

THE STRATIFICATIONS OF HYDROGEN.¹

THE following pages give the outcome of attempts to prepare pure hydrogen, and experiments on the stratifications exhibited by the purified gas under the influence of an induction current. The researches were commenced in 1884 and have been continued intermittently to the present time.

Strips of palladium foil were charged with hydrogen by the electrolysis of dilute sulphuric acid, a 4-cell Grove's battery being used for one hour. After drying, the palladium strips were put in a glass tube and sealed between the hydrogen generator and vacuum tube. At first, crude gas from the generator was used to wash out the apparatus, and after many fillings and exhaustions—the last to the highest possible point—the generator and tap were sealed off, leaving only the palladium and drying tubes attached to the apparatus. A portion of the palladium was now gently heated; the gauge sank 12 cm., when it was again well exhausted and a little more hydrogen liberated. This was repeated three times, when the tube was exhausted to the stratification-point—about 4 mm.

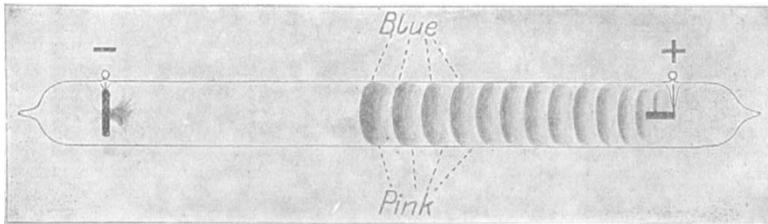


FIG. 1.

Parti-coloured Stratifications.

The strata were twelve in number and of a slightly concavo-convex button-shape, each of a blue colour on the convex side facing the negative pole, and pink on the other side. On reversing the current, the buttons faced round, always presenting

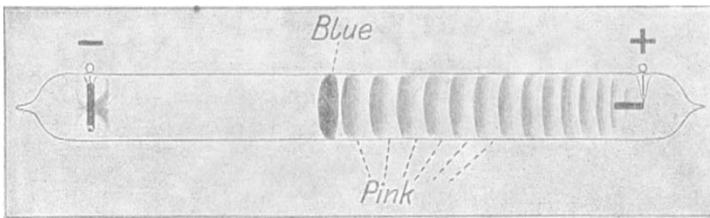


FIG. 2.

the blue face to the negative pole. Examination with a spectroscopic showed strong hydrogen lines in the pink parts and both hydrogen and mercury in the blue parts. Fig. 1 shows the appearance at this stage.

The exhaustion was now raised to 2 mm., when the whole of the blue faces of the parti-coloured button suddenly migrated to one bright blue, well-formed button, nearest the negative pole, all the other buttons remaining pink. The appearance is shown in Fig. 2. Round the negative pole an indistinct halo showed both mercury and hydrogen; but on the blue button mercury only was detected, not a trace of even the brightest hydrogen line being there seen. On the pink portions the hydrogen lines were in excess, but mercury could be seen all along the tube.

A slight difference is produced in the purity of the colours of the strata according as aluminium or platinum poles are used. A pair of vacuum tubes was made, one having the usual shaped aluminium poles, the other having platinum poles of a special construction. Each terminal was of double wire, at one terminal bent into the form of a

ring and at the other a straight pole. The ends of the wires forming the poles were sealed through the tube close together, but not touching, and terminated in loops outside, so that

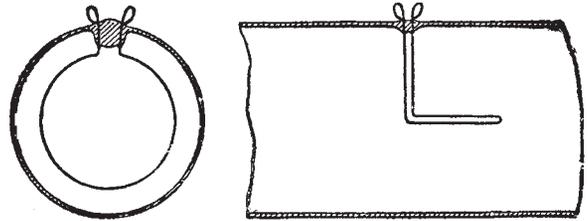


FIG. 3. (Full size.)

they could be raised to red or white heat by connecting them with a few battery cells. The arrangement will be readily understood by reference to the accompanying drawings (Fig. 3).

Thus heat could easily be applied during exhaustion, first to one pole and then to the other, even while the induction spark was passing. At first much gas was liberated from the platinum, but by repeated heating, pumping, and passing the spark, all the occluded gas was abstracted, and then the fillings with hydrogen and subsequent operations were commenced.

The general plan of the apparatus is shown in the drawing (Fig. 4). At the end furthest from the pump is the hydrogen generator, A, consisting of a U-shaped tube filled with dilute sulphuric acid, having in one leg a plate of amalgamated zinc, B, and in the other a sheet of platinum, C. Both the platinum and the zinc are connected metallically to platinum wires sealed through the glass. A funnel with a stopper, D, sealed to the outer limb of the generator admits dilute acid when required. A tap, E, on the other limb enables the reservoir of hydrogen to be disconnected from the rest of the apparatus. Following

this tap is a battery of three tubes, one, F, containing small lumps of dry caustic potash, the second, G, and the third, H, tubes containing phosphoric anhydride. Between the second phosphoric anhydride and the vacuum tube is another tube having sealed on to it, comb-like, seven projecting arms, J J, each containing a strip of palladium foil saturated with hydrogen.

The vacuum tube, K, is eight inches between the terminals and three-quarters of an inch diameter; it comes next to the comb, and then between it and the pump is a battery of tubes, each twelve inches long, to keep out the mercury. The first tube, L, is divided by a constriction in the middle, and contains, in the half next the vacuum tube, bright metallic copper, in the other half sulphur. The three next tubes, M, M, M, contain sulphur, but in the middle of each are placed a few grains of iodine separated from contact with the sulphur by a

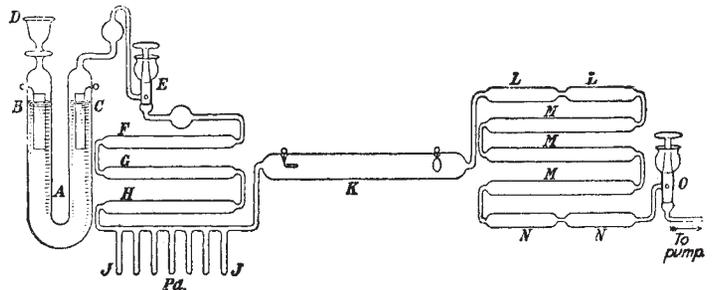


FIG. 4.

plug of asbestos on each side. The sulphur is prepared by keeping it fused at a temperature a little below its boiling-point till bubbles cease to come off, so as to get rid of water and

¹ Paper read at the Royal Society on February 6 by Sir William Crookes, F.R.S.

hydrogen compounds. It is then allowed to cool, and is pounded and sifted so as to get it in the form of granules, averaging a mm. in diameter. Ignited asbestos is packed at each end of the tubes to keep the contents from blowing out when the vacuum is proceeding, or air is suddenly let in. Next follows a tube, N, N, constricted in the middle, containing in the first half phosphoric anhydride, and in the second finely powdered dry caustic potash. A tap, O, connects the apparatus with the pump to prevent diffusion of mercury when the pump is not in use. All parts of the apparatus were built up in place and sealed together with the blowpipe. The glass was new, and the apparatus had been kept apart from mercury until it was sealed together.

The apparatus was exhausted from air, the tap E being closed and D open. Electrolysis was then commenced (D being closed), and the tap E was slightly turned until the escape of hydrogen into the apparatus was equal to the speed of its generation. The apparatus was filled, and several times exhausted, until no improvement in the spectrum or stratifications could be seen. The electrolytic cell was then sealed off at a narrow constriction between the first potash tube, F, and the phosphoric anhydride tube, G. After good exhaustion, one of the branch tubes of palladium was heated, when the gauge sank several centimetres. Exhaustion and refilling from fresh palladium were repeated until no alteration was detected in the appearance of the strata. Then, for the first time, I obtained hydrogen strata showing no blue, either throughout the tube or concentrated in front, whilst the most careful examination showed no mercury. The stratifications were all pink, and showed the hydrogen lines strongly.

Many disadvantages were noticed in the apparatus just described, the chief being the danger of introducing more impurities than were kept out by the copper, sulphur and iodine tubes. The palladium method of introducing hydrogen was not altogether satisfactory, as only small quantities could be dealt with, and occasionally at a critical point the store was exhausted. Also, the electrolytic generator of hydrogen was too small. It was decided, therefore, to devise and fit up an entirely new piece of apparatus. In this another method was used for keeping out the mercury. It had been noticed that the diffusion of mercury from the pump proceeded the more slowly as the distance from the pump and the narrowness of the connecting tubes increased. It was thought that by introducing a long narrow spiral between the pump and the apparatus, one complicated system of tubes, with their attendant dangers, could be removed; the result showed this supposition to be correct. Two vacuum tubes were employed, one having aluminium, the other platinum terminals. The hydrogen generators were increased in size and number, and were so distributed that they could be sealed off one after the other during the progress of the experiment.

Stratifications in Pure Hydrogen.

The arrangement of the apparatus is shown in Fig. 5. The three hydrogen generators are called Nos. 1, 2 and 3. In No. 1 the gas is generated by the action of hydrochloric acid on zinc. This crude hydrogen is only used to drive out the air from the rest of the apparatus and to remove the air dissolved in the liquids. When it had done its work, the generator was sealed off between Nos. 1 and 2, at A. It was considered that having the apparatus to begin with full of even somewhat impure hydrogen was better than starting with it full of air. The second and third generators contain at the bottom a pasty amalgam of mercury and zinc forming one pole, and a piece of platinum forming the other pole; the electrolyte is dilute hydrochloric acid. Platinum wires sealed through the sides of No. 3 carry the current from three Grove's cells to the interior. After the apparatus has had generator No. 1 removed, a large quantity of hydrogen is passed through from the second generator, with the object of replacing the impure hydrogen by some of a purer quality. When No. 2 is exhausted, it also is sealed off at B, leaving only the third generator with its drying tubes connected with the apparatus. Before sealing off No. 2, filling and exhausting is carried on until the hydrogen shows no impurity

when spectroscopically examined in a capillary tube attached to the vacuum tube. The gas from the first and second generators bubbles first through strong caustic soda, C, C, C, to remove any acid carried over from the generators, then through strong sulphuric acid, D, to take away the bulk of the moisture and thus save the drying tubes; it then passes through the purifying arrangements more especially connected with the third generator. Having sealed off Nos. 1 and 2, gas is evolved from No. 3 generator. Hence it passes through strong sulphuric acid in the tube H; then over a tube filled with granulated caustic soda F; and next through a tube, G, tightly packed with phosphoric anhydride. H and I are two taps, having a reservoir, K, between them. When full of gas, H and I are closed, and the tubes L and M, after having been exhausted to a high point, can then be fed with limited amounts of pure dry hydrogen by slightly opening tap I and closing it when equilibrium is restored between L, M and K. N is a spiral of narrow glass tubing immersed in a beaker of ice and water. At O is a tap to keep mercury from diffusing into the pump if the apparatus has to be left all night. The vacuum tube, L, is provided with aluminium poles and the tube M has the platinum poles made double for heating purposes, as shown in Fig. 3.

Hydrogen from the first generator was passed through the apparatus for two hours, when it was sealed off. The whole apparatus was exhausted to a high point and No. 2 generator was set to work. Hydrogen was passed several times at full pressure through the apparatus for one or two hours and then exhausted to the stratification point. During these operations the platinum terminals of one of the vacuum tubes were heated to full redness and the current was kept on both tubes for some hours to drive off occluded gases.

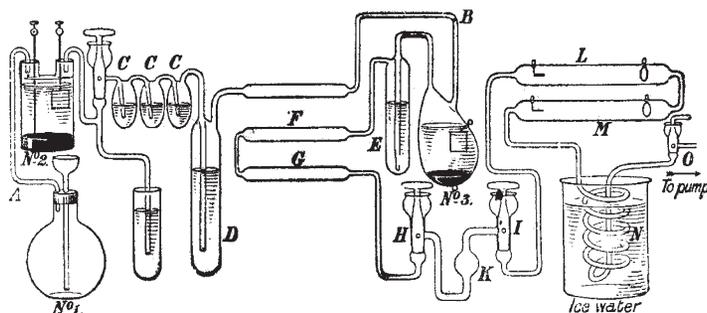


FIG. 5.

Finally, the second generator was sealed off and hydrogen used from the remaining generator. After much washing out with hydrogen at the ordinary pressure, exhaustion and re-filling were continued, and finally the reservoir K was filled, both taps, H and I, being closed. The tubes were highly exhausted to the non-conducting point, and tap I opened and then closed, so as to introduce a little hydrogen. H was then opened and again closed, so as to equalise the pressure in I, and exhaustion proceeded to the stratification point. At first the strata were irregularly coloured with a suspicion of blue on one face, but as the operations just described were continued, the blue faces disappeared, the stratifications assumed a pure pink hue and showed the hydrogen spectrum alone; no mercury was detected in any part of either tube.

From the first to the eighth filling the strata were pink with a trace of slaty blue colour on the faces next the negative pole. From the tenth filling the blue faces disappeared, and after the twentieth-filling no trace of blue could be seen and the spectrum of hydrogen alone was visible.

On examining the spectra of the stratified gas in the two tubes, each showed strongly the line spectrum of hydrogen; but while the spectrum in the platinum-poled tube showed pure red, blue and green lines on a black ground, that in the aluminium-poled tube showed in addition the fainter hydrogen line spectrum in the yellow and orange. This result may be due to the greater surface exposed by the aluminium poles; it was not further examined.

Having at last succeeded in getting hydrogen free from mercury, experiments were instituted to verify the inference that

the blue components of the blue and pink strata usually attributed to hydrogen were really due to the presence of a trace of mercury.

Origin of the Blue Component of Parti-coloured Stratifications.

I used an apparatus similar to the last, but with only one generator. If my idea was correct, that the mercury in the course of a few hours diffused into the hydrogen tube from the pump when it was not at work, there ought to be an access of blue faces to the pink buttons after the exhausted apparatus had been at rest. After filling with hydrogen and exhausting several times, a hydrogen vacuum was obtained showing no blue faces to the pink strata. The apparatus was then left all night and the stratifications examined next morning. The blue colour to each face was now unmistakably visible. The refilling with hydrogen and exhausting was then continued. It was not possible in this way to get the tube entirely free from mercury, although it got less and less, as shown by the diminution of the blue faces.

Occasionally, when no mercury was present, a faint blue edging to some of the front pink strata was seen. This blue was too faint to show lines in its spectrum. After much searching, the blue tint was traced to the phosphoric drying tubes. A clean tube was taken for stratifications and sealed to the apparatus used in the last experiments. The whole was exhausted to a high point, and one of the phosphoric anhydride tubes was gently heated with a gas flame, the current kept going. Instantly a flood of blue light swept through the tube, and when concentrated in a narrow constriction the light showed a complicated spectrum which was not recognised: none of the characteristic lines of the phosphorus spectrum could be seen in it. The tube was cleared of the blue colour by introducing hydrogen and pumping it out a few times, and then hydrogen was introduced and exhaustion continued to the stratification point. The strata now were pink, with no appearance of blue. Warming the phosphoric anhydride tube at once reproduced the faint blue edging to the pink discs. This blue colour was different both in tint and intensity to the blue colour produced by mercury, but it was too faint to show a spectrum except in the constricted part.

It is of importance to ascertain whether the body producing this blue colour can be removed from the phosphoric anhydride. The drying tube was again heated to the subliming point of the anhydride, hydrogen passed in, and the pump worked until the vacuum was almost non-conducting. The heating, passing in hydrogen and pumping were several times repeated, the impurities diminishing each time. Ultimately a point was reached when, the tube being non-conducting, heating the phosphoric anhydride did not communicate any gas to the vacuum tube. At this stage the phosphoric anhydride still retained unimpaired its affinity for water. In any accurate experiment, therefore, the phosphoric anhydride tubes should have a preliminary heating in a vacuum to eliminate the impurity. This may be done with several tubes at a time, when they can be sealed at each end and preserved for future use.

It is thus seen that this blue glow is due to some impurity in the phosphoric anhydride. Likewise I have shown from the examination of its spectrum that it is not due to phosphorus. The glow probably is due to some intermediate oxide of phosphorus. In any accurate work with the mercury pump, where phosphoric anhydride is used as the drying agent, this source of impurity must not be overlooked.

An addition to the apparatus was made, a supplementary tube sealed on containing a grain of corrosive sublimate. This was used as being non-volatile at the ordinary temperature, but easily vaporised by heat. The experiment last described was continued, and immediately after the phosphoric blue edge appeared fresh hydrogen was let in and exhaustion continued till the faint blue was eliminated. The mercury salt was then heated, when immediately a rich blue edging appeared on the face of each pink stratification and the yellow lines of mercury shone out distinctly. Mercury blue is of a fuller colour than that of the phosphoric blue.

Conclusions; Chiefly Theoretical.

The phenomenon of blue faces on the pink discs is probably due to some such action as the following:—At the exhaustion necessary to give stratifications, there is a wide dark space round the negative pole. Here the negative electrons (radiant matter), issuing from the pole with enormous velocity, have

sufficient energy to clear a space in front of them to a distance varying with the degree of exhaustion.

Dr. A. Schuster considers that the discharge through mercury vapour in a vacuum tube, when quite free from air, will not give rise to stratifications, or to the dark negative space.¹ My own experiments (*Journ. of the Inst. Electrical Engineers*, vol. xx. p. 44) show that the dark space will form in pure mercury vapour. Whichever view may be correct, there is no doubt that if stratifications in mercury vapour are not altogether unknown, they are much more difficult to produce than similar phenomena in hydrogen or other diatomic gases. At a certain critical stage of the exhaustion, when both hydrogen and mercury are present, I obtain both mercury and hydrogen strata.

It is known that in a vacuum tube, at an exhaustion approaching the stratification-point, any slight obstruction, such as constriction in the tube, or a series of wires sealed in, will cause luminous strata to hang round the obstruction. In a similar way, the hydrogen strata afford an anchorage, as it were, for the mercury, each hydrogen luminosity having a little blue glow of mercury hanging on to it; whereas, were there no hydrogen, no mercury stratifications would be seen.

The pink and blue luminosities show where the electrons and gaseous atoms meet; when the speed of the electrons is suddenly diminished, the shock throws the atom into greater vibration, which, being communicated to the ether, produces vibrations of definite wave-lengths, constituting the special spectrum of the atom. The dense mercury atom is not driven back so much as the lighter hydrogen atom—hence the blue front to the pink buttons. A very little difference in the exhaustion suffices to break the adhesion between the mercury and the hydrogen; then the mercury vapour diffusing along the tube meets the electrons from the negative pole and is swept back to the head of the hydrogen strata, and becomes apparent as a single button of blue light.

Radiant Matter. Electrons.

I have spoken of "radiant matter" and "electrons" as if they were identical. Nearly twenty-five years ago I was led by experiments in highly rarefied tubes to assume the existence of matter in an *ultra-gaseous* state. Later, in a lecture delivered before the British Association at the Sheffield Meeting, 1879 (*Chemical News*, vol. xl. pp. 91, 104, 127), I first used the expression "radiant matter," or matter in the ultra-gaseous state, to explain the novel phenomena of phosphorescence, trajectory, shadows, mechanical action, magnetisation and intense heat. "In studying this fourth state of matter," I said, "we seem at length to have within our grasp and obedient to our control, the little indivisible particles which with good warrant are supposed to constitute the physical basis of the universe. We have seen that in some of its properties radiant matter is as material as this table, whilst in other properties it almost assumes the character of radiant energy. We have actually touched the borderland where matter and force seem to merge into one another" (*Chemical News*, vol. xl. p. 130).

In twenty-five years one's theories may change, although the facts on which they are based remain immovable. What I then called "radiant matter" now passes as "electrons," a term coined by Dr. Johnstone Stoney, to represent the separate units of electricity, which is as atomic as matter. What was puzzling and unexplained on the "radiant matter" theory is now precise and luminous on the "electron" theory. Thus my early hypotheses fall into order by the substitution of one expression for the other. A chemical ion consists of a material nucleus or atom of matter constituting by far the larger portion of the mass, and a few electrons or atoms of electricity. The electrons are the same as the "satellites" of Lord Kelvin and the "corpuscles" or "particles" of J. J. Thomson.

Electrons probably leave the negative pole with a velocity nearly uniform, modified to a considerable extent by the degree of exhaustion, and to a less extent by the electromotive force behind them. Many experiments—the details I must leave to a future occasion—show that the liberated electrons do not behave as a gas, *i.e.* they have not properties dependent on inter-collisions, mean free path, &c.; they act more like a fog or mist, are mobile and carried about by a current of air to which they give temporary conducting powers, clinging to positively electrified bodies and thereby losing mobility, and settling on the walls of the containing vessel if left quiet.

¹ Dr. A. Schuster, "Experiments on the Discharge of Electricity through Gases," *Roy. Soc. Proc.*, vol. xxxvii. p. 318.

On the other hand, the crowd of hydrogen or mercury atoms, by virtue of molecular motion and inter-collisions, act as gases. Whilst their *mean free paths* are conditioned by the degree of exhaustion, there may be amongst them a certain number of *actual free paths* differing widely on each side of the mean. Under the influence of the electromotive force, and at the right degree of exhaustion, these atoms arrange themselves in groups,¹ while the rushing swarm of electrons driven from the negative pole meet them and render them visible. According to J. J. Thomson, the mass of an electron is about the 1/7000th part of that of the hydrogen atom, and as these masses start from the negative pole in a vacuum tube with a velocity of the order of half that of light, it is easy to see that their heating, phosphorescent and mechanical power must be stupendous.

The basis of the electron, as I foreshadowed in 1879 in the case of radiant matter, is probably the same in all cases—the protyle from which the chemical atoms were assumed to be formed.

On the two-fluid theory, the electrons constitute free negative electricity, and the rest of the chemical atom is charged positively, although a free positive electron is not known. It seems to me simpler to use the original one-fluid theory of Franklin and to say that the electron is the atom or unit of electricity. Then a so-called negatively charged chemical atom is one having a surplus of electrons, the number depending on the valency, whilst a positively charged atom is one having a deficiency of electrons. Differences of electrical charge may thus be likened to debits and credits in one's banking account, the electrons acting as current coin of the realm

SCIENTIFIC WORK OF THE GERMAN ANTARCTIC EXPEDITION.²

THE head of the German Antarctic Expedition, Prof. Dr. Drygalski, has sent from Cape Town to the home authorities a number of full reports on the work which had been carried on by the expedition up to the date of their despatch. As is well known, the ship, which had been specially built for the expedition, was long overdue at Cape Town, and her protracted non-appearance gave rise to some anxiety. We give the following extracts from the official report, which will shortly appear, in order to furnish evidence of the activity of the staff, and of the reasons for the great protraction of the voyage.

In the scheme of operations for the expedition, it had been arranged that visits to two land stations should be made during the voyage to Cape Town, in order to determine, by fresh comparisons with the absolute magnetic elements at those land stations, the changes in the magnetic character of the ship since its determination at Kiel before sailing. The magnetism of a new ship is always subject to changes in course of time, but these changes are more especially caused by change of magnetic latitude as the ship passes from one hemisphere to the other. With this object, the following places were selected as apparently desirable:—The Cape Verdes or Madeira, north of the magnetic equator, and Bahia or Ascension to the south of it.

¹ In an address delivered before the Institution of Electrical Engineers, January 15, 1891, I gave an outline of a theory of stratifications in rarefied gases. The following quotation renders my meaning clear:—"If, in any much-frequented street, at some time when the stream of traffic runs almost equally in both directions, we take our stand at a window from which we can overlook the passing crowd, we shall notice that the throng on the footway is not uniformly distributed, but is made up of knots—we might almost say blocks—interrupted by spaces which are comparatively open; we may easily conceive in what manner these knots or groups are formed: some few persons walking rather more slowly than the average rate slightly retard the movements of others, whether travelling in the same or in an opposite direction. Thus a temporary obstruction is created. The passengers behind catch up to the block and increase it, and those in front, passing on unchecked at their former rate, leave a comparatively vacant space. If a crowd is moving all in the same direction, the formation of these groups becomes more distinct. Hence mere differences in speed suffice to resolve a multitude of passengers into alternating gaps and knots. Instead of observing moving men and women, suppose we experiment on little particles of some substance, such as sand. If we mix the particles with water in a horizontal tube and set them in rhythmical agitation, we shall see very similar results, the powder sorting itself with regularity into alternate heaps and blank spaces. If we pass to yet more minute substances, we observe the behaviour of the molecules of a rarefied gas when submitted to an induction current. The molecules here are free, of course, from any caprice, and simply follow the law I seek to illustrate, and though originally in a state of rampant disorder, yet under the influence of the electric rhythm, they arrange themselves into well-defined groups or stratifications."—*Journ.* of the Inst. Electrical Engineers, vol. xx, p. 10.

² Based upon an Article in *Der Tag*, Berlin, January 25.

After consultation with the magnetician of the ship, Dr. F. Bidlingmaier, I had selected Porto Grande in St. Vincent and Ascension. If, for any reason, Ascension proved to be inaccessible, it seemed advisable to adopt the usual plan, on board ship, and determine the deviation by swinging the ship on eight different courses in the open sea. During our stay at Porto Grande, which lasted until September 11–16, the magnetic observations were our principal business, and we succeeded in determining, on board the ship, the deviations in the Magnetic Declination, Total Force, and in Horizontal and Vertical Force due to her magnetism.

I myself landed, with two assistants, and set up a tent near the spot where the shore magnetic observations were being carried on, in order to secure time observations to rate our chronometers and watches, and also to make some observations of the force of gravity. Owing to the weather, we could make no astronomical observations.

My orders for the next part of the voyage were to cross the equator on the 18th meridian, and then to make for Ascension. The object of the first position was to verify the sounding of 7370 metres (4030 fathoms) [the greatest depth on the line], which had been obtained by the French man-of-war *La Romanche* in 0° 11' S. and 18° 15' W. As this figure is not mentioned on the British charts of soundings, nor in the recent critical representation of sea depths, by Prof. Dr. Supan, I therefore wished to trace its possible connection with the great depths of the Brazilian basin.

The visit to Ascension was to attain the objects above named. It was evident enough that the carrying out of this plan would present some difficulties, for the usual sailing track to the Cape (which was best for our ship, owing to the low power of her engines, which would not allow of steaming against the S.E. trade with its accompanying sea) crosses the equator far to the westward, probably as far as the 25th meridian. A visit to Ascension would entail our steering a south-easterly course immediately on leaving the Cape Verde, so as to be able to make a south-westerly course to the island under sail. The course indicated was to be first tried and tested as to whether it would take too much time. We crossed the belt of calms under steam, between the two trade winds. In this swell the *Gauss* rolled, at times very heavily, so that much glass or other breakable articles in the laboratory came to grief, while the ship, under sail, even with a stiff-breeze and a good deal of sea, had been remarkably steady. This swell retarded our progress considerably, as of course our speed was greatly reduced. This was aggravated by increased fouling of the bottom. As the ship was very low in the water, the screw well, through which the screw and rudder could be lifted, on meeting ice, so as to preserve them from damage, may have contributed to the prolongation of the voyage. In short, we proceeded very slowly along the prescribed track, where the wind failed us, and the currents at least gave no help, though the engines worked perfectly, and gave promise of a very satisfactory performance whenever we should come into a state of sea checked by the presence of ice.

All these impediments retarded us with enhanced insensibility when we met the S.E. trade on the line. This was very fresh (and we should have liked to have had a similar force in the N.E. trade), but we could make no use of it, as it was dead ahead on our course for Ascension, and it brought with it a trying [swell and current. The rate of the ship got less and less, and at last stopped entirely on October 5. In these circumstances, as time was getting on (we crossed the line a few days after the entry of the sun into south declination on October 1, so that we ran directly from the northern into the southern summer), it seemed therefore desirable to reconsider our plan and give up the Ascension visit entirely, and so on October 6 I decided to do this and use the existing S.E. trade for a run to the Cape, starting on that day. As soon as we changed our course we made at once a speed of six or seven knots. On October 7 we disconnected the engines and made sail, but the wind did not last. On October 9 the S.E. wind died away, and these light winds continued, with some slight exceptions, up to Cape Town. The *Gauss* always made very short daily runs, so that we had a very long passage. The light winds and fair weather were the cause, as we had only one storm, November 18–20, just at the end of the voyage. We were naturally obliged to husband our coal so as not to lighten the ship too much.

On October 30, the after steam capstan was connected with Prof. Vanschöffen's vertical net, which was at a depth of