fog or at night time. An emitter on the airship's hull sends out a sound-wave, which is reflected back from the earth to the airship's hull, where a dial measures the time taken for the emission and reception of the sound, and tells the height.

The *Navigraphe's* "eye" is a rule pivoted and bearing on one of its divisions a sighting-glass, and on the other, a scale graduated in kilomètre-hours. The recorder of the instrument is a paper band, unrolling from a slide, marked by a pencil which is attached to rods, connecting it with a collimator. It can be moved to the right or left. Above it, is an adjustable dial graduated from 0°-360° like a compass card and turned by a handle.

On this compass-card is fitted a second dial of smaller diameter, and bearing a pointer, whilst a paper disc, inscribed with parallel lines and concentric circles, is affixed to the dial-plate.

A fixed index-finger on the dial shows the aeroplane's "lubber-line"—or direction of the machine's head in relation to the compass-card. Finally, a flexible line, running from the handle operating the dial-plate, controls repeater compasses in the pilot's cabin.

Let the reader imagine himself standing by the side of an aviator navigating the airways from London to Glasgow. Glancing at a chart in the cabin, the air-navigator finds his first bearing which is the angle made with the meridian by a line, drawn on the chart, between the two cities.

He next turns the pointer on the compass card so as to make the ascertained angle coincide in position with the lubber-line's index-finger. This corrects the airman's route for "declination." The slide is moved so that the pointer may be opposite to the number on a graduated rule showing the aeroplane's speed per hour.

The pilot has now obtained his bearings and steers by them. If the air were perfectly calm throughout the flight, the course set would be a bee-line to the aeroplane's destination (Glasgow), but the wind causes deviation from the course, and the pilot has to take fresh sights in order to correct the deviation. This he does by sighting some point on the ground—a tree, cross-roads, or houses—and, keeping the sighting-glass on this point, he traces with a pencil a line on the recording paper-band referred to above. Two or three similar sights are so traced side by side.

The mean of the three lines is taken, and the rule or reglet adjusted by inclining it to the dial at the angle indicated by the mean of the sights at the time observed. Using a pencil. he can now trace on the graduated paper disc over the dial a line recording the amount of drift or lee-way.

To find the speed of the wind, another sight is taken, and similarly recorded on the dial, and a line drawn from the point of intersection of the two drift-lines across the concentric circles to the centre of the dial will show the speed by reading five kilometres for each concentric circle so crossed.

If a sea-plane wishes to ascertain its bearings, drift and wind-speed at sea, the navigator drops a light-buoy, as a fixed sight-mark, and makes allowance for the fact that the buoy, when it hits the water, drifts rapidly to the rear of the sea-plane.

Are we on the eve of the day when a man touching a magnetic switch in an office in London, Paris or Rome will cause an aeroplane or airship, with no human being on board, to start off on a voyage of thousands of miles, carrying cargo, or mails, and return safely to its home port?

A remarkable experiment successfully carried out in the gulf of Spezia, where Shelley was drowned, seems to suggest that that day is much nearer than one would suppose. Signore Professore Fiamma, the inventor of a remarkable system of radio-steering, recently stood on the terrace of the fortress of Varignano, and, surrounded by Italian statemen, naval chiefs and journalists, merely touched a switch on a key-board at his elbow, causing a 50-ton electric motor launch, the "Orlando," to speed seaward. He touched another switch, and the launch stopped; another, and she turned round and darted shoreward, sounding her syren, and altering her course, in response to successive touches of other switches. Not a man was on board the launch.

The key-board on the parapet of the fort was electrically connected with a controlling device placed in a sentry-box under the terrace, from which wires led to the transmitting apparatus in an underground chamber of the fort. It was uncanny to watch the way in which the launch, travelling at four miles an hour, quickly responded to two pressures on the key-board, one touch altering her helm, the other controlling the working of her motor. The inventor employed a battery of 40 volts, and on his key-board were seven "commands," each independent of the other: "Move ahead" (Marcia avanti); "Move backward" (indietro); "Stop" (arresto); "Helm aport" (timone a dritta); "Helm steady" (a centro); "Helm to starboard" (a sinistra) and "Open the Whistle." The vital nerve-centre of the radio-steerer is a "selector," which responds only to the mechanical impulse intended for it by the transmitter, and each impulse is dictated by a special wave-length governing the action of the mechanical "selector."

Signor Fiamma has crowned twelve years of experiments by this achievement. Two years ago, the Italian Minister of Marine sanctioned an experiment at Spezia when the radio-receiver of the Fiamma steerer was stationed at S. Vito, a hundred metres (one fifth of a mile) away from the Italian battleships, "Citta da Milano," "Andrea Doria," and "Pisa," anchored in the bay.

These battleships emitted from their powerful wireless instruments signals of varying wave-lengths in order to *try if they could create artificially a magnetic disturbance* which would interfere with the signals transmitted from a key-board on a neighbouring anti-submarine boat (MAS 223) to the receiving station at San Vito. The receiving installation could not be touched by any person unless he wished to receive a severe, electric shock. It was found that the receiver of the radio-steerer ashore was not interfered with even if the wave-length of the battleships' radio was the same as that transmitted by Fiamma's device.

At another interesting trial, in the presence of the Italian naval authorities, Signor Fiamma installed his radio-transmitter on board the Italian destroyer, "Cosentz," anchored in the Bay of Spezia, and from her radio cabin again directed the operations of the anti-submarine boat, "M.A.S. 223," with a hull 51 yards in length and a speed of 20 miles an hour. As in the case of the motor-launch, "Orlando," there was no crew on board, and the "M.A.S. 223" responded in like manner to successive touches of the switches of the key-board on the destroyer.

The inventor claims that his system of radio-steering will revolutionise the conditions of naval warfare, since by its use a floating, surface "fire-ship" (brulotto), heavily charged with explosives, entirely under wireless control, and with no one on board, can be driven against the hull of a battleship with terrible effect. A submarine, similarly regarded as a "fire-ship," can be so controlled by radio in under-sea warfare, whilst an attack by aeroplanes and dirigibles on a port can be beaten off by aerial torpedos, steered by the Fiamma system, from a hidden control-station.

The French Government has installed, at the military air dépôt, at Istres, on the Mediterranean, a "wireless" pilot or "telemechanic apparatus," which can be fitted to any type of aeroplane. It is attached to the fuselage just beneath the pilot's seat and consists of a gyroscope for maintaining automatic stabilisation and the apparatus for receiving the wireless waves from the ground and for causing them to operate the controls of the motor and of the aeroplane.

The wireless waves are transmitted to the aeroplane either from the ground or from another aeroplane in the air. Thus a wireless operator in a machine with a pilot can drive in front of him and direct the movements of a whole squadron of pilotless aeroplanes.

An operator working this radio pilot will sit before the wireless transmitting apparatus in the offices of one of the big air transportation companies. He will send wireless orders to pilotless 'planes carrying goods to various towns in France, and possibly to other European capitals. The absence of the pilot will leave so much more extra space for the carriage of goods; but the day when *passengers* will travel in radio aeroplanes is still to come.

Britain, however, has the next best thing in the form of an aeroplane which is stated to be self-flying. It is a Handley-Page bi-plane at the Croydon air station, and is driven by a powerful Rolls-Royce engine and two smaller motors. The stabilising device is an automatic gyro-pilot controlling the rudder, and it is said that, in rough weather, this machine would be safer and keep its course more surely than an aeroplane manned in the customary way.

The story is told of the pilot of a cargo-plane who, on a recent trip to London, switched on his automatic control, and then moved back from his cockpit to the cabin behind, sitting there and reading a book, his mechanic merely keeping a look-out and watching the engines, but not in any way touching the controls. All the time the machine flew itself, keeping strictly to the course which it had been set to follow.

This new automatic "pilot" has been evolved to render commercial flying possible even during the worst kinds of weather.

Ideas on what is possible in flying were revolutionised at Croydon Aerodrome, England, in April, 1925, when English Flight-Lieutenant Bulman caused his aeroplane to lose its flying speed at a low altitude. Aeronautical experts gazing up into the sky, held their breath, expecting the machine to shoot violently downwards, spinning in an uncontrolled dive, and crash to earth. But his aeroplane merely hung motionless in the sky for an instant. Next, the airman swung his 'plane round, with its nose up and its tail down, flew off, and shortly after, made a perfectly safe landing in the aerodrome.

This mechanical wonder was achieved by the operation of the Handley-Page slotted wing device, consisting of an adjustable slot, right through the planes, 18 inches behind the leading edge. When open, this slot increases the lift of the machine in the air and allows a smaller area to support a greater weight at a lesser speed. The wing-slot system, worked in conjunction with the balancing planes or ailerons gives the pilot, it is claimed, six times as much control over his aeroplane as anyone has ever had previously.

If the aeroplane "stalls" (loses its flying speed which lifts the planes in the air), the pilot need not lose his control. He can prevent his aeroplane from spinning and crashing to the ground, and can keep it on an even keel, so that if his machine sinks to the ground, when "stalled,"* all the injury he will sustain will be a damaged under-carriage, and no personal hurt.

The wing-slots are controlled by the movement of a single hand-lever, and ailerons—hinged flaps at the rear of the plane, controlling it laterally—are made more efficient by a slot between the main plane and the aileron. This acts similarly to the front wing slots. Mr. Handley-Page, head of the well-known aircraft company, demonstrated the powers of his machine before the International Air Commission at Farnborough, England, in the same month.

Mr. Anthony Fokker, the well-known Dutch designer of the *Fokker* war-time plane, also flew a safety-first commercial monoplane (Napier-Fokker) at the same time. He went up with eight passengers in the saloon and slowed up his aeroplane until it seemed motionless. It sank lower, but only a very little, and then regained flying-speed by the operation of an automatic device for maintaining a sufficient speed under all conditions.

Such command is given over an aeroplane in flight, by the Fokker stabilising device that on test flights, in August, 1925, the pilot made a large aeroplane loop the loop and tossed it about in mid air as though it were a light aeroplane. Hundreds of feet up in the sky, he gave the aeroplane into the hands of a woman passenger who had had no experience whatever of the handling of aircraft. She piloted the machine without mishap. It is capable of a speed of two miles a minute.

* Captain G. T. R. Hill has invented a "tailless" aeroplane, named the "Pterodactyl," which (June, 1926) is controlled largely by movable wing tips, designed to prevent crashes, should the pilot lose control in the air.

The danger of fire in the airways is a very terrible one and hardly a month passes in which the newspapers do not report the deaths of pilot and passengers in an aeroplane blazing in sudden flames as it rushes along the cloud paths.

A pilot, sitting aloft in his cockpit, scanning the airways has his attention and energies concentrated on the control and navigation of his machine, and the motor may suddenly take fire and go up in flames and smoke before he is alive to the extreme peril of his situation. He cannot stop to put it out. He has to devote all his skill to the job of finding a safe landing-place on the ground beneath, and the operation has to be performed in less than nine seconds, after which experience proves it is impossible to master a fire blazing from the motor. No wonder, then, that an agonising death is often the sequel to a fire on a flying machine. What is he to do?

A famous French aviator, Monsieur Béchard, whose imagination has been quickened by this very real peril, has spent ten years in research and experiment to make the air safer for fliers. He has invented a novel, automatic fire extincteur based upon the principle of the steam engine with tubular boilers, and using compressed air and carbonic acid inside the bonnet of the aeroplane.

The automatic fire extincteur consists of four tubular boilers, like those inside a railroad locomotive. The tubes are connected with a piston made of expanding, aneroid rings, comparable to those of an aneroid barometer. Boiler, tubes and piston are filled with essence of petrol. How does the automatic extincteur work?

Let the reader now visualise himself flying at night time with nothing but the starry skies overhead, and far beneath the droning plane, faintly outlined in the darkness, the plan of the earth. The motor takes fire, and the pilot knows nothing of the disaster. At once, if the aeroplane has a Béchard extincteur, the petrol essence vaporises, like water turning to steam, in the boiler. The growing pressure in the boiler tubes, caused by the expanding petrol vapour, thrusts forward the aneroid-piston, causing the rings to expand and lift a lever, which releases a powerful spring and opens a stop-cock. Compressed air or carbonic acid gas rushes through the outlet from a reservoir and immediately works the pumps of another reservoir containing liquid fire-extinguisher. This liquid is shot, in a series of strong jets on to the seat of the flames.

Simultaneously, the magnetos of the aeroplane motor are put out of action; the petrol gas is cut off from the engine; the petrol essence shut off in the extincteur; and the shutters of the aeroplane's radiators firmly closed to exclude the air from the flames.

In less than one minute, the fire is automatically extinguished, whether the aeroplane is on the ground or in the air.

Béchard was a short time ago put through some stringent tests by the French and Belgian military authorities. In one of a number of flights at Istres aerodrome, Monsieur Béchard's machine was set on fire 1,250 metres (more than three quarters of a mile) up in the air. Such a violent explosion burst forth inside the bonnet of his aeroplane, that he thought—he was piloting the machine—the right side of the motor had been blown away. The extincteur acted instantaneously, and in three seconds, the fire was put out, a dial in the cockpit recording the great speed of the operation.

Two hundred people watched the aeroplane take fire in another test in the air, when smoke and flames completely hid the machine, and a tongue of flame, a yard long, shot out of the escape pipe. Yet, in six to ten seconds, the fire was all over.

The extincteur can also be operated by hand, the pilot merely pressing a switch. After the fire, he can recharge the reservoir with extinguishing liquid, by turning another switch on the dial. It is stated that two litres (3½ pints) of the liquid will master the most violent fire on an aeroplane. A prize of 5,000 francs was recently awarded to the aviator by the French *Union pour la Securité en Aeroplane.*

Then France has also recently given us an *aeroplane-auto*, which flies at 110 miles an hour, descends to earth, and travels as smoothly as a well-sprung motor car at 20 miles an hour, up hill and down dale, and in and out of the thickest traffic on the boulevards of Paris. It opens up new vistas of possibilities for travellers and tourists, as well as explorers in unknown lands, for it is as much at home in the air as on the ground.

Monsieur René Tampier, the inventor, recently fled his machine for two days at Buc Aerodrome, and then drove the aeroplane transformed into a motor car, through the leafy roads of Versailles and the outskirts of Paris into the Aeronautical Exposition at the Grand Palais. The day after the closing of the Exposition, the auto-aeroplane climbed the steep roads leading to the heights of Montmartre, and then motored down into the avenues of Paris, where it ran about for two hours.

When in the air, the Tampier aeroplane-auto, or motor-car-plane, has a wing-spread of about 3 feet 8 inches; but, by raising part of the lower wing of the plane and causing the ailerons, or wing-tips, which permit the pilot to incline his machine to right or left during flight, to intersect each other, and the upper wings almost to touch, the wing-span is reduced by the action of a patent folding "cell," divided into two halves which are turned around the rear mast nearest the fuselage (motor and body of the aeroplane). The Tampier plane is now ready to run as a motor car on the ground, and its wing-spread has now become about eight inches.

At the rear of the plane is a vanishing train of wheels (tyred), hidden in the interior of the fuselage when not in use. These are protruded, and the motor-car-plane is run along the ground by power supplied from an auxiliary engine in the fuselage, working the transmission-gear connected with the wheels on the base in front. These wheels run on ball bearings and can be easily braked.

To make ready the motor-car-plane for the air, the steering-gear is folded under the fuselage, the wings lengthened, the wheels dismantled and fixed securely in the machine, and, in 20 minutes, the machine "takes off" from the ground and soars into the air. The 'plane weighs about 1¼ tons and is driven by a 300 horse power Hispano-Suiza engine which can make head against the strongest winds.

Should a breakdown occur, or the pilot be forced to land, the motor-car-plane can be safely returned by road and housed in a garage like an ordinary motor-car. In war-time, the auxiliary motor, driving the motor-car-plane on the ground, can be used to fire air-bombs, and torpedoes; in peace-time, on reconnaisance in savage countries or uninhabited lands, where engine trouble forced the pilot to land, he could run the 'plane as a motor car to the nearest source of help or fuel.

CHAPTER XII

SCENIC ART OF THE MODERN THEATRE

HOW DRURY LANE WORKS ITS WONDERS—THE MECHANISM OF THE LIGHTING BRIDGES—MASSED BATTENS OF LAMPS—BATTLE OF SCENERY AND ELECTRIC LIGHT—BLAZING SUNS ON THE STAGE—MYSTERIES OF THE JEU D'ORGUES—STAGING SHIPWRECKS AND RAILWAY ACCIDENTS—ELECTRIC AND HYDRAULIC BRIDGES—REVOLVING STAGE OF THE "COLISEUM"—NOVEL, LUMINOUS SCENERY—M. EUGÈNE FREY'S TRANSFORMATION OF GRAND OPERA SCENIC EFFECTS—METICULOUS PHOTOGRAPHY

A WONDERFUL company of Crusading knights in glittering armour, swords girded to their sides, emblazoned with the sign of the Cross, and of tonsured monks, are gathered together in the nave of a great Gothic monastery of the late Middle Ages. They face towards the high altar and bow as the Host is elevated. The tones of a noble organ swell out, and over all rises the solemn yet glorious Gregorian music chanted by knights and monks, through which breathes the wistful soul of the ages of faith. The chant dies away, the priests and soldiers file out, and it is "on bill and battle-axe and mangonel" to the gates of Jerusalem!

This picture out of the pages of Boccacio dissolves, and we are on the Bridge of Sighs, watching through the cool colonnades the gondolier dreamily plashing his way along the canals of Venice. Again the magic carpet whisks us away to gaze on the Hanging Gardens of Damascus, and we stand in the palace of the Soldan, with its baroque splendours of Oriental life and colour, picturesque Eastern mobs and bevies of dancing girls in voluptuous seraglios. The climax of wonder comes when the whole company descends in front of the audience a staircase leading down behind the footlights, the Soldan of Egypt resting on the shoulders of his attendants, and behind him Saladin, Prince of Damascus.

A wave of the wizard's wand, the curtain falls, and you are on the stage of Drury Lane Theatre, behind the scenes at one of its grand spectacular dramas. The white walls of the vast stage tower above you like the nave of a great cathedral, as you gaze up at a forest of timbers and iron girders, lighting bridges and row upon row of electric lamps, flashlight suns, and brilliantly coloured bulbs. Glimmering faintly one hundred feet aloft, daylight falls on the high glass skylights; but the lighting galleries and the "gridiron," or plank ceiling supporting the drop-scene mechanism, far up the walls of this nave, pale in the half light or are lost in the deep shadows.

The staircase which the great company descended in full view of the audience now resolves itself into a number of "bridges" raised by electrical, hydraulic and hand power some three to eight feet above the level of the stage floor. Our brilliant company disperses to their dressing-rooms, and only a few stage hands, electricians and carpenters are to be seen back of the drop curtain.

Some 15—18 feet below the stage floor level, on an iron control platform, stands an engineer, grasping a lever, his eye on one of two electric bulbs. He is waiting a signal, or in theatrical language, his "cue." It comes. The bulb flashes red—a direction from the stage controller above that the bridge is to be lowered. He touches the lever, and the bridge descends into the bowels of the theatre.

Other men touch switches on other bridges, or haul against counterweights, and their bridges descend in succession, until where they stood is once more a level stage floor, with a number of cracks indicating the demarcation line between the bridges.

A tour behind the scenes of the Royal Theatre, Drury Lane, gives not only amazing glimpses of its spectacular capacity, but an insight into the electrician's cunning devices for securing lighting effects which, in combination with photography, are tending more and more to make scenery itself obsolete. There is ample room for scenic effects at Drury Lane, since from side wall to side wall a distance of 80 feet is spanned. The proscenium opening is 46 feet 3 inches wide; and, indeed, to the eye of the observer standing on the stage, the auditorium itself seems smaller than the stage.

Tier after tier of lights in battens, ranging in size from great searchlights and liner's mast lamps to small coloured electric bulbs, reach from the background of the stage to the front of the drop-curtain and just over the footlights. There are seven to eight thousand of them, representing an enormous aggregation of candle power and intensity of illumination.

Electric panorama lamps, with seven ranges of colours and thirty-six lights of two thousand candle power each, are ingeniously concentrated and graduated in intensity or dimmed, to secure realistic sunrise or sunset effects, let us say, over the great cordilleras of the Andes or the Rockies, and bathe in warm tints, brawling mountain streams, rushing along boulder strewn beds at the foot of lower hills, where log cabins and totemic wigwams stand amongst the pines—all this is represented convincingly by the scenery and lights on this vast stage.

These panorama lamps can be swung round in a circle, and, along with flood lights, be concentrated in a beam of rays to "spot-light" the stage stars. Striking colour effects are obtained from ten more electric battens of 260 lamps of forty watt power each, displaying three colour circuits. Then a powerful stream of light can be shot from lighting galleries on each side of the lofty stage walls, where twelve lamps, aggregating 24,000 candle power, cast their radiance over the actors and scenery.

The illumination does not stop here, for, in the proscenium space, just before the footlights, are more two-thousand candle power electric lamps.

Five horizon lamps, on each side of the stage, blaze out with the intensity of ten thousand candle power, sweeping the stage, lighting up its level, and chasing away the shadows from the tops of the towering scenery. These lamps are powerful enough to search the whole of the area behind the proscenium and half way up to the grid-iron or plank-structure just below the roof of the lofty stage. Intensely white limelights also throw into high relief the summits of the scenery, such as mountain peaks, castle towers, church parapets, minaret roofs, ships' masts and railroad viaducts.

Besides these electric battens, there are special arc projector lamps, of 100 amps each, and twenty-four extra limelights of two thousand candle power each, controlled by separate dimmers and switches. The function of these is to project a limelight on the stage to illuminate with dazzling brilliance the dresses of rainbow hues and golden splendour worn by the actresses. Naturally these bejewelled dresses blaze like diamonds under the intense white light. Eleven battens of lamps can be raised or lowered to any desired angle of elevation.

Prominent among these massed lights there stands near the beginning of the proscenium a batten of 56 lamps in three circuits of five colours. They shed down on the artists a glowing scene of blue, yellow, pink, amber and white lights. These charming, fairy-like effects are obtained by automatic changes of removable gelatine slides with which these electric lamps are furnished.

At the moment, the evolution of the art of the theatre has reached the stage in which battle has been joined between scenery as such and the optical effects it has been used to obtain, and electrical lighting devices, growing more technically perfect, which, in combination with photography, are tending steadily to reduce the amount of scenery used, and, consequently, the cost of spectacular production.

Lighting experts have, in many cases, been successful in abolishing hanging cloths and friezes painted to represent the sky and clouds, and with them the lamps illuminating them. The illusions of sky and horizon, cloud and tempest, rain and sunshine, can now be obtained by cunningly focussed lenses and white and coloured lights combined with optical and photographic apparatus which projects the appearance of summer or hurricane skies on transparent cloths suspended from the background of the stage. More, by concentrating the luminous intensity of a 40 ampère arc light on a small area, it is possible by the use of suitable object glasses and a long enough focus to project the image of a burning sun 2,500 times brighter than landscape painted on a sheet in the background of the stage.

At Drury Lane Theatre the wonderful lighting effects conferred by the massed battens of white and coloured lights, without or with lenses, and interchangeable, coloured gelatine slides are controlled, separately or in combination, from a switchboard located on the left wing of the stage, and called the "jeu d'orgues," since it appears like the organ stops of a church. There are two switchboards—a portable one and the permanent jeu d'orgues.

The electrician, standing in the latter lighting cabinet, has under his hand a series of circular dials, graduated with the numbers *1* to *12*, to represent the desired intensity of light required. Levers on these dials operate the "dimmers." If he wants the maximum light intensity of *12*, he merely switches over the lever until it notches at *12* on the dial; if half light, he turns the lever to point 6; and if zero, to the o, when the battens and combinations of lights are extinguished. A touch on the master control in the jeu d'orgues will at once put out every light on the stage. Should the stage controller wish to spotlight an actor or actress, then an operator standing immediately under a trapdoor beneath the footlights gets the signal to switch in his dimmer controlling the footlights, and project a blazing stream of white light on the "star's" head and body. The trapdoor switch is devised to act instantaneously.

Drury Lane takes the most stringent precautions against fire. The massive and lofty doors (four inches thick) at the back of the towering stage are sheathed in asbestos, and no one is allowed to smoke on any part of the stage or its approaches, below in the engine-room, or in any part of the building. To guard against the chance of fusing, the electric wires all over the building, and those conveyed to the jeu d'orgues switchboard, are sheathed in cold drawn steel.

But, to the man in the street, the most remarkable part of the mechanism behind the scenes is constituted by the *six bridges—two* hydraulic, *two electric and two manual* or hand-operated. It is these remarkable bridges which produce the illusions of ship and railroad accidents. The packed and breathless audience, gazing spellbound at a thrilling episode in the " Sins of Society "—one of Drury Lane's spectacular melodramas—saw an ocean liner wallowing in a heavy sea. A hurricane blew, the rain lashed in fury the decks of the liner, which heaved with all the realism of a raging sea. There was a deafening report, and dense clouds of steam blew up from her engine-room, swallowing in a white fog the helmsman at the wheel. The liner sank, her boilers apparently blown up —and the audience, when it recovered from its amazement, wondered how it was all done!

A spectator in the vast well below the stage would have seen that the " liner " was suspended on a mechanical contrivance called a ball and knuckle joint, whilst the engineer, standing on a control platform (of course, unseen by the audience), 20 feet below, waited his cue given him by the flashing of a green light from an electric bulb, on the platform. A touch on the lever rocked the hydraulic bridge, causing the dummy liner above to heave, giving the audience in the theatre the illusion of a heavy storm at sea.

Then, from the boiler-room, yards away in another part of the vast well under the stage, a mechanic, also getting his cue from the stage director, sent a powerful jet of steam through a flexible pipe running up to the wheel-house of the liner. The helmsman, in view of the audience, blew off the jet in a cloud of hissing steam.

The flexible steampipe also played its part most realistically in the "Whip," when Drury Lane play-goers were thrilled by the sight of a locomotive, running in with a shrill whistle on the stage and appearing to plunge over the parapet of a viaduct in a cloud of steam, smoke and wreckage!

As stated above, these bridges were also used to provide a grand staircase when the splendid Byzantine spectacle of "Decameron Nights" was produced at Drury Lane Theatre, in 1922. No less than 184 electric lamps of 500 candle power each were used to illuminate one scene of this spectacular drama, besides multitudes of stage lights of lesser intensity.

The two electric bridges are equipped with reversible gear and safety clutches. They are counterweighted to make them easy to work, and are operated by two 25 h.p. motors. Three powerful projection lamps are mounted on each bridge, besides other lights of half watt power. They can be raised or lowered but not rocked as can the hydraulic bridges. In front of each platform, in full view of the operator, is a scale, graduated in feet, indicating the height to which the bridge can be elevated or sunk. All bridges can be sunk 24 feet below the stage or raised about 10 feet above it, to suit the needs of spectacular productions, such as when, in 1923, the "Ascot Gold Cup" was staged at this theatre, and 16 spirited race-horses were put on at one time, to create the illusion of a first-class racing sensation.

Water comes in from the mains at a pressure of 850 pounds per square inch, but is stepped down to 150 pounds per square inch to operate the 18 inch rams of the hydraulic bridges. A safety valve automatically comes into play in an emergency and shuts off the water pressure should anything befall the operator. Stepping off his control platform and turning his head, the engineer can tell by glancing at a precision instrument the temperature at any given moment in any part of the auditorium. If the audience are feeling chilly, he can raise it by hot air from the engine-room, if they are overheated, he can send a stream of cooling air from the electric fans, and all the air is washed and purified. As for the limelight, which plays an important part in scenic production, more cylinders of oxygen are used at Drury Lane than at many hospitals to supply the two great tanks.

It may be added that the theatre, which is associated with Nell Gwynne, the famous actress, mistress of Charles II, dates back to 1663. It has been twice burned down in its long history, and many famous actors have trodden its boards. The present theatre, which has been beautifully renovated, was re-opened in 1922.*

The revolving stage of the Coliseum, London, has the novel feature that, whilst one scene is in progress, the stage can simultaneously be set for the turns following. This is done by the aid of three concentric discs, all on the same level. They can be interlocked and the stage revolved as a whole, or they can be detached and revolved singly in the same or in opposite directions. The top speed obtainable is more than 20 miles an hour, but the

* The writer's thanks are due to the courtesy of Sir Alfred Butt, who permitted the taking of photographs, and to Messrs. Webb (Acting Manager), Mather (Engineer), Munns (Master Carpenter), Tyler (Property Manager), and their staffs, who spared no effort in the difficult work of facilitating the taking of photographs.

These operations are as laborious as they are delicate. No less than eight months were needed to produce the luminous scenery for "Persian Nights."

While the scenery is being projected, the stage lighting follows the luminous changes on the screen so as to harmonise the parts played by real objects on the stage with that of the luminous scenery. The cost of the installation is comparatively small, it eliminates much hand labour, and the cumbering of the stage with heavy, movable objects.

Producers of grand opera in Paris, London, Amsterdam, Brussels, Milan, and at Monte Carlo, are "trying out" luminous scenery. The "Ride of the Valkyries," when staged at the Opéra, Paris, used to require a tremendous assemblage of iron rails, towering mountains, and fantastic properties, costing more than £4,000. The up-to-date producer, to-day, can achieve the same results more vividly and realistically by the use of a simple screen.

CHAPTER XIII

REVOLUTION ON THE OCEAN

MOTOR SHIP AND ROTOR SHIP—FUNNELS MERELY DUMMIES—WHAT BRITAIN AND AMERICA ARE DOING—MORE CARGO CARRIED—HUMAN SIDE OF MARINE "MOTORISATION"—TIMID PASSENGERS RE-ASSURED BY DUMMY FUNNELS!—THE S.S. "AORANGI'S" NOVELTIES—FLETTNER'S ROTOR SHIP—THE CONTROL CABIN—FUTURE OF THE WIND-TOWER SHIP

THE motorship, speeding along the seaways without boilers, and the rotorship, sailing without sails, are the signs and portents of the silent revolution that is being worked in the methods of ocean transport.

The world's largest motor-liner, the "Asturias," which started on her maiden trip on the Royal Mail Steam Packet Line to South America, in January, 1926, is the forerunner of a great fleet of trans-Atlantic liners, forecasting the passing of the turbine steamers, with their twin, triple and quadruple funnels. No dense pall of smoke belches from the "smoke stack" of the "Asturias," for she has no smoke stacks. Successive issues of Lloyd's Register of Shipping have shown that the motor liner is slowly but surely driving the steamship off the sea. The invention of the remarkable Diesel engine has brought about this transformation.

Thirty-three years ago, a German engineer, Dr.

Rudolph Diesel, first conceived the idea of this internal combustion engine, and by 1900 had brought it to perfection in the factories at Augsburg. In 1926, the first main line Diesel locomotives made their appearance on the railways of Russia and the United States, where their 1,000 horse power engines using no water, except a very small amount for cooling the engines, have hauled trains for many thousands of miles. The United States Government is so impressed by the idea of the Diesel engine for purposes of marine navigation, that in 1924 it authorised the U.S. Shipping Board to spend £5,000,000 in converting 50 steamships to motorships. Thus the race for supremacy in the commerce of the world's seas is now well on.

In the Diesel system of locomotion, power to drive a ship on the sea or a railway locomotive on land, is obtained by the burning of a mixture of gas in the cylinders of an engine resembling that used in a motor car, save that no electric spark is used to fire the gas. This is how it is done.

The air in the cylinder of a Diesel engine is compressed with a force of 500 pounds to the square inch. This compression raises the temperature of the air to about 1,000 degrees Fahrenheit, and so hot does it become that oil, sprayed into the cylinder at the high pressure of 750 pounds to the square inch, immediately takes fire. The heat grows greater and generates an expansive force which drives the piston operating the ship's propellers. On the "Asturias" no less than 20,000 horse power is delivered on 2 shafts, and the boat carries 1,740 passengers and crew.

In days where, more than ever before, reduction of operating costs is a potent factor in ensuring a margin of profit, the advantages of the motorship are very great.

A MOTORSHIP'S DIESEL ENGINES IN THE MAKING.

Photo by courtesy of Burmeister and Wain, Kjöbnhavn.

To face page 244.

Ships driven by Diesel motors save 75% on the space needed to carry fuel, which, of course, means that more space is set free for cargo with appreciable increase on the earning power of the ship. The fuel bill of a motorship is small compared with that of a steamer or an oil-burning ship with boilers. At sea, a motorship of average size will use 15 tons of oil a day, where an oil-burning ship would consume 30 tons. A high seas motorship can also carry more cargo than a steamer of the same size, because a very large amount of space in the engine-room of a steamer is taken up by boilers which are not needed by the motorship.

Water ballast tanks, carrying a non-paying element on board a steamer are absent on a motorship, as may be seen in the case of the "Fulda," built and launched by the German Weser Company at their Bremen yards, very recently. A novel feature of the "Fulda's" construction is a "bulge" which does away with the need for water ballast, replacing it with a storage reservoir for oil. The net result of this innovation is that the "Fulda" can carry 20% more cargo than a steamer of the same size.

But the human side is even more important than the commercial side in this revolution on the sea. We now witness the passing of the grimy toil-worn sailor dropping under the exhausting labour of coaling a ship under a burning tropical sun; or, stripped to the waist, sweating and thirsting in the inferno of a steamer's stokehold in equatorial waters, shovelling coal into a cauldron of flame or spraying oil under a ship's boilers at a gasping heat.

The Scandinavian countries are maintaining their Viking traditions by vying with each other in transforming their ocean-going steamers into motor liners. The Swedish-American line has just started a huge 24,000 ton motor liner, the "Gripsholm," on the Gothenburg-New York service. She carries some 1,700 passengers at 17 knots an hour and is nearly 600 feet long. This motor liner has funnels looking just like those of a steam turbine liner, but they are used merely as lift shafts to convey luggage or cargo from deck to hold or hold to deck. An ex-prime minister of Norway, Mr. Gunner Knudsen, is chairman of a shipping company which recently launched a twin-screw motor liner of 6,800 tons, the "Borgestad," the builders being the famous shipbuilding firm, Burmeister and Wain, of Copenhagen, the pioneers of the Diesel motor for large ocean craft. A Swedish engineer invented an ingenious rudder, in 1926, by which a motor-ship can be stopped in 10 minutes with the propeller still in motion.

It is curious to see how sentimentality clings even to matters of engineering and mechanics. Use is second nature in many things, so that it is not altogether surprising to find many people who would feel a pang of regret if the familiar funnel totally disappeared from the great ocean steamships. Funnels, as we said above, are of no earthly use as smoke-emitters on motor liners, but for appearance sake they are none the less installed. Not only the "Gripsholm," but a British-Indian Diesel ship doing a coastal trade in Oriental waters, uses her dummy funnels for other purposes. The British ship uses them as ventilating shafts, up which the foul air from the ship's interior is expelled by a powerful blast. A humorous side-light on the change in ocean transport is shown by the Jew immigrants bound for Buenos Ayres on the powerful motor liner "Sarmiento," who said they thought no ship could be safe without smoke-stacks. The Hamburg-South America shipping line was accordingly compelled to instal two dummy funnels on the liner, or lose the valuable immigrant traffic!

The motor ship has also its dummy steam syren. This takes the form of an air whistle emitting what looks like steam. Such a device plays a very useful part in a crowded fairway, where many ships are passing up and down, because the pilot, standing on the bridge of his tug, is accustomed to depend upon the sight of the white jet of steam blowing from the incoming or outgoing liners, rather than the sound of the syren, as a signal showing which ship requires his aid. In a high wind or gale he probably cannot hear the ship's whistle. On the motorship, in the ordinary way, he would not see steam issuing from an air or electric whistle. The Sperry Gyro Company has devised, however, a visible air whistle, blown by compressed air and emitting a white cloud of smoke in the same way that military aeroplanes send out smoke screens. The man on the liner's bridge opens the whistle valve, letting air into a nozzle, which takes "liquid smoke" from a tank and blows it out in a white cloud from the syren.

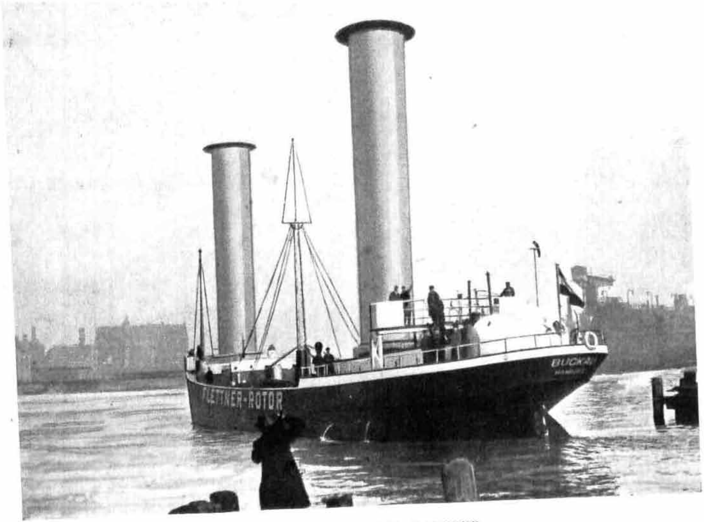
The first skirmish in the fierce battle between oil and coal was opened by the sailing of the world's first ocean-going motorship, the British liner "Aorangi," on her maiden voyage from Southampton to Vancouver and New Zealand. She maintained on the voyage an average speed of 17½ knots on the outward trip to Vancouver, burning 56 tons of oil a day for the use of both Diesel engines and for the auxiliary purposes of the laundry, cooking and steam heating. When the "Aorangi" reached Vancouver she had burned 1,250 tons of oil at a cost much less than that of oil from an oil burner's sprays or coal under a steamer's boilers on a voyage of the same length.

Twenty years of arduous experimental work bore fruit in the " Aorangi " with its 4 screws and accommodation for 970 passengers and 330 officers and crew. Hardly any firemen or oil trimmers are needed on this ship, which is so free from vibration that, in a violent gale in mid-Atlantic, her saloon was almost as motionless as a hotel lounge would have been ashore. She has a specially sprung dance floor and a wireless cabin with all the latest instruments for receiving news and musical programmes from Europe and America, or for transmitting messages to far-off marts and exchanges from latitudes and longitudes of Southern Seas. Even her lifeboats are motor driven, carry 50 people each, and are launched by gravity from automatic davits.

If the dynamos in the ship's engine-room were flooded by inrushing sea-water in time of collision and wreck, a Diesel engine on the ship's top deck would come into play and supply power and light until the last moment.

Valves in the ship's engine-room are regularly " scavenged " by airblasts from a " turbo-blower " which prevents them clogging on the voyage and so delaying the ship's arrival at port.

It is by way of a digression to consider how far the Diesel engine on land is likely to make obsolete the steam railroad locomotive; but perhaps the reader mechanically minded may be interested to know the story of the Diesel railroad engine in Russia. One of the difficulties of railroad engineering in waterless parts of Europe and Asia is the provision of water for the boilers. As we know, water is not required for power generation on the Diesel engine, and for fuel a crude oil far cheaper than is burnt by oil-consuming locomotives is all that is needed for the Diesel engine. The first Diesel engine for the Russian railroads was built at the famous German locomotive factories at



ROTOR SHIP IN KIEL HARBOUR.
Photo by courtesy of Herr Anton Flettner, Berlin.

Augsburg, and was put on rail in 1925, since when it has run 40,000 miles and more. It climbed 6,500 feet up Mount Ararat, in the presence of the British chargé d'affaires in Moscow, and a representative of the British Foreign Office. The Soviet Government is now building a Diesel locomotive at the State railway factories at Leningrad, and has ordered others from England and Germany, besides offering prizes for a public competition open to engineers who can design the best Diesel locomotives. In England, so far, the use of the Diesel locomotive has been confined to experiments on main line railways where small trains of freight and passengers have been successfully hauled at a low cost for operation and fuel. Sir Henry Thornton, the president of the Canadian National Railroads, probably expresses the views of most British railway managers when he says that " the Diesel engine is likely to go a long way towards the solution of branch line problems and motor omnibus competition."

Unlike the motorship, the rotorship which is the creation of Herr Anton Flettner of Hamburg, and inheritor of forgotten experiments made a quarter of a century ago, by the German professor Magnus of Göttingen University, seems destined—so far as can be seen at the moment —to supplement rather than supersede existing methods of marine locomotion.

The invention is the work of many months and is the result of secret experiments carried out in a glass-sided air tunnel (at Göttingen University) into which artificial winds of any speed can be made to blow and where the effects of air currents on rounded surfaces can be seen.

The Flettner rotorship, as it is called, has two round metal towers 50 feet high and 10 feet in diameter on her decks. These towers are hollow and revolve on pivots at the bottom of the ship. Small electric motors rotate the towers and the wind, driven against their rounded surface, acts with far greater force than upon stationary sails. The Flettner rotorship can sail with the wind and tide behind her or against the wind when the tide turns. By stopping the rotation of one of the towers the rotorship can be swung completely round. The propulsive effect is stated to be about 15% greater than that on a similar area of canvas. Boats equipped with these towers have an auxiliary power which can be used to turn the propeller, and it would seem that the wind-rotated towers might themselves be used to operate a dynamo and thus obtain a cheaper power-supply.

A man in the wheel-house controls the speed of the towers, and a dial shows the rate at which they are turning. By turning a handle, he can accelerate, slow or stop the rotation. Over 70 years ago, the German Professor Magnus discovered that wind, driven against rapidly-rotating cylinders, acts with much greater force than upon stationary sails.

On the open sea, the motors were stopped in a recent test, and the ship driven forward by rotors, the wind blowing at 5 miles an hour, and the speed of the ship reaching 8 knots. The best speed is obtained when the wind strikes the ship at an angle of 35 degrees to her course.

Herr Flettner, who is a naval officer of 42 years of age, says that his rotor system, in its present stage of development, is a valuable auxiliary aid to other forms of motive power.

In navigating the strange rotorship, it is found that, when the cylinder revolves the wind exerts greater pressure on the side turning towards it, and less on that turning in the same direction. The ship therefore moves at right angles to the wind, and whether forward or backward depends on the direction in which the cylinder rotates. If there is no wind, the revolving cylinder causes a whirling of the air round it, and the area of whirling air is wider according to the rapidity of the rotations. If a wind springs up, it meets the whirling air round the cylinder.

On the one side, where wind and whirling air are in the same direction, there is a low pressure, and on the other side, where the currents clash, there is a high pressure. Therefore, on one side of the cylinder there is a suction and on the other a " drive," and the ship, with two 60ft. high revolving cylinders, will move at right angles to the wind.

During a recent test, between Hamburg and Leith, contrary winds blowing west across the North Sea, are said to have necessitated the use of the auxiliary motor aboard to keep the vessel from drifting out of her course. But the last has by no means been heard of the rotor, either on the sea or in the air, where it seems likely to form an exceedingly useful source of supplementary power, as it did on the recent voyage of the rotor-ship " Baden-Baden," from Kiel to New York harbour.

CHAPTER XIV

TELEVISION AND NOCTOVISION, TO-DAY AND TO-MORROW

A GENIUS IN A GARRET—THE LIGHT SHINING ON THE LONELY CABLE-STATION WINDOW—HUMAN EYE AS AN IMPERFECT TELEVISOR—CONTINENTAL PIONEERS OF SEEING BY RADIO—CATHODE-RAY WONDERS—BELIN'S PREDICTIONS—A PARADOX OF HUMAN VISION—WOULD PERFECT TELEVISION SMASH THE MACHINE?—A FRIGHTENED OFFICE BOY—HOW "SPARKS" ON THE LINER "BERENGARIA" SAW HIS SWEETHEART 1000 MILES AWAY—SOUND WAVE OF A CABBAGE—FIRST SUCCESSFUL TRANSATLANTIC TELEVISION—TERRORS OF SEEING BY RADIO TO-MORROW—STRANGE POWERS OF THE NOCTOVISOR—TRANSMITTING PICTURES THROUGH A FOG—WHAT AMERICA IS DOING—U.S. RADIO PRESIDENT SAYS FIVE YEARS HENCE WILL SEE PERFECT TELEVISION ACCOMPLISHED!—X-RAY TELEVISOR OF THE INTERIOR OF THE HUMAN BODY.

THE whole romantic story of the labours of fifty years of investigators in the fields of modern science, whether radio or mechanics, is a constant reminder of the fact that creative genius is by no means necessarily a product of academic laboratories, with shining machines and costly lenses, or of University chairs with rich endowments and State grants-in-aid. In the sphere of electrical television, for example, the white-haired scientist with his band of devoted technical assistants and post-graduate research workers has, before now, found the co-operative efforts of many brains set in the shade by the discoveries of some obscure genius, harassed by ill health and poverty, working in a garret up four flights, with no assistant, and an apparatus of sealing-wax, string, biscuit tins, old bicycle parts, and bull's-eye lenses picked off a dust heap!

Television, which may seem the latest scientific toy, is not really quite so new or amusing as the man in the street and train may think. The first impulse came from the chance discovery of a cable operator in the lonely Atlantic station at Valentia, on the rugged south-west coast of Ireland. One afternoon, in the year 1873, the sun was shining through the window of his instrument room, when this operator noticed the needle unaccountably move on the dial of the instrument. He was puzzled by the aberration of the needle, then he saw that the needle moved every time the sun's rays touched the selenium used to create resistance to the passage of the current.

Scientists were quick to note the importance of this chance discovery. It meant that selenium had the power of converting the sun's light into electricity. The electric "eye" had, at last, been found. Here was the first step towards electrical television; already had the electric ear, in the shape of Bell's telephone, been discovered. But, scientists asked themselves, might not the solution of the problem of finding and using the power of the electric eye be assisted greatly by a closer study of the working of the apparatus of the *human* eye? What really happens when the eye telegraphs an image to the brain?

Light falls on the crystalline lens of the human eye, which projects an image upon a screen called the retina. The surface of the retina of the human eye consists of a network of millions of hexagonal cells, connected to the brain by the filaments of the optic nerve. Along these filaments, light impulses are conveyed to the brain in a way analogous to the transmission of an electric current along a cable. In the human eye, the transmission of the light impulses is greatly assisted by what is called the "visual purple" flowing through the hexagonal cells of the retina. This visual purple is a light-sensitive substance, by whose aid millions of microscopic images are transmitted from the microscopic hexagonal cells of the retina to the brain, where they are built up into a complete image of light and shade, corresponding to the image of the original object so transmitted.

Accordingly, in 1906, two French scientists, Fournier and Rignoux, set to work to construct an apparatus based on the optical machine of the human eye, which, be it observed, despite pious statements to the contrary, is not itself a quite perfect instrument. They made a transmitter consisting of 64 selenium cells set on a wall. Two wires ran from each cell to a receiving screen of 64 shutters, each shutter being controlled from one of the 64 cells. At the transmitting end, a bright light was directed on a selenium cell. This cell converted the light into an electric current[1] which flowed through the wire and opened a corresponding shutter at the receiving end, or screen. By this primitive device, letters of the alphabet were successfully transmitted; but, obviously, such an enormous number of cells and shutters would be needed in this system, that it would be too expensive to be practicable.

The Russians, a race numbering some of the world's cleverest and most brilliant chemists and physicists, worked on the problem of television. They were the first to use the

[1] These photo-electric currents are exceedingly minute, and tend to distort the transmitted image. In 1928, two German scientists are stated to have accidentally discovered a photo-electric current of 100 ampères, when experimenting with a mercury arc lamp rectifier, in the Siemens-Schuckert Works. If this is so, German television has taken a great stride forward.

cathode ray in the receiving apparatus. The cathode ray is an electrical discharge occurring when electricity is forced through a high vacuum, where it is emitted in a pencil-like form, and can be guided in any direction by magnetism or electricity. Having no weight, and consequently no inertia, or tendency to remain stationary, there is no limit to the speed at which the cathode ray can travel. A crystalline plate of fluorescent material placed in the path of the cathode ray is lit up by a brilliant spot of light. As the reader may know, an amazing speed is necessary in the operation of a television device reproducing images of active life and living things, which is why the cathode ray has been used in conjunction with the fluorescent screen.

A propos of the cathode ray, it will be remembered that, in October 1926, the famous American physicist, Dr. W. D. Coolidge, assistant director of the General Electric Company's laboratories in Schenectady, New York, told the Franklin Institute, at a meeting in Philadelphia, that he had devised a wonderful cathode-ray tube generating billions of electrons. This tube is stated to be able to produce as many electrons a second as a ton of radium would yield, and since the world's present yield of radium is 1/2000th of a ton, and the rays are non-penetrating, this cathode-ray device should prove of great use in the science of healing. Already, in Austria, electrons have been made use of in television.

The Russian Professor Rosing, dispensed with mechanical parts in his television device (in 1908), and by using, as his transmitter, two mirror polyhedrons, or many-sided solids, rotating at right angles to each other, he made their combined revolutions pass an image of the object to be transmitted over a light-sensitive cell. From the cell, a varying current was sent to the receiver, where it charged two condenser plates which deflected the cathode ray away from a diaphragm or aperture in its path, so that the amount of the ray passing through was proportionate to the potential of the two electrified plates. The ray crossed a fluorescent screen and produced a brilliant spot of light. Professor von Mihaly of Vienna used small mirrors vibrating on wires in a magnetic field. The mirrors explored the image, and were used together with a selenium cell. It may be said that the characteristics of European Continental devices for television, invented in the laboratories, are these moving mirrors, rotating and beating from side to side like the wagging of the pointer of a metronome. In England and America, television research workers and inventors have followed a rather different line in devising their apparatus.

Now, the pioneers in the field of television found the selenium cell, when in use, was apt to grow tired—or to use the laboratory terms suffered from "time lag" and "chemical inertia"—and this was a serious defect in the field of high-speed transmission and reception of images. Then the genius Hertz, of Hertzian-ray fame, discovered the photo-electric cell. Ultra-violet light, falling on a spark gap, he observed, allowed the electric discharge to pass more readily. Herr Hallwach, the German physicist, found that the photo-electric effect was at the negative pole, and that potassium, sodium and rhubidium gave much more pronounced effects. So the next thing was the invention of a photo-electric cell, using a plate of potassium and another collecting wire enclosed in a vacuum tube. This photo-electric, light-sensitive cell was instantaneous in action and did not get tired; but, unluckily, it proved in action too insensitive to respond to the minute quantities of light in television. The cell would transmit shadows well enough, but failed in the transmission of little, middle or half lights.

To-day, the amount of progress made by television research workers in European laboratories[1] may be gauged in what we have to tell of the work of M. Edouard Belin, well known in France, in the field of photo-telegraphy. His words are worth quoting to all folk who are sceptical whether television will ever reach the stage when we shall be able to sit in a room in London and see what is taking place in Bombay, Tokyo, San Francisco, Sydney, Melbourne, New York or Moscow; or that the day will come when people will sit by their firesides, or other form of heat radiators, and listen to the words of a Shakespeare or Shaw play, while gazing simultaneously on a screen showing the movements of the actors and the stage scenery.

" In our modern age, the time factor in the perfection of an invention is becoming shorter and shorter. In 1830, Daguerre succeeded in fixing on a metallic plate images produced in the dark chamber of a camera. From his invention to the modern cinema film is a stretch of three-quarters of a century. I believe that events in television will move far faster than that. Of course, in the actual state of things, I cannot divulge details of my present researches. *Je tiens à ce que l'honneur de l'avoir trouvée revienne à mon pays seul. Orgueil légitime, n'est-ce pas?*"

Belin distinguishes three forms of television—telephotography, or the reproduction of a document of some form; television proper, or the reproduction on a screen, at a great distance away of some living person or actual event; and an intermediate form, telecinematography, in which is

[1] The great German trust, the A.E.G. were, in 1928, said to be using for television experiments, a light valve, invented by Dr. Karolus, and based on a physical device invented by the Rev. Dr. John Kerr, F.R.S., died 1907. This valve comprises two Nicol prisms placed between plates immersed in nitro-benzine. When a current is applied to the two plates light at once passes. The device has no time lag.

reproduced a film rolled off on a luminous screen in New York, say, and reproduced in Paris or London. He explains that an image to be transmitted by television is simply a collection of points of light reflected by the human face, railway engine, aeroplane, horse race, or whatever that image may be. Once admit that a source of light, like a voice before a microphone in a broadcasting studio, can act on a radio-electric transmitter, then, if you have the apparatus for converting the Hertzian radio waves back into a combination of the points of light transmitted and corresponding with the complete image, you have solved the problem.

Briefly, Belin's televisor, so far as was known in March 1926, consisted of a device of several mirrors, a lens, and a photo-electric cell. Over the surface of the image to be transmitted, a luminous ray travelled line by line like a pencil moving vertically up and down. So high is the speed necessary for perfect television, that the whole image must be transmitted in one-tenth of a second, and each point of light, reflected by the image, must pass the receiving apparatus in 1/250,000 of a second. Here arises a curious optical fact which looks like a paradox—the retina of the human eye registers and retains for one-tenth of a second a luminous emission transmitted in 1/250,000 of a second, which means that a point of light reflected from the image remains impressed on our eyesight for a period 25,000 times longer than it actually takes for such point to be transmitted! M. Belin used this apparatus for transmitting a photograph, but Mr. Baird has gone much further in that he has successfully transmitted the image of a *living, moving object!*

Belin set a slide containing a photograph in front of an electric light and a condenser, which reflected the image on to a lens from which it passed to a drum of moving mirrors. These mirrors moved in two directions—they rotated and waved alternately from side to side. This motion is in order that the light ray may explore every point of the image to be transmitted and reflect details of light and shade. The reflected image fell on a photo-electric cell in front of which was set a diaphragm, pierced by a small opening to let through the electric impulse converted from light, by the cell. The electric impulse passed on to the receiver, where it was converted into the original light wave, and so there was built up on the screen a mosaic of points reproducing the image of the original photograph on the slide at the transmitting end. Of course, this device is still in the laboratory stage, and later developments have been kept secret. But so great is the speed needed for transmission in television that Herr Professor Max Dieckmann is reported to have said that machines of wood and steel would explode before they attain the required speed. He has *invented a televising device using electrons, or the infinitely* small and moving electrical charges surrounding the atom, and is said to have a receiver using electrons. Nevertheless, despite the alleged mechanical impossibility of perfect television, corresponding in clearness, vividness and life to the best cinema films, he would be a foolish man who would dogmatically set limits to the future advance of scientific mechanism, in the field of television or any other branch of science. When poor Richard Trevithick ran his pioneer locomotive in an enclosure where Euston Square, London, now stands, and when a century later, the brothers Wright experimented with the pioneer aeroplane, how many were the people who scoffed at the "impossibility" of railroads and flying machines! Yet the world of mechanism still moves, and wireless broadcasting and radio-controlled aeroplanes are now as commonplace as may be real radio television less than fifty years hence!

Mr. John L. Baird, the British inventor of the "Televisor," is a native of Helensburgh, Scotland. He has known the ups and downs of fortune, and a few years ago was working alone in a garret of a flat in Soho, London, with an apparatus of biscuit tins, sealing-wax and string. He has now sprung on to a pinnacle of fame as the world's first man to transmit or "televise" an actual, living image. Mr. Baird has been a lone investigator; for one thing, he had no money to pay for assistance. It is said that, when he wished to obtain information on some department of science of which he knew little or nothing, but which was vitally connected with the progress of his researches, he used to go out to a public library and read up all the books available on the subject. We described earlier in this book (see Chapter V) his system of revolving lenses and a colloidal cell which he invented. On January 27, 1926, forty members of the Royal Institution of London gathered in relays in Mr. Baird's little laboratory in Soho, and watched him transmit the image of the human face from one room to another. The face was that of an office boy, who was so frightened that he had to be bribed with *2s. 6d.* to submit to the operation! The original television machine of Mr. Baird is now in the Science Museum of South Kensington, London.

On May 24, 1927, Mr. Baird gave a successful demonstration of television between London and Glasgow. He used ordinary post office telephone wires for the transmission and reception, and the lines connecting the stations were 438 miles long. In some cases, the images were unsteady, but in most of the experiments the reception was both clear and steady. His next advance was to transmit across the Atlantic, from London to New York, the images of faces and hands. In March 1928, a young woman sat for fifteen minutes in the Baird Television Laboratory in West Central

London, near Covent Garden, gazing at a transmitting screen. She smiled excitedly. Some 1000 miles away, in mid-Atlantic, the wireless operator of the liner "Berengaria," who is the sweetheart of the young woman, watched her face appear on a screen in a cabin of the liner. He said afterwards that he recognised her by the style of her head-dress and saw her turn her profile on the screen.

Mr. Baird has shown that sound waves can be reconverted into electricity by playing the phonograph records of sounds in front of a microphone, which passes them on to the sensitive light cell, by which they become electricity. Of the actual nature of the type of sensitive cell used in the Baird televisor—and, of course, that is the brain of the instrument—one cannot speak, since Mr. Baird has had to follow the example of European Continental investigators in keeping secret such details, for the present. He says he has found that every face has its own peculiar sound when televised. By his system, the sitter's face is first transformed into fluctuating electric current, which is transmitted like a telephone message, except that the "waves" or impulses here correspond to scenes instead of sounds. All sound waves can be reconverted into electricity by playing the phonograph in front of a microphone and passing the electricity again through a televisor. At a demonstration before the Physical Society at the Imperial College of Science, South Kensington, Mr. Baird gave phonograph records of the "image-sounds" of a cabbage, a pair of scissors, a match-box, and a bowler hat.

In January 1928, it was said by an official of the Baird Television Company that success had attended six weeks' secret experiments between New York and London, when a television sending station was set up on the outskirts of South London and a receiving station in a cellar outside

New York city. Contact with New York was established, and, on several occasions, it was added, faces and hands were seen on a screen, but the features were indistinct. An attempt was made to transmit a picture across the Atlantic, but failed through lack of power. On February 9, 1928, Mr. Baird arranged a demonstration, in the early hours of the morning, in the laboratory in Long Acre, W.C. He put a ventriloquist's dummy under a flood of light equivalent to 600 candle power. Such high light is necessary because the whole of the light reflected, say, from the human face even when lit by lamps of 1000 candle power, is less than that of a single candle, and even of that small light only a residue is available for television purposes.

He turned the switches on an ebonite panel and at once the dummy's red hair and nose were sent over a land line to the transmitting station at Coulsdon, Surrey, and thence across the Atlantic. In the cellar outside New York, a member of the Baird company watched the tiny blocks of light revolve on a glass screen, and then condense into an outline of the dummy's head, standing clearly against the black background. The American observers saw the dummy's mouth open and shut in response to the twitching of a string in London, where on a pilot screen the same image flickered to show the quality of the transmission. A Morse message came from America : " Please ask Mr. Baird to go in now." For half an hour, Mr. Baird sat before the televisor twisting and turning his head and profile for the watchers in New York to see. Then Mrs. Julia P. Howe, an American woman, had her image televised across to New York from London, and was seen by watchers in New York opening and closing her mouth before the televisor. As the dawn came over the sky, atmospherics interfered and the experiment was discontinued.

"We have been trying to get images across the Atlantic for months," said Mr. Baird to the writer, "but we have always been foiled by atmospherics. This time, in spite of the extremely low power used, we have succeeded. The next step is to increase the power, and, with that object, I am building an entirely new televisor with which I hope to transmit to America much larger images in far greater detail. At present, however, I would rather not speak of the commercial possibilities."

So successful have these Anglo-American experiments proved, that in June 1928, it was said the "looking-in" service rights had been bought by an American syndicate controlling a chain of radio stations in Canada, the United States and Mexico. This syndicate was stated to have erected a radio-television station on Long Island, New York, and hoped to start a regular service in 1928. Special receiving sets with practical machines are to be placed on the American market. At the same time, in the House of Commons, the Postmaster General said: "I am advised that television is still in the experimental stage, and I do not consider the time has come to arrange for the provision of a public service" (May 22, 1928).

Of course, the next stage in the development of television out of the limits of the laboratory into the light of day and the ken of the public will be for the televisor machine to proceed from simple head and shoulder images—in which it is at present necessarily crude and imperfect—to the presentation, let us say, with cinema-film vividness, of the Derby at Epsom, the yachting at Cowes, the Cup Tie Final at Wembley, our legislators all at play in the House of Commons, the deliberations of the Congress at Washington, the Russian "Ogpu" or secret police of the Cheka dragooning the unemployed in Moscow, the Fascist Labour Day celebrations in Rome, the adoration of the white elephant in Bangkok, the funeral pyres of the Ganges, the champagne suppers of West African chiefs fraternising with ex-Colonial ministers in Sierra Leone, and anything else the reader may fancy. It is predicted that, in less than ten years, Mr. Baird's television system will bring the actual views as well as the noises of events, sporting or otherwise, to the firesides of radio enthusiasts. He is even said to have held out the truly horrifying prospect that a Televisor owner may witness all the actions of the neighbours next door—from which possibility many of us will fervently pray to be delivered! By unspooling one "master film" on a single projector hundreds of miles away from the screens of the receivers, it may be possible to give performances in hundreds of cinemas and thousands of homes. One can hear the frenzied wails of theatre-owners and actors of the year 1960 already rending the empyrean!

Similarly, M. Belin says of television: "Distance is a factor of inertia in human realisation which will disappear. Thousands of miles will be instantaneously leapt by the eye. Imagine, for example, the delicate task of a field commander in a war such as that from which we have hardly emerged. He is obliged to reconstitute for himself events which he can know only from the reports of his subordinates. With television . . . he need not budge from his post in order to be transported successively and in a few seconds to the scenes of battles. . . . By phototelegraphy, an aviator will transmit instantaneously to his commander sketches he has just drawn over the strategic positions. More, he can show his commander by television the military terrain he is observing, and by means of spies or observation posts, one may be able to see all that is passing in the enemy's camp. . . . In the domain of social life, television will arrest the exodus from the country to the town. . . . Men hostile to the progress of science are in revolt. They reproach science with intensifying life, with complicating it, with increasing the risks and the dangers. That is, perhaps, true. But in face of these drawbacks, is there not for each individual the intense satisfaction of having subdued these natural forces to his own will?"

Noctovision—the strange power of the eye of radio enabling the human observer to see in the darkness objects many miles away was accidentally discovered by Mr. Baird when, as he told the writer, he was experimenting to get rid of or modify the blazing white light turned on to the faces of folk who were sitting in front of his machine, waiting to be televised. He startled the world of British scientists by a remarkable demonstration, in January 1927, before the members of the Royal Institution, of an amazing device which presents to the eye of a watcher images of people or things located in light or darkness twenty-five miles away. Soon the range of vision may be extended. Its use in war was so obvious that Mr. Baird received many visits from agents of the war offices and departments of Britain, America and France anxious to test his invention. In the noctovisor, Mr. Baird has used the invisible and very powerful infra-red rays at the end of the spectrum of sunlight.

A person whose features are to be "noctovised"—the neologism is calculated to make the academic purist writhe in agony—on a screen in a studio miles away from him, stands in total darkness in front of a wire mesh. The infra-red rays are projected from a light source, consisting of powerful electric lamps, screened by an ebonite frame which lets pass only the invisible but penetrative "black light," or infra-red rays. These fall, in an invisible beam, on the person's face. He feels a slight warmth on his skin, and this is the only physical manifestation he has of the presence of the rays. The unseen rays are reflected from the person or object they are aimed at, and fall upon an analyser, which splits them up and sends them forward to a sensitive light cell. This light cell controls a light traversing device connected with the analyser, and translates the invisible rays into spots of light visible to an observer. The spots of light rapidly traverse a screen on which is reconstructed a complete image of the unseen object as the observer would see it were he standing by that object.

A demonstration of noctovision was given by Mr. Baird at the Leeds meeting of the British Association, in September 1927, when queues of scientists waited to see his exhibition of the new power, over the 200 miles of lines between Leeds and London. Sir Oliver Lodge was an interested spectator and saw his own face noctovised.

Startling surprises may follow the perfection of this new device of television. If attached to a searchlight, the noctovisor will give warning of the approach of a destroyer creeping up at night to torpedo a battleship. An image of the destroyer, perhaps fifty miles or more away, will be seen on a screen in a cabin of the battleship. Searchlights, equipped with the new black light projector, may be turned on an enemy aeroplane, following and picturing on a screen the plane's every move, until she is shot down by the guns of the defender. Soldiers creeping up to make a night attack will invisibly and unconsciously " noctovise " their movements to the defenders. So much for the way in which this wonderful invention impresses the savage minds of our professional warriors and stone-age war ministries of the modern world. One would prefer to dwell on their use, in social affairs, in a more rational world than we appear to be living in at the moment.

Mr. Baird says the invisible rays have at present a range of about twenty-five miles, and use lenses similar to those of an ordinary searchlight. Greater safety for airmen and seamen in time of fog, and less possibility of railroad collisions are promised by the use of the black-ray noctovisor, which can actuate signals miles away. It should presently be possible to control the direction of these rays. In guiding an aeroplane to its destination, the invisible rays would register signals on a sensitive cell, mounted on the pilot's instrument board, where a tube would become fluorescent in response to the controlled invisible light. In the case of safety working on railways, a tube would light at the near approach of another train. The device could also be used in the darkness to take films of wild animals in the dense jungle, or at the drinking-places, and it is even possible that, some day, such a perfected device turned on Mars or the Moon might solve the riddle of what conscious or sub-conscious life exists on the planets.

Coming back to daily life, one may say that the present cost of a "looking-in"[1] set, fitted to the ordinary radio receiver, is about £25. "I first tried to use ultra-violet rays for television," says Mr. Baird, "but not only did I nearly blind myself, but I found I was becoming very ill. So I turned to the other end of the spectrum, and modified my apparatus accordingly. I can trace the movements of an aeroplane on the blackest night by using my screen, and the movements could be broadcast any distance. Ships can be seen through the thickest fog, making the apparatus of the greatest value to the mercantile marine." In fact, Mr.

[1] Instruments in a case 24 inches square and 18 inches deep will be connected to the aerial. "Head and shoulder views of actors and speakers will be seen on a glass screen, 8 inches wide." (Mr. Baird, August 1928.)

Baird thinks noctovision likely to be of earlier commercial use than television. The British Air Ministry, according to Sir Samuel Hoare, Air Minister, in February, 1928, is studying the invisible searchlight. It has been found possible to see through fog sixteen times better than with ordinary light, but water is impenetrable to noctovision. In April 1927, Mr. Baird turned his invisible searchlight on to the top of the Nelson column in Trafalgar Square, London, and created such a red glare in the sky, that someone rang up the fire brigade, thinking a fire had broken out! He has transmitted a picture through a thick fog, and has fitted a coasting steamer, running between London and Dundee, with the invisible searchlight.

As we have seen, rotating and wagging mirrors characterise the present European Continental devices for television, but in America investigators have set to work on the problem with light sensitive cells and perforated rings. There were, at the end of 1927, three kinds of television in use in America and England: sight of one speaker by the other in conjunction with telephony; sight of a public speaker by audiences at a distance, as when President Coolidge addressed faraway audiences, and when Mr. Hoover, then secretary of Commerce at Washington, D.C., conversed with Mr. Walter S. Gifford, president of the American Telegraph and Telephone Company, who, then in New York, saw the image of the face of Mr. Hoover in Washington; and the broadcasting of scenic events of general interest, in cinemas. I quote Professor Rankine of the Imperial College of Science:—

"Two sizes of screens are now being used: two by two and a half inches for individual sights, and two by two and a half feet for audiences. These will be made larger and will vary as the now intricate television apparatus is simplified.

The cost at this time of installing the mechanism is prohibitive except for wealthy corporations, but the elaborate research now going on will reduce this expense in time. The telephone companies will at last go in for television quite as inevitably as they have done with the telegraph. The transmitting of the human face is done by taking as a starting-point a half-tone engraving, which gives a fairly good reproduction. The image is made up of some 2500 elementary areas which, to present a picture to the human eye at the other end, must change at the rate of the photographs on a cinema film, which is one-sixteenth of a second. At the receiving end, a bright image is presented by the use of self-luminous surfaces of glowing lamps filled with neon gas, whose brightness changes with sufficient rapidity to follow the incoming signals. Synchronisation is secured by mounting the scanning and receiving discs on the same axle. The scanning, or effective observation of the image of the face transmitted is ensured by means of a projected and moving beam of light. In years to come," concludes Professor Rankine, " a face will be relayed round the world by wireless television. An image transmitted from London to New York will be sent across America into Asia and back again, if need be."

Dr. E. F. Alexander of the General Electric Company's Laboratories of Schenectady, New York State, has invented a televising machine, which, to use his own words, " is as simple in use as learning to drive an automobile." His machine takes the form of a large square cabinet, looking like a gramophone, and this is the first home receiver for radio-transmitted images. The dials of a receiver are set on the centre of the cabinet, and above, at the level of the eye of the seated watcher, is a three-inch-square window, behind which is the screen on which the images are formed.

The ticklish problem of synchronism—the same apparent time of operation of transmitter and receiver of the television machine—he is said to have solved by ignoring it! Dr. Alexander does not use (I am speaking in the early months of 1928) an expensive and complicated apparatus to keep the whirling circle of pinholes, reflecting the image on the receiving screen, in time with the mechanism of the transmitter. His home television machine is furnished with a rheostat control, that is, an instrument regulating current to a constant degree of force, and this is fixed on the end of an extended cord permitting the spectators to do their own synchronising. If the receiving motor runs a little too fast or too slow, the picture on the screen gets out of focus and slips off the screen. This is corrected by slowing down or speeding up of the television receiver, which brings the transmitted picture back into focus and its proper position on the receiving screen.

A group of people, in March 1928, sat in their homes at Schenectady and saw the actors in a distant broadcasting studio flit across the screen, and from the loud speaker of the wireless set heard them talk. In the studio, the actors stood before an ordinary arc lamp. Between them and the electric light was a large disc revolving eighteen times a second. In the disc were forty-eight holes arranged in a spiral, so that in each revolution of the disc successive beams of light swept across each part of the actors' faces. A photo-electric cell was directed towards the actors to convert the light rays into radio waves. The tiny current wave from the photo-electric cell was magnified into a powerful signal and transmitted through the air as an ordinary radio wave. At the receiving end one receiver picked up the voices of the actors, while the television receiver was operated on a different wave-length. A sensitive neon-gas-filled bulb, capable of being turned on and off a million times a second and leaving no after-glow, stood before a duplicate of the disc at the transmitting station. It revolved eighteen times a second and was kept in time by the control in the watcher's hand. As the disc's forty-eight pictures swept in turn across the light, they passed pulsating beams, now rising in brilliancy for a high light, now fading for a shadow or half light. Between the disc and the watcher's screen was a magnifying lens doubling the picture each way and enlarging it to three inches square.

It is stated that when the broadcasting of images becomes a regular thing in America, anyone will be able to build television receivers, since none of the principal features will be covered by patents. Mr. David Saranoff, vice-president of the Radio Corporation of America has predicted that within five years television will be an art and an industry in America.

Up to the present time, a televised image seen on a far-away screen is apt to flutter and become blurred. An American investigator, in April 1928, has tried to overcome this defect by the use of vibrating quartz crystals. These crystals are said to control the electric oscillation and synchronise the sending and receiving units more accurately. Another idea is the use of an improved screen formed from a large grid-like electric-discharge tube, bent backward and forward, through which the luminescence travels so rapidly that, to the eye, the screen seems to be brilliantly and steadily illuminated. From all of which it appears, as indeed engineers say, that many improvements will be needed before television becomes the art and industry spoken of by Mr. Saranoff.

One cannot close this chapter without a few words on the recent application of television to medical technique. When Röntgen discovered X-rays and showed their value for looking within the human body and piercing the opaque walls of tissue, some medical scientists said it would be wonderful if instead of Röntgen-ray pictures of the interior of the human anatomy, the various shadows could be shown stereoscopically, or in the round plastic form, as they are in life, rather than as flat silhouettes. In March 1928, Herr F. E. Bornhardt of Munich invented a device combining television with X-rays. The device is said to give cinema peeps of the interior of a patient. The observer views the X-ray screen through a mechanical apparatus with diaphragms rotating before the eyes, in synchronism with the impulses from the X-ray tubes. The result is that one eye sees the image produced by one tube, and the other eye the image produced by the other tube. The brain combines both pictures into a stereoscopic view, presenting an apparently continuous picture, since each eye is furnished with fifty pictures a second.

Developments in the Baird (British) process of television, in the summer of 1928, comprised: television of the images of objects, in their natural colours. A three-colour process, transmitting and superimposing the three primary colours, was used. Glow discharge lamps of neon (red rays), helium (blue) and mercury (green and blue) are the light sources. A perforated disc traverses the image, and the three colours are combined so that the eye perceives on the screen at the receiving end the transmitted image in its natural colours. Mr. Baird televised, in natural colours, a human head with pink tongue, fruit, flowers, and a policeman's helmet. He also succeeded in using natural daylight, when the sun was clouded, to transmit by television.

Printed in Great Britain by Phototype Limited, Barnet, Herts.