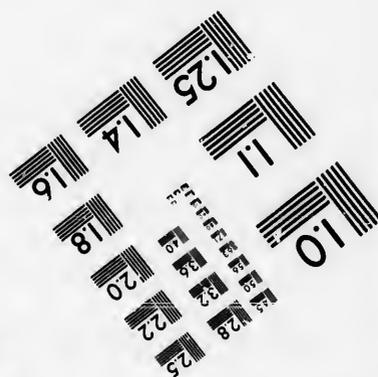
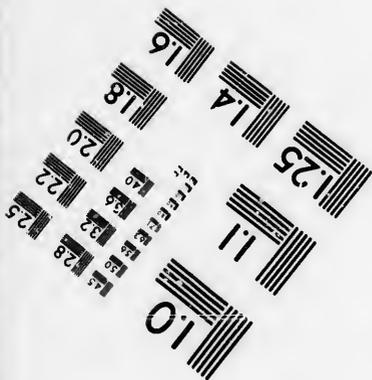
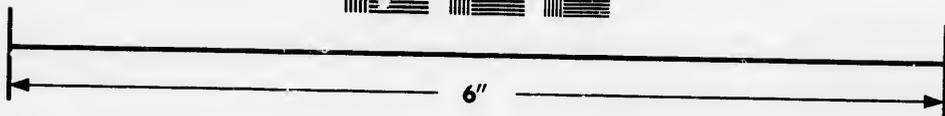
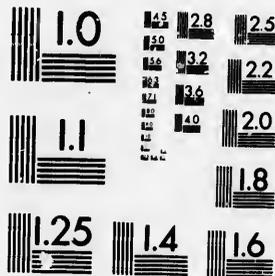
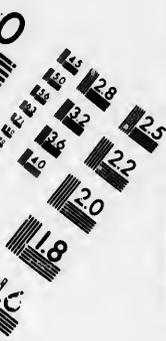


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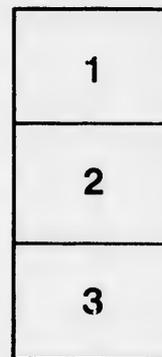
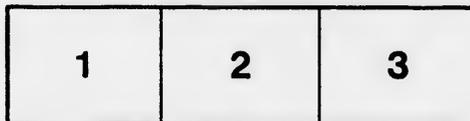
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Report upon a Letter addressed by M. LE BARON DE HUMBOLDT to HIS ROYAL HIGHNESS the PRESIDENT of the ROYAL SOCIETY, and communicated by His Royal Highness to the Council.

To His Royal Highness the President and Council  
of the Royal Society.



PREVIOUSLY to offering any opinion on the important communication on which we have been called upon to report, we feel that it will be proper to lay before the Council a full account of the communication itself. In this letter M. de Humboldt develops a plan for the observation of the Phenomena of Terrestrial Magnetism worthy of the great and philosophic mind whence it has emanated, and one from which may be anticipated the establishment of the theory of these phenomena.

After his return from the equinoctial regions of America, M. de Humboldt, in the years 1806 and 1807, entered upon a careful and minute examination of the course of the diurnal variation of the needle. He was struck, he informs us, in verifying the ordinary regularity of the nocturnal period, with the frequency of perturbations, and, above all, of those oscillations, exceeding the divisions of his scale, which were repeated frequently at the same hours before sunrise. These eccentricities of the needle, of which a certain periodicity has been confirmed by M. Kupffer, appeared to M. de Humboldt to be the effect of a reaction from the interior towards the surface of the globe—he ventures to say, of “magnetic storms”—which indicated a rapid change of tension. From that time he was anxious to establish to the east and to the west of the meridian of Berlin, apparatus similar to his own, in order to obtain corresponding observations made at great distances at the same hours, but was for a long period prevented putting his plan into execution by the disturbed state of Germany and his departure for France.

The Baron de Humboldt and MM. Arago and Kupffer having, by the cooperation of many zealous observers, succeeded in establishing permanent magnetic stations extending from Paris to China, M. de Humboldt solicits, through His Royal Highness the President, the powerful influence of the Royal Society in extending the plan, by the establishment of new stations. The plan which he proposes, and which has been successfully carried into execution over a large portion of the north-eastern continent, is that magnetical observations, whether of the direction of the horizontal and inclined needles, or for the determination of the variations of the magnetic force,

should be made simultaneously at all stations, at short intervals of time, for a certain number of hours and at fixed periods of the year, precisely similar to the plan which has been recommended and adopted by Sir John Herschel with reference to observations of the barometer and thermometer.

Referring in terms of commendation to the magnetical observations which have originated in this country, M. de Humboldt expresses his wish that such observations may, by the adoption of an uniform plan, and by connecting them with the observations now in progress on the continent of Europe and of Northern Asia, be rendered more proper for the manifestation of great physical laws. He then enters into a historical detail of the establishment of stations for magnetical observations, stating the important results obtained by MM. Arago and Kupffer by means of simultaneous observations, which appear to establish the isochronism of the perturbations of the needle at Paris and Kasan, stations separated by  $47^{\circ}$  of longitude. Under the patronage of the Governments of France, of Prussia, of Denmark, and of Russia, magnetical observatories have been established at Paris, at Berlin, in the mines of Freyberg, at Copenhagen, in Iceland, at St. Petersburg, Kasan, Moscow, Barnoul at the foot of the Altai Chain, Nertschinsk near the frontiers of China, even at Pekin, and at Nicolajeff in Crimea.

M. de Humboldt states that the lines representing the horary variations at Berlin, Freyberg, Petersburg, and Nicolajeff affect parallelism, notwithstanding the great separation of the stations and the influence of extraordinary perturbations; that this, however, is not invariable, since even at small distances, for example, at Berlin and in the mines of Freyberg, one of the needles may show considerable perturbations, while the other continues that regular course which is a function of the solar time of the place.

The epochs at which it had been proposed that simultaneous observations should be made at all stations were,

20th and 21st of March,	} from 4 o'clock in the morning of the first day until midnight of the second, observing, at least hourly, night, and day, at each magnetic station.
4th and 5th of May,	
21st and 22nd of June,	
6th and 7th of August,	
23 and 24th of September,	
5th and 6th of November,	
21st and 22nd of December,	

But as many observers have considered these as too near to each other, the observations most to be insisted upon are those at the times of the solstices and equinoxes.

England from the times of Gilbert, Graham, and Halley to the present, observes M. de Humboldt, has afforded a copious collection of materials, adapted to the discovery of the physical laws which govern the changes of the variation, whether at the same place, according to the hours of the day and the seasons of the year, or at different distances from the magnetic equator and from the lines of no variation. After adverting to the continued observations of

Gilpin and of Beaufoy, omitting, however, to mention the important ones by Canton, he observes that the arctic expeditions have furnished a rich harvest of important observations to Captains Sabine, Franklin, Parry, Foster, Beechey, and James Ross, and Lieutenant Hood \*; and that thus physical geography is indebted to the attempts which have been made to discover the north-west passage, and also to the explorations of the icy coast of Asia, by Wrangel, Lutke, and Anjou, for a considerable accession of knowledge in terrestrial magnetism and meteorology. Excited, he observes, by the great discoveries of Oersted, Arago, Ampere, Seebeck, and Faraday, MM. Hansteen, Due and Adolphe Erman have explored, in the whole of the immense extent of Northern Asia, the course of the isoclinal, isogonal, and isodynamic curves; and M. Adolphe Erman has had the advantage during a long voyage from Kam'schatka round Cape Horn to Europe, of observing the three manifestations of terrestrial magnetism on the surface of the earth, with the same instruments and by the same methods which he had employed from Berlin to the mouth of the Obi, and thence to the sea of Okhotsk.

M. de Humboldt remarks that our epoch, marked by great discoveries in optics, electricity, and magnetism, is characterized by the possibility of connecting phenomena by the generalization of empirical laws, and by the mutual assistance rendered by sciences which had long remained isolated. Now, he observes, simple observations of horary variation or of magnetic intensity made at places far distant from each other, reveal to us what passes at great depths in the interior of our planet or in the upper regions of our atmosphere: those luminous emanations, those polar explosions which accompany the "*magnetic storm*" appear to succeed the changes which the mean or ordinary tension of terrestrial magnetism undergoes.

M. de Humboldt considers that it deeply interests the advancement of mathematical and physical sciences that, under the auspices of His Royal Highness the President, the Royal Society should exert its influence in extending the line of simultaneous observations, and in establishing permanent magnetic stations in the tropical regions on both sides of the magnetic equator, in high southern latitudes, and in Canada. He proposes this last station because the observations of horary variation in the vast extent of the United States are yet extremely rare. Those at Salem, calculated by Mr. Bowditch, and compared by Arago with the observations of Cassini, Gilpin, and Beaufoy, may, he remarks, guide the observers in Canada, in examining whether there, contrary to what takes place in Western Europe, the (diurnal?) variation does not decrease in the interval between the vernal equinox and the summer solstice.

In a memoir published five years ago, M. de Humboldt states that he has indicated as stations extremely favourable for the advancement of our knowledge, New Holland, Ceylon, the Mauritius, the

\* To this long list we may now add the name of Captain Back; nor ought the name of Mr. Fisher to be omitted.

Cape of Good Hope, the Island of St. Helena, some point on the Eastern Coast of South America, and Quebec. In order, he observes, to advance rapidly the theory of the phenomena of terrestrial magnetism, or at least to establish with more precision empirical laws, we ought to extend and, at the same time, to vary the lines of corresponding observations; to distinguish, in the observations of the horary variations, what is due to the influence of the seasons, to a clear or a cloudy atmosphere, to abundant rains, to the hour of the day or night solar time, that is, to the influence of the sun, and what is isochronous under different meridians: we ought, in addition to these observations of the horary variation, to observe the annual course of the absolute variation, of the inclination of the needle and of the intensity of the magnetic forces, of which the increase from the magnetic equator to the poles is unequal in the American or Western, and in the Asiatic or Eastern hemisphere. All these data, the indispensable basis of a future theory, can acquire certainty and importance only by means of fixed establishments, which are permanent for a great number of years, observatories in which are repeated, at settled intervals and with similar instruments, observations for the determination of numerical elements.

Travellers, remarks M. de Humboldt, who traverse a country in a single direction and at a single epoch, furnish only the first preparations for labours which ought to embrace the complete course of the lines of no variation; the progressive displacement of the nodes of the magnetic and terrestrial equators; the changes in the forms of the isogonal and isodynamic lines; and the influence which, unquestionably, the configuration and articulation of the continents exert upon the slow or rapid march of these curves. He will, he considers, be fortunate if the isolated attempts of travellers, whose cause he has to plead, have contributed to vivify a species of research which must be the work of centuries, and which requires at once the cooperation of many observers, distributed in accordance with a well-digested plan, and a direction emanating from many great scientific centres of Europe. This direction, however, not being for ever restricted by the same instructions, but varying them according to the progressive state of physical knowledge and the improvements which may have been made in instruments and the methods of observation.

In begging His Royal Highness the President to communicate this letter to the Royal Society, the Baron de Humboldt disclaims any intention of examining which are the magnetic stations that at the present time deserve the preference, and which local circumstances may admit of being established. It is sufficient that he has solicited the cooperation of the Royal Society to give new life to a useful undertaking in which he has for many years been engaged. Should the proposition meet with their concurrence, he begs that the Royal Society will enter into direct communication with the Royal Society of Gottingen, the Royal Institute of France, and the Imperial Academy of Russia, to adopt the most proper measures to combine what is proposed to be established with what already exists; and

adds, that, perhaps, they would also previously concert upon the mode of publication of partial observations and of mean results.

M. de Humboldt finally refers to the labours and accurate observations of M. Gauss at the Observatory of Gottingen. The methods, however, adopted by M. Gauss being already before the Royal Society in a memoir which has been communicated by him, renders it unnecessary here to enter into the explanation given of them by M. de Humboldt. He has referred to them in order that those members of the Royal Society who have most advanced the study of terrestrial magnetism, and who are acquainted with the localities of colonial establishments, may take into consideration, whether, in the new stations to be established, a bar of great weight furnished with a mirror should be employed, or whether Gambey's needle should be used: his wish is only to see the lines of magnetic stations extended, by whatever means the precision of the observations may be attained.

M. de Humboldt concludes by begging His Royal Highness to excuse the extent of his communication. He considered it would be advantageous to unite under a single point of view what has been done or prepared in different countries towards attaining the object of great simultaneous operations for the discovery of the laws of terrestrial magnetism.

Having very fully laid before the Council the contents of M. de Humboldt's letter, we have now to offer our opinion upon the subject it embraces. There can, we consider, be no question of the importance of the plan of observation which is here proposed for the investigation of the phenomena of terrestrial magnetism, or of the prospect which such a plan holds out of the ultimate discovery of the laws by which those phenomena are governed. Although the most striking of these phenomena have now been known for two centuries, although careful observations of them have within that period been made, and that still more care and attention have been bestowed upon those more recently discovered, yet the accessions to our knowledge, not only regarding the cause of the phenomena, but even with respect to the laws which connect them, bears a very small proportion to the mass of observations which have been made. This has arisen in a great measure, if not wholly, from the imperfection of the data from which attempts have been made to draw conclusions. Whatever theories may have been advanced in explanation of these phenomena, or attempts made to connect them by empirical laws, still, whenever comparisons have been instituted between the results of observation and such theories or laws, it has, in general, been doubtful whether the discrepancies which have been found might not, as justly, be attributed to errors in the observations as to fallacies in the theory or incorrectness in the laws. Under these circumstances, the Royal Society, as a society for the promotion of natural knowledge, cannot but hail with satisfaction a proposition for carrying on observations of phenomena most interesting in their nature and most obscure in their laws, in a manner that

shall not only give greater precision to the observations, but at the same time render all the results strictly comparative.

There are, however, other grounds on which such a proposition as that made by M. de Humboldt should be most cordially received by the Royal Society. This Society is here called upon, as a member of a great confederation, to cooperate with several other members, already in active cooperation, for the attainment of an object which ought to be common to all; and to such a call the Royal Society can never be deaf. Those who know best what has been done by cooperation on a well-digested system, and what remains undone in many departments of science for the want of it, can best appreciate the benefits that would accrue to science, by the adoption of the extensive plan of cooperation advocated by M. de Humboldt. Independently of our acquiring a knowledge of the laws which govern the phenomena here proposed to be observed, we ought to look to the effect which the adoption of such a plan may have on other branches of science. The example being thus once set of extensive cooperation in a single department of science, we may anticipate that it would be eagerly adopted in others, where, although our knowledge may be in a much more advanced state than it is regarding the phenomena of terrestrial magnetism, still much remains to be accomplished, which can scarcely be effected by any other means. We might thus hope to see the united efforts of all the scientific societies in Europe directed to the prosecution of inquiry, in each department of science, according to the plan of cooperation best adapted for its development.

We must now, after these remarks on the general bearing of M. de Humboldt's communication, go somewhat into detail on points connected with it. One point of view in which we consider the proposed plan of great importance, and to which M. de Humboldt has not expressly referred, is this. However defective ordinary dipping instruments may be considered to be, there are few persons who have had opportunities either of making observations with the ordinary instruments for determining the variation of the needle, or of comparing those made by others by the usual methods with such instruments, who will not admit that these instruments and methods are fully as defective—possibly much more so. Thus, however we may multiply the points on the earth's surface at which such observations may be made, still great uncertainty must always rest upon such determinations of these two important elements; and in all comparisons of such observations with laws, whether empirical or deduced from theory, it will ever be doubtful whether the discordances which may be found are due to errors of observation, or are indicative of the fallacy of these laws. This source of uncertainty must, in a great measure, if not wholly, be obviated by observations made at fixed stations, with instruments of similar construction, which have been carefully compared with each other. And we have no hesitation in stating our opinion that more would be done in determining the positions of the poles of convergence and

of verticity on the earth's surface and other points, most important towards the establishment of anything like a theory of terrestrial magnetism, by simultaneous observations made at a few well-chosen fixed stations, than by an almost indefinite multiplication of observations by the ordinary methods.

That a magnetic chart that should correctly exhibit the several lines of equal variation, Humboldt's "Isogonal Lines", would be of the greatest advantage to navigation, those who are best qualified to judge are most ready to admit. If to these lines were added the isoclinal lines, or lines of equal dip, the value of such a chart would, for the purposes of navigation in particular, be greatly enhanced. Whatever may be the magnitude of the influence of the iron in a ship on its compass needle, the extent of the deviation of the horizontal needle due to that influence, on any bearing of the ship's head, is a function of that bearing and of the dip of the needle at the place of observation. The extent, therefore, of the horizontal deviations, in various bearings of the ship's head, having been ascertained at any port where the dip of the needle is known, their extent at any other place, however distant, at which the dip is also known, may readily be calculated. Consequently a chart which should correctly exhibit the isoclinal, in conjunction with the isogonal, lines, would readily furnish the means of obtaining the correction to be applied to the ship's course by compass, both for the variation of the needle and for the deviation due to the ship's influence upon its compass. Whatever charts of this description may have already been constructed, and whatever materials may exist for the construction of more accurate ones, it is well known that great discrepancies exist among the data requisite for such constructions. And it appears to us that such a careful inquiry into the whole of the phenomena of terrestrial magnetism as is proposed by M. de Humboldt, is the means best adapted to ensure the accuracy which would be of such inestimable advantage in this most useful application of scientific knowledge.

Although our views with regard to the stations proper to be selected for permanent magnetical observatories in general accord with those expressed by M. de Humboldt, we shall, we consider, be only conforming to his wishes, if we point out those stations which, from particular circumstances of position, appear most desirable. We consider that it would be of the greatest advantage if two or more permanent magnetical observatories were established in the high latitudes of North America, on account of the proximity of stations so situated to the northern magnetic poles of convergence and verticity, whether these poles are two different points or one and the same: indeed, continued observations at such stations would go far to decide this question, highly important in a theoretical point of view. M. de Humboldt has mentioned Quebec as a desirable station. To this place, and also to Montreal, we conceive that an objection exists, of which possibly M. de Humboldt is not aware: many of the houses in those cities are roofed with tinned iron. This objection may not, however, exist in some of the esta-

establishments in the vicinity of either of these cities. We consider that the most advantageous positions would be, one near the most northerly establishments in Hudson's Bay, and another at or near to Fort Resolution on Great Slave Lake. As, however, observers in such positions would be placed almost beyond the pale of civilization, we fear that, for some time at least, it will be found quite impracticable to obtain regular observations at these important stations. It would likewise be desirable that there should be a station in Nova Scotia or Newfoundland: the latter would be the preferable position.

If the Government of the United States were to give their cordial cooperation to M. de Humboldt's plan, by the establishment of three or more permanent magnetical observatories, in different longitudes, these, with what we may expect to be undertaken by Russia in the extreme north-west, and our own establishments, would afford the means of obtaining a mass of more interesting magnetical observations than could perhaps be derived from any other portion of the earth's surface.

M. de Humboldt mentions New Holland, Ceylon, the Mauritius, the Cape of Good Hope, St. Helena, and a point on the east coast of South America, as desirable stations, and we fully concur in the propriety of the selection. Although Van Dieman's Land, from its greater proximity to the southern magnetic pole, would be a more advantageous position for magnetical observations than Paramatta, yet the circumstance alone of there being an astronomical observatory established at Paramatta, renders it peculiarly adapted for a magnetical station. Possibly circumstances may hereafter admit of magnetical observations being also made at Hobart's Town, in conformity with the general plan which may be adopted.

The Island of Ascension, from its proximity to the magnetic equator, would possess peculiar advantages for a magnetical station; but these must, in a great degree, be counterbalanced by the nature of its soil, which, being wholly volcanic, would exert an influence on the needle that would render observations made there of a doubtful character: indeed, the same objection applies to St. Helena and most of the islands of the Atlantic. Some recent observations, those of Lieut. Allen, R.N., in the expedition up the Niger, would point to the Bight of Benin as a desirable station; but the insalubrity of the climate and other circumstances prevent our recommending its adoption.

M. de Humboldt has not referred to any station in our West Indian colonies, but we consider that circumstances point to Jamaica as a station where it is very desirable that accurate magnetical observations should be made. It is generally considered that the variation there has, for a very long period, undergone but little change; and, on this account alone, it would be very desirable to ascertain, with precision, the amount of the variation, so that hereafter, the nature of the changes it may undergo, may be accurately determined. Its position also, with reference to the magnetic equator, is one which would recommend it as a magnetical station\*.

\* Mr. Pentland, who has been appointed Consul-General to the Republic of Bolivia, having, since the Baron de Humboldt's letter was referred to us,

Although M. de Humboldt has not adverted to any other point beside Ceylon in our Indian possessions; yet, no doubt, he would, with us, consider it desirable that observatories should be established at different points on the continent of India; and it appears to us that Calcutta and Agra are in positions well adapted for the purpose. As, however, there is an Astronomical Observatory established at Madras, there would be greater facility in obtaining magnetical observations there than at places where no such establishment exists. We feel assured that the East India Company, which has shown so much zeal and liberality in the promotion of scientific inquiry, and such a desire for the advancement of scientific knowledge in the extensive possessions under its controul, would afford its powerful assistance in the establishment of observatories for the investigation and determination of the laws of phenomena intimately connected with navigation, and, consequently, with the commercial prosperity of our country.

We consider, also, that Gibraltar and some one of the Ionian Islands are very desirable stations for the establishment of permanent magnetical observatories; and, to come nearer home, that such observatories should be established in the North of Scotland and in the West of Ireland.

M. de Humboldt adverts to another very interesting class of magnetical observations; those in the mines of Freyberg. The mines of Cornwall from their great depth, some being 1200 feet below the level of the sea, are peculiarly well adapted for observations of this description; and, from the spirit with which philosophical inquiry has been carried on in that part of England, we do not anticipate that much difficulty would occur in the establishment of a magnetical station in one of these mines.

Having enumerated the stations, which by their position appear best adapted to furnish valuable results, and having likewise pointed out the facilities which some afford for the execution of this plan of observation, immediately that the nature of the instruments to be employed has been determined upon, and that such instruments can be provided, it may be proper to advert to stations where, although the same facilities do not exist, we consider that zealous and able observers might be obtained without much difficulty. We conceive that such is the case in Newfoundland, in Canada, at Halifax, Gibraltar, in the Ionian Islands, at St. Helena, and Ceylon; and we have authority for stating that there would be no difficulty in obtaining observers in the Mauritius, and even at the colony on the

offered his earnest cooperation in the objects contemplated in that letter, we cannot hesitate, now that this has been communicated to us, to recommend that an offer so liberal should be made available to science. If accurate magnetical observations were made at some station on the elevated table-land of Mexico, and simultaneously, at another, not very distant station, nearly at the level of the sea, we consider that they would determine points relative to the influence of elevation on the diurnal variation, the dip and intensity, respecting which our information is at present, to say the least, extremely deficient.

Swan River, the latter being a most desirable station. We have not alluded to the observatory at the Cape of Good Hope; if however no such establishment existed, the presence of Sir John Herschel would ensure cooperation there, in any plan calculated to advance scientific knowledge. Thus, altogether, there might be formed a most extensive spread of stations, in which the principal expense would consist in the purchase of the requisite instruments; and the means of establishing stations where the same facilities do not exist might afterwards be taken into consideration. As it would be necessary that, at all the stations, observations of the barometer, thermometer, and of atmospheric phenomena should be made simultaneously with the magnetical observations, these would altogether form a mass of valuable meteorological information which it would be scarcely possible to collect by any other means.

There is one point in M. de Humboldt's communication on which we have not yet touched: the nature of the instruments best calculated to attain the objects in view by the establishment of magnetical observatories. This is a subject on which it will be most proper to enter fully when their establishment has been determined upon, and we would recommend that then a Committee should be appointed to investigate the subject, and that this Committee should report to the Council of the Royal Society what instruments they consider it would be most advisable to adopt at all the stations, and, at the same time, give in an estimate of the expense that must be incurred for one complete set of such instruments. We may, however, in the mean time, offer a remark on one apparatus referred to by M. de Humboldt, that of M. Gauss. However well we may consider this apparatus to be adapted for the determination of the course of the regular diurnal variation, yet we apprehend that the great weight of the needles employed would prevent their recording the sudden and extraordinary changes in the direction of the magnetic forces, which are, probably, due to atmospheric changes. Another, and we conceive a very serious objection to this apparatus is, that bars of the magnitude employed must have an influence so widely extended, that there would be great risk of the interference of one of these heavy needles with the direction of another, especially in places where the horizontal directive force is greatly diminished, unless the rooms for observation were placed at inconvenient distances from each other.

By referring to M. de Humboldt's letter, it will be seen that the plan of observation so comprehensively conceived by him, has been most powerfully and liberally patronized by the Governments of France, of Prussia, of Hanover, of Denmark, and of Russia: indeed, it is quite manifest that a plan so extensive in its nature must be far beyond the means of individuals, and even of scientific societies unaided by the governments under which they flourish. To suppose, even without the example thus held out, that the Government of this, the first maritime and commercial nation of the globe, should hesitate to patronize an undertaking, which, independently of the accessions it must bring to science, is intimately connected with na-

vigation, would imply that our Government is not alive either to the interests or to the scientific character of the country, and would show that we had little attended to the history, even in our own times, of scientific research, which has been so liberally promoted by the Government. Although the investigation of the phenomena of terrestrial magnetism was not the primary object of the expeditions which have now, almost uninterruptedly, for twenty years been fitted out by Government,—another of which, and one of the highest interest, is on the point of departure,—yet a greater accession of observations of those phenomena has been derived from these expeditions than from any other source in the same period. We therefore feel assured that, when it shall have been represented to the Government that the plan of observation advocated by the Baron de Humboldt is eminently calculated to advance our knowledge of the laws which govern some of the most interesting phenomena in physical science; it appears to be perhaps the only one by which we can hope ultimately to discover the cause of these phenomena; and that, from it, results highly important to navigation may be anticipated—that the patronage to the undertaking which is so essential to its prosecution will be most readily accorded. We beg, therefore, most respectfully, but at the same time most earnestly, to recommend to His Royal Highness the President and to the Council, that such a representation be made to the Government, in order that means may be ensured for the establishment, in the first instance, of magnetical observatories in those places which, from local or other causes, afford the greatest facilities for the early commencement of these observations.

S. HUNTER CHRISTIE.  
G. B. AIRY.

9th June, 1836.

