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The History of the British Meteorological Office to 1905

Doctor of Philosophy. The Open University

History of Science and Technology.

Submitted 31 October 1988.

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This thesis is my own work and has not previously been submitted for a degree or other qualification to any university. Parts of chapters 2 to 5 inclusive were included in my paper "Robert FitzRoy and the early history of the Meteorological Office", B.J.H.S., 19, (1986), pp. 147-176.

(J.M.C. Burton)

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The completion of this thesis sees the culmination of almost fifteen years of study with the Open University. In 1973, as a C-registered undergraduate with no credit exemptions, my main aim was to raise my academic awareness so that I could the more readily assist the efforts of my two sons through their school careers. That done - and an honours degree having been attained more or less as a by-product - it seemed rather a waste not to carry the process further. The present work was embarked upon as combining two of the author's major interests: meteorology (which is my job) and history (which has been my lifetime fascination). The project was especially attractive because no other comprehensive study of the subject has ever been made and so it does, in large measure, break into new ground.

My debt to many people along the way has been immense and it is only possible to name a few. First must come my supervisors, Dr. Colin Chant and Dr. Vance Hall, who guided my first uncertain steps along the paths of serious historical research. Vance had soon to go overseas but continued his occasional exhortations from afar. Colin I saw regularly until my own removal from the metropolis to the open lands of Yorkshire in 1984; somewhat less frequently thereafter, but by then my feet were moving firmly along the road. The advice I have received from both has been fundamental to this work although its imperfections are my own. Prof. Roy MacLeod will never know how invaluable was the help he gave so readily to the outsider who approached him for advice in 1980. His open invitation to attend his seminars at the London Institute of Education brought me into contact

with the way scholars in the field think, and some of that knowledge must surely have rubbed off. Amongst other science historians I would also mention Dr. David Knight, who gave unstinting assistance in turning my first draft of a paper on the FitzRoy period into a fully fledged article for the B.J.H.S. in 1986, and taught me much in the process.

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My research has taken me into many libraries, and my debt to the librarians, archivists and staff has been enormous. To list them all would be too lengthy here but they are severally noted in the footnotes. I must, however, make a special mention of the excellent National Meteorological Library, which is situated in the

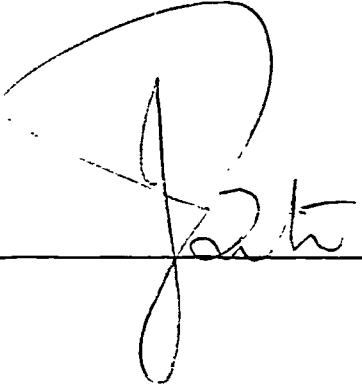
Meteorological Office itself, and of its successive Librarians Mr. Eric Harris and Mr. Maurice Crewe. Their friendly assistance, and that of their staff, has been useful again and again throughout the course of my work. The pecuniary demands of the research have not been negligible and here I must thank the Crowther Fund Awards Board for giving me limited but invaluable assistance for much of the period of my research. The Fund was, of course, established as a tribute to the University's first Chancellor and is used for the purpose of assisting Open University graduates to extend their work. As that work neared its completion the task of typing loomed ever larger. I was fortunate, indeed, that Mr. David Shaw, the Principal of the Meteorological Office College, was able to give his consent to my making use of the College facilities. My very real gratitude is due to him, and to Mrs. Jacquie Coombes who has carried out the actual typing with enthusiasm, efficiency and despatch; also to Mrs. Linda Swanson who gave a vital hand with the lengthy and complex footnotes.

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Abstract

This thesis covers the first half century of the British Meteorological Office and events leading to its foundation. After an introductory chapter the narrative describes how growth of marine transportation led to awareness of possible benefits from knowledge of wind patterns. Moves to collect marine weather statistics worldwide were supported with reluctance by Britain, but eventually resulted in the foundation of a new Department of the Board of Trade devoted to collection of marine observations. Robert FitzRoy, its first head, later transformed this work into provision of the world's first operational weather forecasting system.

After FitzRoy's death an investigation into the Department was followed by a complete re-organization that replaced it by a Meteorological Office under the control of an unpaid supervisory Committee (later a paid Council) financed by an annual grant. The subsequent evolution of the Office is described. Its relationships with other bodies were not always smooth, nor was its development rapid, but it laid a foundation for what was to follow.

The Office's story impinges upon many aspects of the contemporary scene and is set within their context. The reaction of Treasury to its financing is dealt with at some length. The gradual growth of public services is recounted and it is noted that, at a time of supposed laissez-faire, there was no attempt to turn the Office into a revenue raising organization, the primacy of public service always being evident. A characteristic of science has been the division arising from the dichotomy between "pure" and "applied" approaches to problems, and this is highlighted within the narrative.

Despite its disappointing role at the turn of the century, the Meteorological Office is seen as a prime force in the emergence of meteorology as a science within this country. The thesis closes with a glance to the future.

CHAPTER 1

THE EARLY DEVELOPMENT OF METEOROLOGY

1.1 In the beginning

Awareness of the weather and of its significant - and sometimes devastating - effects upon his activities must have been amongst the earliest perceptions of emergent man. Primitive groups readily turned to the atmosphere's driving force, the sun, as an object giving them warmth and light and so worthy of their awe and worship. In the cradles of civilization around the area we now term the Middle East the sun was also recognized as an accompaniment to drought, the drying up of water holes and the purveyor of thirst and death as life shrivelled under the summer heat of a cloudless sky. It is not surprising that in such regions the object of veneration was sometimes the life saving and life giving rain, the natural irrigator of man's crops. Life upon Earth has grown up around the cycle of the sun's apparent motion around the planet; remarkable man made features such as Stonehenge, with its evident relationship to the sun, bear testimony to the importance vested in it by early man. Worship of a sun god is well known and chronicled, and the importance of rain in ancient times is shown, for example, by the ancient sky religion of Egypt and its associated rain makers, which date back to well before 3500 BC (1).

It is not intended to incorporate a comprehensive account of the early history of meteorological thought into this thesis, but it would seem appropriate to provide at least an outline review of the early development of weather study as a framework for the main body of the

work. This review will be derived almost entirely from secondary sources and so the author cannot necessarily vouch at first hand for the accuracy of all the facts and views that will be noted.

The first record of a systematic attempt to describe and understand weather phenomena appears to lie with the ancient Greeks. Thales of Miletus (c624-546 BC) was amongst the first of the philosophers to consider the weather and its effects and to him was ascribed a theory relating the etesian winds of the eastern Mediterranean and the phenomena of the Nile floods. The etesian winds form part of the western edge of the circulation due to the summer monsoon of India and the Arabian Sea, and they form the most persistent and steadiest winds of the Mediterranean region. Thales thought that it was their strength and persistence which held back the outflowing waters of the great river, and so caused the regular overflow of its waters by acting as a dam across its entrance to the open sea (2). It was Thales' pupil Anaximander (c611-547 BC) who gave us the definition of wind as a flowing of air, a description that would still be found satisfactory by a present day meteorologist (3). Thales' theory was disputed by Democritus (c460-371 BC), who had travelled widely and was aware of the heavy seasonal rains over the source regions of the Nile. Democritus also felt that the etesian winds were important in explaining the seasonal rise of the river but his reasoning was very different from that of Thales. He looked not to the damming of the river mouth, and the consequent overflowing of the waters unable to get out, but to the reasons for the rains across the head waters of the river. Democritus conceived the idea that cloud laden air was driven southwards causing heavy storms and filling the large lakes that form the various sources of the Nile (4). He was mistaken in this - the rains originate from the moist air penetrating eastwards from the Guinea coast - but the concept of air from different regions advecting across, and affecting the weather in, other parts of the world

certainly has a relatively 'modern ring' about it. This idea of the possible movement of coherent weather systems was not accepted and was to be overlooked for many centuries.

It was to be a near contemporary of Democritus who was to have the greatest influence on weather study, amongst many other things, throughout much of the next two thousand years. This was, of course, the immortal Aristotle (384-322 BC). The great philosopher's interests were universal and he did not neglect the form and workings of the atmosphere. The Greek concept of meteorology was much broader than that accepted as being within its province at the present day. Meteorologica was Aristotle's principal work on the subject (5). It was based on the concept of four elements, fire, air, water and earth each transferable one into another, each potentially latent in the others, and from which all the observable phenomena could be explained. Of the four, fire always rises to the top, earth always sinks to the bottom, whilst air and water bear to each other a mutual relation similar to that of fire and earth respectively - air being nearest to fire and water to earth (6). Aristotle dismissed the idea of wind as air in motion, considering it to be caused by exhalations from the earth; and he thought that rain was due to gradual accumulation of water formed from condensation of vapours.

Aristotle defined meteorology as everything which happens naturally but with a regularity less than that of the primary element of material things (from the fifth element of which the heavenly bodies are made). This theory embraced all the phenomena of the skies including shooting stars, aurorae, the Milky Way, comets, thunder, rainbows and all the varied manifestations of the weather. He was followed by his pupil Theophrastus of Eresus (c371-287 BC), who made a study of winds. He also produced a book on weather signs and gave rules for prophesying the future course of the weather. These were largely based on folklore and

observation and the poet Aratus (c315-245 BC) later expressed many of the rules in popular verse (7). Seneca provided a broad review of much of this foregoing work in his Naturales Quaestiones but added little that was original although he did opine that winds were a consequence of flatulence as the earth digested its nourishment. He noted that it was fortunate that nature always digests thoroughly what she consumes, otherwise we might well have a more offensive atmosphere! (8).

Little was done in the way of weather study for many centuries after Aristotle had produced his treatise. Aristotle's system was all pervading, it covered all known phenomena and there was neither cause nor means to overthrow its reasoning. In Britain the first scholar to take an interest in the weather appears to have been Bede, in his De natura rerum written about 703 (9). Several chapters in this work dealt with weather phenomena, and Bede joined the line of thought that considered wind to be air in motion. There was no mention of the theories of Aristotle since these were unknown in Western Europe at this time, and there was, perhaps, something of superstition in statements that linked thunder accompanied by a west wind with a very bad pestilence, but Bede's work was still a clear advance in the way natural knowledge was regarded in this country.

Astrology and folk-lore still remained the main tools for those interested in attempting to foresee changes in the weather, and the results were not always advantageous to the aspirant forecasters (10). Astro-meteorology, which attempted to link weather to the movements of the sun, moon and planets was regarded as a very legitimate study until quite recently as will be seen again when we consider the state of weather prognostication in the latter half of the nineteenth century (see p. 49). One delightfully named book (to modern eyes) that dealt with the foretelling of weather was Leonard Digges A prognostication of

right good effect, that appeared in the mid-sixteenth century. This contained advice such as: "Venus in Cancer combust (ie under the beames of the Sunne), a quyet calme tyme" (11). The stock of weather lore, which had originated - in an organized manner at least - with Theophrastus (see pp. 3-4), was expanding and within Britain many of the sayings were eventually collated and codified by J Claridge in 1744 as The Shepherd of Banbury's rules (12). Some of the rules are clearly based on sound and shrewd observation and there are good physical reasons why they should prove accurate, some are somewhat wild and woolly and probably based on inadequate and subjective impression. Whatever the verdict on the rules they certainly form a large and carefully compiled bank of weather observations. Clearly weather was considered a subject worthy of close study both for the benefits such knowledge might confer as well as for intrinsic interest in the subject for its own sake.

But by this time a more systematic approach to weather study was already well advanced. The great natural philosopher Roger Bacon (1214-1294) has been credited with a significant role in the move towards a rational approach to knowledge and he wrote treatises on grammar, logic, mathematics, physics and philosophy at the request of Pope Clement IV, these seeing the light of day as Opus majus, Opus minus and Opus tertium. Bacon did not attack Aristotle's theories, and his contribution to the sum of knowledge was not outstanding in itself, but he was insistent on proper research, experimentation and observation as an essential background to philosophy (13).

1.2 The genesis of systematization in study of the weather

It was not long after the death of Bacon that the keeping of weather diaries in a regular and organized manner is known to have begun. There was little or no co-ordination between the various observers at first but

a number of records have survived to the present day. Many of the early observers were clergymen, one of the earliest being William Merle of Digby in East Lincolnshire who kept a diary for at least seven years between 1337 and 1344 (14). The adoption of systematic observation was eventually to prove the death knell for the ideas of Aristotle. The full story of the way in which meteorological thinking gradually threw off its dependence on the mores of ancient Greece is well beyond the scope of this thesis, although a good account is given by Frisinger (15). Weather lore and astrology retained their importance for a considerable time and, indeed, the former are still quoted with gusto to the present day (16). Astrological influences remained prominent until well into the nineteenth century, and many of the early weather diaries show attempts to relate weather to the motions of the various heavenly bodies. The rules produced by Digges have already been mentioned but a much better known name associated with these quasi-astrological methods was that of Johannes Kepler (1571-1630) (17).

The final death blow to the Aristotelian ideas came as the observing networks expanded and as the invention of accurate and reliable instruments spread to cover all the meteorological elements. With the advent of good and, above all, comparable means of measurement, the way was open to a much more soundly based theory of the weather. Many of the meteorological instruments emerged during the sixteenth, seventeenth and eighteenth centuries. There are a number of accounts relating to their development, the most comprehensive being due to Middleton (18). The vital invention of the barometer was made by Torricelli, a former student of Galileo, in 1643. The relationship between changes in the height of the mercury column and the patterns of weather that are experienced soon led to the idea that here was an instrument that could be used to foretell the weather directly. Someone - it is not certain who - decided that there was a definite correlation between barometer height and

weather, and so labelled the instrument with the words now so familiar to anyone with a barometer on their wall today - fair, change, very dry, etc - to the continued consternation of those attempting to use the indications as a positive guide. The rather more complex relationships that do exist will form a part of the story that is to be related in the following narrative (19).

Preceding these practical refutations were the more philosophical attacks on Aristotelianism by Cardano (1501-1576), in his De subtilitate rerum, and Descartes (1596-1650). Descartes proposed an entirely new particulate theory and, in an appendix to Discours de la methode which he entitled Les meteoires, he introduced a system that queried many of the ancient philosopher's ideas. He still lacked the means to investigate the atmosphere in a quantitative way, but his growing authority was sufficient to hasten the end of Greek dominance of meteorological theory (20).

The quantification of meteorological observation was to follow relatively quickly. The advent of the barometer has already been noted and the invention of the sealed thermometer, attributed to no less a personage than Ferdinand II, Grand Duke of Tuscany, was almost exactly contemporaneous (21). The means of measuring many of the principal remaining elements were to become available during the next hundred or so years, and were continuously refined (see note 18). The application of investigative analysis to meteorological problems was now becoming feasible. Conditions in one locality could be compared more objectively with conditions elsewhere. Rival hypotheses about the weather processes could, to some growing extent, be quantified. The next step was to combine the observations of a network of observers using similar instruments and similar methods. And that step was soon being taken.

According to Frisinger's account, the first concerted instrumental meteorological observations were made during the period 1649-51 (22). These were apparently to test the capacity of the barometer as a weather forecasting tool, and the observations, which were made in Paris, Clermont-Ferrand and Stockholm, involved Boyle, Hooke, Mersenne, Leibniz and even Descartes himself, amongst others. The date seems remarkably early after the barometer first became known (see p. 6) and, indeed, remarkably perceptive that the importance of its variations should have been realized so soon, but other and more comprehensive observing networks were to follow. The Accademia del Cimento was founded under the auspices of Prince Leopold of Tuscany in 1657 and its operations lasted for some ten years. Not unnaturally its work was much influenced by the experimental method of Galileo, and its activities ranged widely. Meteorological observations were an important part of the programme carried out, and the elements observed included temperature, pressure, humidity, wind direction and state of sky (23). Most of the data came from Italy but also from as far afield as Paris and Warsaw.

The Royal Society of London became involved in the quest for meteorological information in 1723 when James Jurin, the secretary of the Society, invited all weather observers to submit records of their observations; details of how to record the data were given and the results were intended for publication annually in the Society's 'Philosophical Transactions' (24). Indeed, sixty years earlier Hooke had proposed a 'Method for making a history of the weather', suggesting a format for recording observations and instructions for making them (25). Jurin's appeal met with a good response at first and the American mathematician Isaac Greenwood sought to enlarge upon the scheme by collecting marine observations as well as those made by land based observers (26).

The impetus behind Jurin's initiative faded after a few years but in 1780 a more ambitious scheme was founded by the Elector Karl Theodor of Bavaria. This was the Societas Meteorologica Palatina, centred on Mannheim, which organized a network of meteorological reporting stations throughout Europe and extending as far as Massachusetts and Greenland in the west and north to Rome and Moscow in the south and east. In all some 57 observing sites were used. The period during which the society operated was 1780-1795 and the observations made included readings of barometer, thermometer, hygrometer, rain gauge and wind vane (27).

1.3 The evolution of theory

Interest in the weather was not confined to mere observation of its various manifestations. Study of the physical processes of the atmosphere had also been facilitated by the improvement in instrumentation and the growth of systematic investigation. The variations in height of the barometer were a source of speculation for many years, and explanations ranged from the possibilities of changes in the height of the atmosphere (de la Hire 1705), through the suggestion that advection of warm or cold air at upper levels in an atmosphere of uniform thickness might be responsible (Placentini 1711), to changes in the water vapour content (Deluc 1772, Changeux 1774) (28).

The period of the seventeenth and late sixteenth centuries has been referred to as the era of the 'Scientific Revolution' (29). Certainly there was a major transformation of thought during this time and the subsequent years saw a continued advance in scientific understanding. It is not surprising that meteorological theory tended to follow the major discoveries in other fields. The popularity of chemical theories of weather coincided with the identification of different gases in the atmosphere by Black, Cavendish, Priestley, Lavoisier and others;

electrical influences, work on which was pioneered by Benjamin Franklin in America, were also suggested by Volta in Italy (30). The limitations in the chemical theories gradually became evident as continuing research showed the nature of atmospheric changes to be physical in nature and they were never accepted by, inter alios, John Dalton, whose interest in meteorology preceded his more celebrated contributions to chemistry (31). According to Middleton '... by about 1835 meteorology could reasonably be regarded as a branch of physics again ...' despite some '... wildly speculative ...' theories that had abounded in the preceding few decades (32).

Meteorological activity within Britain was evident throughout this period and, besides Dalton, it had attracted some of the most prominent names in the scientific world. Amongst these was the versatile Erasmus Darwin, physician, botanist, inventor and member of the influential Lunar Society of Birmingham (33). Darwin's interests were manifold and some of his ideas were original in the extreme. He speculated on the possibilities of controlling the weather and suggested the towing of icebergs to the tropical regions as a means of cooling the weather. He investigated the phenomena of adiabatic expansion (34); and he was not above suggesting changes in the use of language, advocating the use of the more precise term 'devaporation' in place of the more usual but rather ambiguous 'condensation'.

Adiabatic expansion of air is allied to the formation of clouds and study of the clouds themselves was also an interest of Darwin's. But a fuller examination of clouds was made by another Englishman, Luke Howard, a manufacturing chemist by trade and a Quaker (35). Howard was the author of a number of publications, mostly on religious or meteorological topics. His Seven lectures on meteorology was a comprehensive survey of the subject at that time but the most lasting of his works concerned the

classification of cloud types (36). He named four basic types - stratus, cumulus, cirrus and nimbus - and with these four and their combinations, such as cirrostratus, he classified all the cloud types that occur in the atmosphere. It is a formulation that has stood the test of time and the present day system of cloud classification uses many of Howard's original ideas.

Howard was a member of several societies dedicated to the advancement of scientific thought. These included the Askesian Society, the Linnean Society and the Geological Society of London. He was also a founder member of the Meteorological Society of London, formed in 1823 (37). The very formation of such a society would seem indicative of a growing desire by interested participants for a discussion forum on meteorological topics, and for a means of organizing the collection and comparison of observations. Although considered '... hardly yet a science ...' as late as 1841 (38), and destined to remain a largely Baconian observation-collecting activity for some years to follow, meteorology was beginning to emerge as a subject of genuine interest to a growing number of adherents. That its furtherance and study could also have substantial benefits for society at large was to emerge during the succeeding decades, and the study of this emergence will make up a significant proportion of the following chapters.

CHAPTER 2

PATTERNS IN THE WEATHER

2.1 Storm investigations and maritime meteorology before 1830

The concept of weather systems moving across the globe and affecting areas remote from where they originated is an ancient one and appears to date at least from the time of Democritus (see pp. 2-3), but the idea does not appear to have been pursued and it was many centuries before it came to be accepted and utilized. A thousand years after Democritus, and with a perception that seems truly remarkable in view of the limited information available at the time, Edmund Halley put forward a theory to account for the pattern of winds over a large portion of the earth's surface (39). Halley published a map showing his ideas of the winds and suggested that the cause was due to the distribution of solar radiation received over the globe and the differential heating caused thereby. This was the first attempt to link the atmospheric circulation with the distribution of heat across the earth's surface and the map was quite remarkably accurate when viewed against what is now the known normal distribution of winds.

An extension of Halley's ideas was proposed by George Hadley in 1735 (40). Hadley sought to explain the mechanism behind the persistence and direction of the trade winds on both sides of the equator. His paper has proved to be an enduring classic, and the concept of the 'Hadley cell' that derived from his theory is still used as a starting point in many explanations of the general circulation of the atmosphere (41). Hadley envisaged heated air rising over the equator, spreading polewards at high levels and sinking back to earth in the higher latitudes - thence flowing along the surface equatorwards and so forming

the trade winds as it moved back again across the tropical regions. A simple cellular circulation would, of course, produce trade winds which were straightforwardly northerly and southerly (in the northern and southern hemispheres respectively) and Halley had made allowance for the known deflection to northeast and southeast by assuming that the displaced air would follow the sun on its return equatorwards. Hadley suggested that the deflection was due to the air retaining an eastward component of motion appropriate to the rotational velocity at its initial latitude. This was less than the rotational velocity at the equator and so the air was deflected to the right (in the northern hemisphere - to the left in the southern) of its direction of motion (42). Hadley's work was duplicated by John Dalton, who was apparently quite unaware of his 1735 paper and published what was, effectively, an identical theory, some sixty years later. Having learned of Hadley's primacy in the matter Dalton immediately acknowledged the fact (43). Somewhat more surprisingly, a separate derivation of the same idea has also been attributed to the great German philosopher Immanuel Kant (44).

With the development of accurate and comparable instrumentation, the consequent, if erratic, growth of weather reporting networks and the emergence and extension of meteorological theory, there came an increasing interest in the study of large scale atmospheric disturbances. By the 1820s the nature of storms was receiving attention on both sides of the Atlantic and there was a growing conflict of theories as to their nature and method of formation. In Europe H.W. Brandes became the first person to construct a series of weather maps and, with their use, he advanced a theory in which barometric depressions were envisaged as moving from west to east above the earth's surface, with the wind blowing inwards from all sides in order to establish an equilibrium (45). Brandes' theory was almost immediately challenged by one of his own pupils, Heinrich Dove, who first put forward his law of gyration in 1827

(46). Dove's model of the atmosphere was dominated by two basic currents of air, one being a warm and humid southwesterly the other a cold dry northeasterly, which successively replaced one another across any particular locality as the whole atmospheric system moved slowly and bodily eastwards (47).

2.2 The Espy - Redfield dispute

There was certainly debate concerning different ideas relating to storms on the eastern side of the Atlantic, but the differences of opinion that were generated on the western side were soon to magnify into a dispute that was to prove as tempestuous as the object under investigation. William C. Redfield was an American river steamboat and railway engineer. He became interested in meteorology after observing the effects of a major Atlantic hurricane that caused serious damage to parts of the northeast of the United States in September 1821. In a journey through Connecticut shortly after the storm Redfield noted that uprooted trees at either end of his route had fallen in opposite directions to each other. He concluded that his observations were consistent with the hurricane being in the form of a massive whirlwind. Several years later a chance meeting on one of the steamboats with Denison Olmsted, the professor of natural philosophy and astronomy at Yale, led to Redfield publishing his ideas in the American Journal of Science (48). Redfield was encouraged to pursue his study of the nature of storms and undertook an extended investigation into the behaviour of storms affecting the Atlantic coast of America. Not unnaturally he concentrated his work more particularly on the more severe manifestations of this type of weather disturbance that were experienced in this area. These were the great tropical hurricanes generated each year over the tropical southwest North Atlantic and the Caribbean during the summer and early autumn. Many of these storms move initially to the west and northwest and cause considerable

damage along the eastern seaboard of North America before recurving northeastwards and eventually losing their intensity as they move into extra-tropical regions. A characteristic feature of this type of storm is the intense whirling cyclonic vortex around the centre, and Redfield concluded that the wind field associated with such an atmospheric disturbance consisted of an anti-clockwise flow of air blowing tangentially around a centre of low pressure. He ascribed this pressure minimum to '... the centrifugal tendency or action which pertains to all revolving or rotary movements, and which must operate with great energy and effect upon so extensive a mass of atmosphere, as that which constitutes a storm ...' (49).

Redfield compared the effect with that caused by stirring a fluid in a circular vessel, although he denied that this inferred a downward motion of the air in the centre of the storm. In proposing this model Redfield was effectively pre-empting Buys Ballot's celebrated law by some twenty-six years, although he never explicitly stated the relationship between wind direction and pressure in the form that has been familiar to students of meteorology for well over a century (50).

The idea that wind flow in storms was circular in nature was not new. Shaw notes that the Hanoverian geographer Bernhardus Varenius had treated hurricanes as a form of whirlwind as early as 1650 (51), whilst Piddington mentions Langford (1698), de Ulloa (1743), Capper (1801), Horsburgh (early 19th century), and Romme (1806) as all contributing to the concept of circular wind flow around storms. In the same book Piddington also suggested the term 'cyclone' for '... circular or highly curved winds' (52). As has been seen (see pp. 13-14), the weight of evidence favouring the circular theory of wind did not prevent other proposals from being made. James Pollard Espy, another American, was strongly opposed to the idea and suggested a storm model in which the release of

latent caloric (heat) was envisaged as making a significant contribution towards the energy input of a storm. Espy's model incorporated the idea of vertical upward motion at the centre of the storm and consequently had to allow for divergent air flow at some upper level in the atmosphere, to disperse the rising air, and for convergent air flow near the surface to feed the rising column of air at the centre (53). Redfield's theory was purely mechanical in nature and gave no rigorous explanation for the way a storm started or for the way in which any driving force was applied in order to keep it going. Rather it '... assumed that the leading storms ... originate in detached and gyratory portions of the northern margin of the trade winds ...' (54). The idea put forward by Redfield was that a portion of the atmosphere might be detached at a specific meridian throughout a period of one day, and given a counter clockwise gyratory motion by some not very clearly defined force. After twenty four hours a diurnal cycle would operate and the new rotating mass of atmosphere would act on a following mass in a contrary manner, giving it a clockwise rotation, somewhat in the manner of a cog wheel. In this way a family of alternately anti-clockwise and clockwise rotating vortices were formed, and these then moved from the source area as a succession of storms interspersed by quieter periods. Redfield did not consider the wind flow to be purely rotatory but as being composed of a rotatory component and of a component due to the motion of the storm '... winding no doubt spirally inward and upward at the same time, in the manner of all ascending vortices' (55).

By contrast Espy's work was concerned more with the causative phenomena than with the actual pattern of winds around the storm. In fact Espy was responsible for a major conceptual advance in atmospheric dynamics. As noted above, he argued that heat release due to condensation in the rising air would significantly increase the energy of a storm by exerting an acceleration to the growth of clouds through thermal

reduction in the cloud density, hence leading to yet further convection and condensation. But, although it was peripheral to the main thrust of his 'thermodynamical' ideas, Espy was insistent that his storm model could only be sustained by a flow of air directed radially in towards the storm centre, as in the wind structure suggested by Brandes earlier (see p. 13) (56). The network of observations available was still too sparse, and their accuracy too variable, for a decisive answer to be readily available on the question of the wind direction relative to the centre of the moving storm, and conflicting interpretations were made by the proponents of the two theories. Espy's centripetal ideas received considerable support for a time, and his proposals regarding the energy budget of storms won a large measure of approval when he addressed the French Academy of Science in Paris during 1840, although the British Association had been somewhat more sceptical earlier the same year. He also influenced the work of Loomis and Ferrel, who were both at the forefront of meteorological research in the United States during the mid to late nineteenth century (57). Unfortunately he was '... not prone to examine and re-examine premises and conclusions, but considered what had once been passed upon by his judgment as finally settled ...' (58).

When the availability of increasing numbers of simultaneous observations eventually showed the concept of centripetal inflow to be untenable Espy refused to modify his ideas, even though a pattern of wind flow on the Redfield principle of circular flow with an inwards component could have been adapted to the main body of his theory. His intransigence cost Espy his rightful place in the mainstream development of meteorology and it is only comparatively recently, in publications such as those cited, that his reputation as a major worker within the field of atmospheric physics has been restored.

2.3 William Reid and the Law of Storms

In the meantime Redfield gained a powerful ally when the British army officer William Reid arrived in Barbados in 1832 following a disastrous hurricane on the island (59). Reid was responsible for rebuilding government buildings that had been damaged by the hurricane, and the task induced him to take an interest in the nature of such storms. He was much influenced by Redfield's recently published paper (see note 49) and the two men entered into a lengthy correspondence, collaborating closely on future investigations (60). Reid studied the progress of a number of storms, collecting records of observations from ships' log books and from observers on land. His work convinced him of the validity of Redfield's ideas, and he was deeply impressed with the possibility of producing rules for the safe navigation of shipping in the vicinity of storms. He published the results of his work in 1838 and gave simple rules to mariners for the avoidance of storms at sea (61). This publication was warmly welcomed by Redfield in an article that also contained a strong refutation of Espy's ideas (62).

Reid had actually left the West Indies during 1834 but he returned some five years later as Governor of Bermuda and spent the next few years as governor of one or other of the West Indies colonies. His interest in the nature of storms continued and, in a second book he suggested that high latitude storms are different in character to the tropical hurricane (63). As has been pointed out recently by Gisela Kutzbach, there was considerable confusion amongst meteorologists concerning different types of storm during the first half of the nineteenth century and authors tended to describe tornadoes, hurricanes and large mid to high latitude depressions under the all encompassing word of 'storm' (64). The disagreements between Redfield (who largely studied hurricanes), Espy (who was more concerned with young mid-latitude disturbances) and Dove

(who was familiar with mature European depressions), are more readily understood when this point is borne in mind. Also in his second book Reid suggested that meteorological observations could well be used for prognostic purposes, noting that if model storms (represented by circles) are moved about the chart then wind changes accompanying the movement of each storm can be visualized and therefore predicted (see note 63). Piddington had made a similar suggestion in his book published the preceding year although whether Reid knew of this or not is unknown (65).

Reid followed up his ideas and took the initial steps towards setting up a wide network of meteorological observing stations. His first move was to persuade the Colonial Office to circularize governors of British colonies requesting them to organize the taking of meteorological observations in their respective areas (66). Reid next approached his former commanding officer during the Peninsular Campaign, John Fox Burgoyne, who was at this time the Inspector-General of Fortifications, to try and enlist the services of Royal Engineers officers overseas (67). Burgoyne acted on Reid's suggestion and in 1851 he authorized the setting up of a network of observing stations, giving the responsibility for developing the project to another Royal Engineers officer, Henry James (68). The embryo organization was quickly set up, and James duly made arrangements for the taking and recording of observations, issuing instruments and instructions on how to use them to a number of Royal Engineers stations overseas, although these were not entirely to the approval of James Glaisher, the Secretary of the recently formed British Meteorological Society (69). Burgoyne now sought to expand the scope of the whole scheme and approached the U.S. Government, through diplomatic channels, with proposals for British and U.S. collaboration. The proposals reached Washington in November 1851 and, after passing through

the Department of State, the Navy Department and the Bureau of Ordnance and Survey, they eventually arrived on the desk of Lieut Matthew Fontaine Maury U.S.N. (70).

2.4 Matthew Fontaine Maury and the internationalization of enquiry

Maury had been an active serving officer in the U.S. Navy until he was injured in a stage coach accident in 1839 and invalided out of active service. The previous year, under the strong influence of Espy, the U.S. Navy Secretary James K. Paulding had instigated the collection of regular meteorological observations by the depot of charts and instruments. Maury was put in charge of the depot and immediately began an intensive collection and collation of maritime weather observations, starting with a number of ship logs that were destined for the waste bin. He appealed to shipmasters for observations and started to compile charts and data with which he hoped to show the most advantageous sailing tracks across the oceans (71). By 1851 the depot had grown into the naval observatory and hydrographic office with Maury as superintendent. His charts and sailing directions had received much favourable comment and he claimed that ships using them were showing savings of one third in passage times from east coast ports to San Francisco (72). This was the time of the California gold rush, time was money, and Maury calculated that the financial advantages of using his charts were of quite staggering proportions (73).

Maury's response to Burgoyne's request was both positive and immediate (74). He welcomed the initiative but pointed out that the system of observing introduced by James differed from that used by most U.S. observers. Clearly a conference would be necessary to discuss the way toward a uniform method of observing and, if such a conference were to be called, it seemed a good idea to invite other countries and to

broaden the whole scheme to include marine observations as well as those over land. He specifically mentioned France, Russia and Germany as countries who might be invited.

Burgoyne was not known for his readiness to work with foreigners and his reaction to Maury's reply was less than enthusiastic (75). He thought that the project would be better restricted to Britain and America who '... intercommunicate in the same language and ... have the same weights and measures ...', but he did recommend that the file on the subject be forwarded to the Royal Society for comment. This was done and the Society's report forwarded to Maury. Their recommendations were, broadly, that the idea of working towards a more uniform system of observations at sea was worthy of serious attention, but that the time was not yet propitious for a similar attempt with land observations due to the wide variety of systems in operation. Presumably it was felt that once agreement had been reached over marine observations then co-operation might be extended to cover land observations as well. Maury accepted the recommendations in full and wrote to the Secretary of the U.S. Navy, quoting the Royal Society report verbatim and requesting that invitations to attend an international conference be issued to the United Kingdom, France, Russia, Holland, Denmark, Sweden and Prussia (76).

There were at this time a number of factors favourable to the calling of such a conference. First was the prospect of increased profitability of trading due to the more efficient usage of shipping that would ensue from a better knowledge of probable weather conditions across the sea lanes. This idea had already been pioneered by Maury himself, as has been outlined above (see p. 20), and its ready extension was likely to prove of considerable value to shipping merchants. Second was a clear possibility of strategic military advantage deriving from a greater knowledge of storms. A third factor was the increasing pressure from a

growing international lobby that sought to lessen the considerable perils of sea transport by showing captains how to navigate away from the dangers associated with atmospheric disturbances. This was clearly the interest of Reid and Redfield and, indeed, the former had foreshadowed the need for broadly based weather observing networks to facilitate this purpose more than ten years previously (77). Within Britain it was also in line with an existing movement towards improving safety at sea. Parliamentary Committees were appointed to look into the subject in 1836 and in 1843, but their recommendations were defeated by strong vested interests and the antipathy of the shipowners, who opposed the expensive measures that would have been required to implement them (78). The second enquiry had looked, inter alia, into the question of dangers to shipping caused by storms at sea. Capt Robert FitzRoy R.N., who was at that time Member of Parliament for Durham and had been active in having the committee appointed, both sat as a committee member and was called as its first witness. FitzRoy had had a brilliant career as a marine navigator, especially when in command of H.M.S. 'Beagle' during her circumnavigatory voyage of 1831-36, and held strong views regarding the use of the barometer as a weather predictor. He thought that a neglect of attention to the barometer had led to the loss of many ships at sea and suggested that

'... if barometers were put in the charge of the coast guard at the principal stations round the coast ... they might be the means ... of preventing the great losses of life which take place every year ... owing to fishing vessels and boats going to sea when bad weather is impending; because no bad weather ever comes on our coasts without timely warning being given by the barometer' (79).

At this point FitzRoy was removed from the scene on being appointed Governor-General of New Zealand and the work of the committee lapsed, but the agitation for raising the standards of safety at sea did not go away. Government involvement was called for, and came eventually in the

formation of the Marine Department of the Board of Trade in 1850. The great Merchant Shipping Act of 1854 followed. The fourth and final factor supporting the call for an international meteorological conference was the strong support given by influential persons who were interested in the study of meteorology for its own sake. In Britain this category included Sir John Herschel and, perhaps most importantly, Lord Wrottesley, who was shortly to become President of the Royal Society. Wrottesley was a very close personal associate of Burgoyne (80).

The conference that Maury was proposing was not the first projected international meteorological gathering. Amongst the most important documents on the science produced in the first half of the nineteenth century were the reports by James D. Forbes for the British Association for the Advancement of Science (81). Forbes had pleaded for a greater uniformity in the study of the atmosphere and the Association responded by inviting a number of foreign scientists to a conference on magnetism and meteorology which was to be held in conjunction with their annual meeting at Cambridge in 1845. In the event only a handful of overseas delegates turned up but there was a substantial response to a questionnaire that involved both general matters, such as the relationship between private and government involvement, and more specific topics - one of the latter being the probable closure of a number of observatories following the termination of a five year programme of magnetic observations (82). The conference called by Maury was to be more successful in its attendance.

CHAPTER 3

THE FOUNDATION OF THE METEOROLOGICAL DEPARTMENT OF THE BOARD OF TRADE

3.1 The Brussels Conference

Maury's conference met in Brussels from 23 Aug to 8 Sep 1853. It was attended by representatives from ten nations. The British delegates were F.W. Beechey R.N., the Professional Member of the new Board of Trade Marine Department, and Henry James R.E., the officer responsible for setting up the organization that had acted as the trigger leading to the calling of the conference (see p. 19). Little enthusiasm had been evoked in Whitehall and British participation came only after strong supporting speeches had been delivered, first by Wrottesley to the House of Lords in April, then three months later, as time drew short, by Sir Robert Inglis to the Commons. Five days after the second of these speeches a strong deputation waited upon the First Lord of the Admiralty, Sir James Graham (83). Graham eventually assented to sending a delegation but was unenthusiastic and was not prepared at this stage to consider establishing a separate department for recording observations. When the delegation was eventually despatched its members were given orders not to commit the Government to any expenditure. The lateness of the decision to send it at all was shown by its arrival on the evening of the first day of the conference.

The conference went into great detail regarding the type and timing of meteorological observations to be made by both merchant vessels and ships of war, and the form of log to be used for recording them. The proceedings were amicable and constructive and agreement was reached on

all major points. The final report, prepared by Maury and Beechey, was adopted unanimously and the delegates dispersed, amidst warm declarations of goodwill, to report back to their respective governments (84).

3.2 The formation and setting up of the Meteorological Department

Beechey duly reported. Delay was inevitable as Government ministers were preoccupied with events leading up to the Crimean War at this time (85). Official notification that a new department was to be formed charged with responsibility for marine meteorological observations did not come until 6 Feb 1854, in response to a parliamentary question (86). The original intention had been to take the relevant vote with the Navy estimates. In the event the new department was absorbed within the expanding tentacles of the Board of Trade and placed under the overall surveillance of the Board's Marine Department (87). When the President of the Board, Edward Cardwell, presented the vote on 30 Jun 1854, Mr John Ball (Carlow) was moved to express the hope that

"... the observations made ... would be collected, as, if that were done he anticipated that in a few years, notwithstanding the variable climate of this country, we might know in this metropolis the condition of the weather 24 hours beforehand ..."

the Hansard account follows this contribution with "(laughter)" (88).

How this reversal in Governmental attitude was brought about is not clear. It was common practice for the Government to seek advice from the Royal Society on scientific matters, so it seems probable that such a consultation took place (89). Wrottesley, who was shortly to become President of the Society, and Edward Sabine, the Society's treasurer, were both interested in meteorology and keen to expand work on the subject. Both would certainly have had a hand in formulating any reply that might have been made to an official query on the desirability of the scheme, and both would have responded positively. Whatever was the

triggering mechanism, Wrottesley sought the opinion of Captain Robert FitzRoy R.N., regarding the practical details of organizing an office to carry out the projected work. As already noted (see p. 22), FitzRoy had long been convinced of the importance of meteorology to seafaring men, and he made a number of constructive suggestions. Wrottesley's approach must have been accompanied by at least a hint that FitzRoy himself would be a leading candidate for the position of head of the new department and, although the latter's official reply was impersonal in tone, a copy forwarded by him to Sabine was accompanied by a letter showing obvious anticipation of such an appointment (90).

FitzRoy's interest might seem surprising. He was a senior naval captain with a distinguished career behind him and his social standing was high. It might have been expected that he would aspire towards an appointment carrying greater prestige (and salary) than that of a small and experimental government department. But there were good reasons for FitzRoy's wish to secure the post. He had been without suitable employment since somewhat precipitately resigning command of HMS "Arrogant" in 1850 due to his wife's supposed ill-health and other domestic difficulties. His applications for another command and, later, for the position of Superintendent to the Compass Department of the Admiralty were unsuccessful. In 1852 Sir Francis Beaufort, the Hydrographer of the Navy, recommended his appointment in charge of a proposed Atlantic tidal survey, but the proposals came to nothing (91).

Two years later he became private secretary to the C-in-C of the Army, his uncle Lord Hardinge, but the job was not to his taste and he pined for work connected with the sea. His interest in the maritime uses of meteorology was well known. Perhaps more to the point he was very close to Beaufort, who was well aware of his wish to secure a

suitable position, and the latter was well acquainted with Sabine and Wrottesley. FitzRoy was an ideal candidate for the job and he was keen to have it. He was appointed officially on 1 Aug 1854 (92).

The following months were busy ones for FitzRoy. His department was small but it broke into areas of thought and activity that were unusual for the British civil service. The administrative details required attention; office accommodation was needed, and was found at no. 2 Parliament Street, a site very close to that now occupied by the Cenotaph (93); a plentiful supply of reliable and tested instruments had to be made available, a problem eased by the British Association who arranged for testing and standardization at their Kew Observatory; agents were required at principal ports in order to liaise with ship's masters about the supply of instruments and the making of observations, and the agents had to be selected and instructed in their duties. FitzRoy's original submission envisaged that a draughtsman and clerk could carry out the routine office work but the Board asked for seven staff, including FitzRoy, as there was already "... a mass of materials sufficient to occupy the (sic) much larger staff than is proposed ..." (94). In the event four clerks were appointed from within the Board of Trade: Lack, who was to be deputy to FitzRoy, Patrickson, Babington and Townsend, but the Statistical Department for which Lack worked refused to release him, so the initial appointees numbered only three. No replacement deputy was forthcoming and the position was left temporarily vacant. The Board intended to meet additional needs by recruitment of supplementary clerks (95).

3.3 Meteorology and the public purse

The full staff began work early in 1855. For all the ideological as well as scientific importance of instituting a government department devoted to the subject of meteorology, it could scarcely be claimed that the formation of an organization comprising one naval officer, however distinguished, and three assistants was prima facie an event of major significance. But it was evidence of a realization by Government that involvement of public money was necessary for undertakings that were, for one reason or another, unsuitable for development by private capital. The popular view of the mid-Victorian era as an age of unbridled laissez faire does not stand up to serious scrutiny anyway, and state intervention was a growing reality of the time (96). Meteorology, surely the most international of the sciences, was never likely to be amenable to study within the confines of a single country, let alone within the resources and limited vision of entrepreneurs motivated by profit. If advantages were to ensue from an improved knowledge of weather at sea then they self-evidently had to be obtained by means of government action and with international co-operation. This fundamental point never seems to have been queried, and the principle of government involvement appears to have been debated simply in terms of the advantages that might or might not result from the proposed service. Some 20 years earlier, under the influence of Humboldt, work on terrestrial magnetism had similarly expanded beyond mere national confines and developed a high degree of international collaboration. Of necessity governmental co-operation was needed and, in Britain, Sabine had been active in acquiring it (97).

3.4 The initial role of the Meteorological Department

Interest in meteorology within Britain was growing and formation of the new department was no more than a part of this development. FitzRoy was not even the first full time government appointed meteorologist. That distinction could be claimed by James Glaisher, Superintendent of the Magnetic and Meteorological Department at Greenwich since 1840, as well as Secretary and principal driving force of the British Meteorological Society (later the Royal Meteorological Society) since the time of its formation in 1850 (98). The Society had itself developed quickly and rapidly set up a network of voluntary observers throughout the country. The Scottish Meteorological Society was founded in 1856 and a year later, prompted by a cholera scare, the Medical Officers of Health for the Metropolis inaugurated an investigation under Dr J.W. Tripe, the Medical Officer for Hackney, into the effects of weather upon public health (99). Alongside all this activity the organization set up by James in the Royal Engineers continued to function, but the most influential body of all was undoubtedly the Kew Committee of the British Association, which had been formed to control the meteorological and magnetic work of the Kew Royal Observatory at Richmond following its acquisition by the Association in 1841 (100). However, apart from inheriting an Admiralty responsibility for processing meteorological observations from various outposts of the Empire, the work of the Meteorological Department was strictly confined to marine meteorology. Links with these other groups were, therefore, tenuous and had little influence upon its early development. That individuals lobbied Government on the Department's behalf, that FitzRoy became a vice-President of the British Meteorological Society, and that Kew acted as a testing centre for instruments are all true, but the overall effect was small and these other bodies did not figure significantly in the story of the Department at this stage.

Indeed, the role of the new Department was strictly limited. The directive under which it was later alleged that FitzRoy should have considered himself circumscribed was contained in a letter from the Royal Society to the Board of Trade, and actually written by Sabine, in response to a request for guidelines (101). This letter dealt almost exclusively with methods of observing although one passage urged that ship's captains should be shown how to distinguish between rotatory storms and gales "... of a more ordinary character ..." an evident sign of the influence of Dove who held that all storms were not of a rotatory character, especially in the European area and away from tropical influences. However the letter was not written until after the Meteorological Department had been fully operational for some weeks and no check was made upon the way that FitzRoy chose to run his department. He regarded the letter as purely advisory and did not consider himself bound in any way by its contents.

The initial resources of the Department were restricted indeed. Apart from three clerks of the Board of Trade and some rather cramped premises, which were soon to prove completely inadequate as the pile of records mounted, FitzRoy was granted an authorizing vote of expenditure amounting to £3,200 for the first year in respect of the Board of Trade and an additional £1,000 in respect of the Admiralty. These sums were to remain unchanged for the first five years, then decrease slightly for the next three. FitzRoy's own salary of £600 per annum was charged as £300 to each of the two department's votes. The salaries of the clerks initially came out of the Board of Trade general vote, but after the first two years they were charged to the specific Meteorological Department vote, which was therefore effectively decreased for other purposes by this amount. The vote was initially taken under the head of the Department of

Science and Art, but it was found more convenient to place the work under the Marine Department of the Board and the sum voted was transferred accordingly. A record of sums voted and expended is given in Table 1.

CHAPTER 4

THE FIRST PHASE - OBSERVATIONS AND STATISTICS - AND A NEW BEGINNING

4.1 Statistics for seamen

It was within severe limitations, therefore, that FitzRoy set to work; but he set to work with a will. His first report was written only five months after full operational work began yet it showed evidence of considerable progress having been made (102). In the programme as first envisaged there were two main features: (1) the supply of instruments, instructions and registers to ships of the Mercantile Marine and the Royal Navy; (2) the compilation of statistical summaries from the completed registers of observations. These functions were indicative of the strong links between meteorology and statistics at this time. Indeed much of the work on meteorology during this period was concerned with a Baconian collection of observational data and its subsequent presentation in lists and tables. That FitzRoy's initial designation was Meteorological Statist; that Lack, his intended deputy, was an officer in the Statistical Department; and that the only civilian present at the Brussels conference had been the noted Belgian statistician Quetelet, all pointed to the prominence of the statistical approach in much of the contemporary work on meteorology.

FitzRoy had already appointed agents at the principal ports through whom instruments and registers might be issued, and by May 1855 fifty merchant ships and thirty men of war had already been supplied. The agents were paid fifty shillings for each vessel serviced and the instruments were loaned free of charge, provided the masters undertook to return observations, or alternatively could be purchased at cost price (103). Co-operating mariners were also supplied with copies of Maury's charts

and sailing directions, which had been provided free by the U.S. Government but, despite this apparently disinterested generosity by the Americans, FitzRoy's personal feelings towards Maury himself were less than completely friendly, and in Britain at least he was not alone in his antipathy. In a letter to Herschel (who clearly shared his views) FitzRoy wrote, caustically,

"... Entirely do I subscribe to your (private and strictly confidential) opinion of Lieut Maury. He has collected facts (aided by a large staff) ... He has given good sailing directions - and has duly trumpeted -according to the fashion - (however unworthy) of the day; therefore - in America - he has a large reputation among men of my cloth - who have not heard of old Dampier - Cook - Flinders - Dalrymple - Horsburgh etc etc as educated men in England have generally. Maury's adoption of other men's ideas - and nonrecognition of their origin is sad ..." (104).

FitzRoy was probably referring to earlier work by Beaufort and Belcher in the Indian Ocean and was obviously envious of Maury's larger resources. He may well have modified his views later but there was ill-feeling felt toward the American by others in Britain. In particular the fairly explicit charge of boastfulness made here by FitzRoy was later supported by Joseph Hooker who, in a letter to Charles Darwin, referred contemptuously to Maury (and also, incidentally, to Glaisher) as being amongst "... those cattle who live by self-glorification ..." (105). Christoph Buys Ballot, the well known Dutch meteorologist, was also very critical of Maury's work (106).

Clearly it would be some considerable time before observations from British instrumented ships could be used for compiling meaningful statistics. FitzRoy had no wish to cool his heels for months before producing something positive to show for his efforts, so he began modifying Maury's data for presentation in a diagrammatic form he

(FitzRoy) thought would be more readily understood by "seafaring men". Maury was apparently agreeable to this modification of his original work. FitzRoy termed the diagrams he devised "wind stars". Each wind star provided a summary of the data for a ten degree "square" of ocean for a three month period. Observations made in each square were referred to its mid-point as to a single observatory, those emanating from the same ship being separated by a minimum period of eight hours, so that up to three observations could be included for one ship on any particular day. The three-monthly periods selected were Jan to Mar, Apr to Jun, Jul to Sep and Oct to Dec (for an example of a wind star see fig 1). The extreme months normally assumed for land observations are Jan and Jul, but temperature changes over the sea show a marked time lag and FitzRoy was making due allowance for this. The method of grouping the observations was less sound and both Maury and FitzRoy were making the same error; if a vessel was moving quickly then a square would be traversed in a comparatively short time, permitting few observations; conversely if moving slowly then more observations would be made. All observations were not, therefore, of equal value and, for sailing vessels at least, the means would be biased towards occasions of light winds (107). The method of combining observations in ten degree squares had been originated by William Marsden, then Secretary to the Admiralty, around 1800 (108). Before the work of Maury and FitzRoy there had been no firm meteorological or oceanographical data available over most of the world's trading routes, and the new information was of immense value to mariners. The compilation and extension of this task was sufficient to keep FitzRoy active for the next two to three years.

Other work had also been performed by the Department during this period. FitzRoy designed a barometer, and prepared a manual of directions for its use that went into many editions (109). In addition an impressively long list of publications had been issued. Amongst this somewhat motley

collection was a series of numbered "papers" of which the most important was probably the third, published in 1858 and consisting largely of a translation of Heinrich Dove's Das Gesetz der Sturme (110). This publication was of especial significance to the Meteorological Department since, as well as showing where FitzRoy's predilections lay (he was a close follower of Dove), the translation was carried out by Robert Henry Scott, an Irishman who was destined to become head of the Meteorological Office when it eventually superseded the Department in 1867. FitzRoy's debt to Dove lay in the latter's concept of the middle latitude circulation consisting of alternating northerly and southerly windflows (strictly, northeasterly and southwesterly, the "wind poles"), with migrating circular storms originating from the conflict between them. FitzRoy's development of this idea will be discussed below (see pp. 49-51).

Despite these not inconsiderable achievements it was never likely that FitzRoy would remain contented with the largely static role that descended upon the Meteorological Department once the early flurry of inaugurating the new service had subsided. Over the next three or four years a routine developed. Instruments were obtained, tested at Kew, and issued to selected ships of the Mercantile Marine through port agents, and to men-of-war through the Admiralty (111). Completed observation books were returned to the Department and reduced, recorded, tabulated and filed. Each class of observation was taken out of its register separately and recorded in data books dedicated to the element under consideration, each page in the book covering a five degree square of ocean. Books were provided for observations of pressure, temperature, specific gravity (of the sea), wind, weather, ocean currents, magnetic variation, depth soundings, crossings, passages, storms, ice, shooting stars and meteors, aurora and electricity. Each element was tabulated separately together with a record of the ship's name, the date and time,

latitude and longitude for each individual observation. This process was called "collecting". The next step was then to re-copy the observations collected into sheets, each devoted to a particular month. This was called "grouping" (112). A growing mass of data was being accumulated and statistics prepared, but FitzRoy's restless temperament would never let him remain content as a mere compiler of numbers or be happy with the superintendence of a minor department in an obscure government office. Beechey died in 1857 and FitzRoy's first overt sign of impatience with his position was to apply for the consequent vacancy as Professional Officer to the Marine Department. To his considerable disappointment the post was filled by Sullivan, a former midshipman and protege of FitzRoy's during his days in command of the Beagle. His former junior was now Captain Sullivan and had a brilliant record during the Crimean War behind him (113).

4.2 Problems for FitzRoy

FitzRoy sought other outlets for his energies and ambition. A much earlier incident in his career still influenced his thinking. Shortly after assuming command of the "Beagle" in 1829 he had almost lost her in a violent storm or pampero off the coast of South America. He ascribed the near disaster to a failure in his use of the barometer. The lesson was never forgotten. He became a strong advocate for training ship's officers in a proper understanding of the instrument, and as early as 1843 he outlined a scheme for using barometers to give warning of storms along the coast of Britain (114). FitzRoy was first and foremost a sailor, steeped in the traditions of the Royal Navy. He was also a man of deep humanitarian instinct. Now he found himself in a position where weather observations were coming in to him in large numbers but days, weeks or even months after they were made. He used these observations to construct what he termed "synoptic" charts with which he was able to

study the weather patterns across the ocean and in the seas around the British Isles (115). The movement of weather systems as traced on his charts convinced him that it was possible to foreshadow changes at a locality by combining a knowledge of the barometer and its changes with intelligent interpretation of conditions actually occurring at places upstream along the direction of movement of the weather. All his instincts and training pointed towards the next step. His Department had been set up as an agency for assisting mariners to achieve more efficient usage of their vessels - a primarily commercial function. A man of FitzRoy's character was much more likely to be impressed by the possibilities of reducing the appalling annual carnage amongst seamen around the British coasts due to the unpredictable nature of the weather (see Table 2).

A distraction for FitzRoy was an atmosphere of unrest amongst his staff. Its origins came early in the Department's life following the collapse of Lord Aberdeen's coalition Government under the pressures of the Crimean War (116). In his first ministry Palmerston appointed Lord Stanley of Alderley to the Presidency of the Board of Trade. FitzRoy had been involved with Stanley's distant cousin, the future Earl of Derby, some ten years earlier when the latter was Colonial Secretary and FitzRoy was Governor of New Zealand. He had quarrelled violently with the colonists over their treatment of the Maoris, and was recalled to Britain by the Colonial Secretary in response to the settler's calls for his dismissal. FitzRoy was deeply hurt by this treatment and his reactions to the name of Stanley were unlikely to have been cordial (117). Stanley promptly made them worse by filling the vacant position of FitzRoy's deputy with Lieut Simpkinson R.N., a young naval officer who had been recommended to his patronage. The appointment proved unsatisfactory - FitzRoy described Simpkinson as being "... of a flighty, irregular turn of mind ..." - and he requested Simpkinson's dismissal, but the new

deputy resigned (118). Stanley, piqued at the rejection of his nominee, refused to appoint a successor so FitzRoy nominated Pattrickson to act in the position. Unfortunately a reorganization within the Board of Trade, following upon the Northcote-Trevelyan Report, now saw Babington promoted from the grade of Supplementary Clerk to that of Junior Clerk, over Pattrickson's head. FitzRoy thought that Pattrickson should have gained promotion on merit and, although thinking highly of Babington, felt the latter had been favoured because of close family connections with Lord Macaulay (Thomas Babington Macaulay) - an anomalous result, if true, since one of Northcote's main aims was to lessen the effects of patronage. Pattrickson continued to draw a higher salary and FitzRoy continued to regard him as his deputy. Babington was quite happy to accept this arrangement, but the more junior Townsend now refused to obey Pattrickson's direction. The resulting difficulties led to Townsend's resignation and his replacement by a Junior Clerk, Jennings, who also refused to serve under Pattrickson and was consequently removed at the request of FitzRoy. The situation was eventually resolved when FitzRoy's vigorous efforts resulted in Pattrickson being granted a special status as deputy as long as he remained within the Meteorological Department, but without promotion in his substantive rank. The relations between FitzRoy, Babington and Pattrickson appear to have remained harmonious throughout this somewhat bizarre episode. FitzRoy's efforts on Pattrickson's behalf extended over a period of two years and involved him in lengthy and laborious correspondence with many of the Board of Trade's most senior officers. This lengthy exchange could be interpreted as mere stubborn determination by FitzRoy to get his own way but it is probably more realistic, and certainly more charitable, to see it as indicative of loyalty towards a worthy subordinate whom he considered to have been wronged (119). Ironically, Pattrickson left the Meteorological Department in 1863 but remained on the Board's staff, being promoted to Junior Clerk later the same year and to Senior Clerk in 1867 (120).

4.3 Tragedies at sea - and a new way forward

Despite these problems FitzRoy was to press forward with his gradually maturing ideas for using meteorological information to provide greater safety at sea. The development of a scheme for this purpose had already been undertaken by Urbain Le Verrier in France following the loss of the naval vessel "Henri IV" during a storm in the Black Sea whilst engaged in the blockade of Sevastopol. Le Verrier was approached by the French Government to investigate how such storms were produced. He contacted meteorologists across Europe for observations around the time of the disaster and his subsequent report showed that the storm was clearly traceable, and by inference predictable, as it moved across the continent. His principal recommendation, to establish a meteorological reporting network so that warning could be given of the existence of such storms, was promptly adopted by the Government and Le Verrier was placed in charge of the project. He established a network of French and foreign stations linked by the newly developed electric telegraph and used it to produce daily weather bulletins and charts, but he made no attempt at prognostication (121). In the Netherlands, Christoph Buys Ballot was also working on the same problem. He instituted the first prognostic storm warning service in 1860 using a device he called an aeroclinoscope to give notice of expected winds, but the organization was on a small scale using observations from only four stations in the Netherlands. The system was based upon the well known law that is still associated with Buys Ballot's name (see note 50). He described his methods in a paper read to the 1863 meeting of the British Association (122).

FitzRoy set out to go beyond the limitations of the French and Dutch systems and to provide a full operational storm warning service for shipping. The idea of using the newly developed electric telegraph to

give warnings of bad weather already occurring at a locality had been made in Britain as long ago as 1848 by John Ball, and Ball had coupled this idea with the suggestion that prognostication might well be attempted if a sufficient number of observing stations were used and the movement of the weather systems could be calculated (123). A similar proposal had been made even earlier in America by Joseph Henry, Secretary of the new Smithsonian Institution, in a letter dated 8 Dec 1847 to the Institution's Regents. A network of observers was, in fact, formed but no attempt at actual prognostication was made for over twenty years despite Henry's clear inference that this could be done (124). FitzRoy aimed to put these ideas into working practice but before proceeding further he consulted Herschel as to the soundness of the idea. Herschel promptly threw his great authority behind the scheme, and emphasized his support publicly in written evidence to the Royal Commission on lights, buoys and beacons. In answer to a questionnaire he stated that

"The most important meteorological communication which could be telegraphed would be information ... of a cyclone actually in progress ... and working its way towards the locality. There is no doubt that the progress of a cyclone may be telegraphed and might secure many a ship from danger by forewarning" (my underlining) (125).

Doubtless FitzRoy had done some lobbying in support of his gradually maturing ideas and at its 1859 meeting in Aberdeen the Council of the British Association passed a resolution

"... praying the Board of Trade to consider the possibility of watching the rise, force and direction of storms and the means for sending, in case of sudden danger, a series of storm warnings along the coast". (126).

The Prince Consort was President of the Association at this time and he became actively involved in the proposals. Two subsequent meetings of the Council were held at Buckingham Palace to discuss the subject and a

second resolution was formulated, this time resulting in an urgent recommendation being forwarded to the Board of Trade pressing for immediate consideration of the inauguration of such a storm warning service (127).

The reason for this sudden increase in urgency is not hard to find. On the night of 26-27 Oct 1859 the modern, well found, iron vessel "Royal Charter" was wrecked in a storm on the northeast coast of Anglesey with the loss of nearly everyone on board (128). The vessel was equipped with powerful auxiliary engines but these were insufficient to prevent her being driven ashore when a strong southeast wind suddenly changed to a hurricane force northeasterly as she rounded the north of the island, en route from Australia to Liverpool. A smaller American ship, the "William Cumming", which was in the same area at the same time and was only equipped with sails, not only rode the storm out safely but suffered little damage in so doing.

The loss of the "Royal Charter" affected FitzRoy greatly. He made a close investigation of the circumstances and published his preliminary findings in Dec 1859 (129), later presenting a full account to the thirteenth meeting of the British Association at Oxford. FitzRoy was convinced that the catastrophe could have been averted had there been a proper warning system in operation. He ascribed the success of the "William Cumming" in surviving the storm to the fact that her master was guided by the instructions laid down by Maury for ships encountering storms at sea (130).

FitzRoy's arguments, with their influential backing, prevailed. The authorization he was seeking for the Meteorological Department to initiate a storm warning service for the benefit of shipping around the British coasts was eventually given under a minute from the President of the Board of Trade dated 6 Jun 1860 (131).

CHAPTER 5

THE SECOND PHASE - FORECASTS AND WARNINGS

5.1 The start of weather forecasting

Once approval was given FitzRoy acted swiftly. Within three months instruments were in place at thirteen coastal stations around the British Isles and a programme of observations had commenced, the arrangements being made as a collaborative effort with the principal telegraphic companies. The instruments, after verification at Kew, were issued to clerks in charge of selected stations situated in coastal districts. In using telegraph clerks to make the observations FitzRoy was following a practice initiated by Le Verrier in 1856. There were obvious advantages in the observers being directly associated with the actual telegraphic services, especially as the clerks made the observations as a part of their regular duties. FitzRoy and Le Verrier thought that these factors, ensuring the prompt and regular despatch of telegrams, would outweigh any lack of meteorological knowledge on the part of the observers (132). The telegraph companies carried out this work without charge, apart from the cost of telegrams, and also rebated their charges by one third for meteorological telegrams. No training was ever given to the observers apart from a printed list of instructions but apparently the organization worked satisfactorily from the outset, at least according to FitzRoy's reports. In addition a daily exchange of messages with Paris was arranged in order to extend the range of the observational coverage. This provided FitzRoy with six observations from the continent, five U.K. observations being sent to Paris in return. Tables of the observations were also collected and passed to several newspapers, who published them daily (133).

FitzRoy prudently, and somewhat uncharacteristically, allowed the system to settle down to a steady routine before taking the next step. Until Feb 1861 he limited action to the receiving of observations, but his authorization had extended to the giving of warnings of storms and he was determined to use this authorization to the full. On 6 Feb 1861 he issued his first storm warnings to shipping. According to FitzRoy they were ignored at Shields by a fleet of vessels, many of which were subsequently wrecked with considerable loss of life. During the next six weeks he issued eight further warnings, this disturbed period being following by a long spell of quiet weather, and he noted that very few wrecks had occurred during the "... notoriously tempestuous weather of February and March 1861 ...", clearly inferring that the warnings had been responsible for this happy state of affairs (134). The system continued to develop. During the period between 1 Mar 1862 and 31 Mar 1863 47 warning signals were recorded by the Department as having been issued, and a summary prepared by Babington recorded that 42 were followed somewhere around the coast by gales, storms or heavy squalls, or resulted in severe damage to shipping (135). The warnings were issued by telegram to the observation station(s) likely to be affected. The message would consist simply of a list of places with the words "North Cone" or "South Cone" (for northerly or southerly gales), "Drum" (for gales successively), or "Drum and North (or South) Cone" (for heavy gale or storm, probably at first from the north (or south)). On receipt of a signal the station(s) concerned would hoist the appropriate signal on a staff, this being repeated at prominent points along the coast by the Coast Guard or by other authorized stations. The visual signals devised by FitzRoy are shown in Fig. 2. They possess the great merits of simplicity and, most importantly, of appearing the same from all directions, a property singularly lacking in Buys Ballot's

aeroclinoscope. Despite many attempts no symbols have been found to improve upon FitzRoy's for the purpose of giving a simple visual warning (136).

This was not the only innovation that was now bearing fruit. As early as 1857 the Meteorological Department had started the practice of loaning 'fishery barometers' to fishing villages and other seafaring centres, together with copies of FitzRoy's Barometer Manual and/or a simplified card containing instructions for using the instrument (see p. 34). This service was extended over the next few years with significant assistance from private benefactors such as the Duke of Northumberland, who placed at least fourteen barometers at points along the northeast coast, and Lady Kay-Shuttleworth (137). The response from recipients was extremely favourable (138).

To this point FitzRoy had acted within his authorization, but the next step certainly seemed to exceed his brief on storm warnings. In Aug 1861 the Meteorological Department started to issue routine weather forecasts, and by May 1862 a complete forecasting service was being provided for coastal regions (139). Reports were now received from twenty coastal stations in the morning and ten in the afternoon, plus five once daily from the continent. The forecasts, FitzRoy's term, were simple in preparation. Following a list of observations the forecast for each coastal district gave the expected surface wind and one or two words on the expected weather. The period covered was two days. A typical example, taken at random from The Times for Mon 28 Jul 1862, is shown in Fig. 3. They were passed to six daily newspapers plus several other recipients, including the Board of Trade and the Admiralty. FitzRoy made

no exaggerated claims to accuracy, insisting that

"Prophecies and predictions they are not; - the term forecast is strictly applicable to such an opinion as is the result of a scientific combination and calculation". (FitzRoy's underlining)
(140)

but this innovation was to cause a controversy that was soon to threaten the whole future of his meteorological work.

By 1862 the routine of the Department was showing marked changes from that of its earliest days. It had already outgrown its original premises. As the volume of records accumulated it became necessary to extend into the adjoining building at no. 1 Parliament Street (141). The staff was now ten in number (including FitzRoy) and still included Patrickson and Babington, who were the only clerks on the regular establishment of the Board of Trade. Babington, who had read mathematics at Trinity College, Cambridge, was becoming more and more involved in the work of forecasting, whilst Patrickson, apart from his special skills as a draughtsman, was engaged largely on the administration. The other seven were all non-established supplementary employees, and several were destined to have long careers in the Department and to play a significant role in its development. One of the clerks working on the extraction and reduction of observations at this stage was G.J. Symons, who was shortly to found and run the British Rainfall Organization for many years. Another clerk, Richard Strachan, founded a monthly journal The Meteorological Magazine in 1864. Unfortunately this ceased after only four editions due to lack of funds but Symons undertook the task of producing another magazine on more modest lines. Symons's Meteorological Magazine outlived its founder and lasted for more than fifty years, eventually being replaced by an official publication bearing the same name as Strachan's when the British Rainfall Organization was absorbed by

the Meteorological Office after the first world war. Symons himself became a most influential figure within the world of meteorology and was elected as a F.R.S. in 1878 (142).

Overall costs had risen remarkably little in the meanwhile, although the pattern of expenditure had altered to allow for the costs of telegraphy. Detailed figures are given in Table 1. The collection of statistics continued at a diminished level but FitzRoy thought the Department had already amassed sufficient data for statistical purposes and, indeed, the sheer volume of material was reaching a point where it threatened to inundate his limited resources. He thought it would be "... advisable to utilise them, while manageable, rather than continue a mere accumulation at the risk of being confused, if not overwhelmed ..." (143).

The forecasts issued by FitzRoy were prepared directly from the observations and despatched within an hour of these being received (144). Operational weather charts were not prepared routinely, although retrospective synoptic charts had been drawn in the Department since 1857, but use was made of outline maps, wind markers and cyclone glasses or 'horns' to get an overall picture of windflow patterns (145). The omission of chart preparation from the forecast process was not so obviously unreasonable as it would seem today. Such charts had been known for over thirty years (see p. 13) but the data available was scanty, and the technique of drawing isobars to delineate the pressure patterns associated with weather systems was still in its infancy and not accepted by many meteorologists, including FitzRoy (146). Additionally, and perhaps more significantly, FitzRoy had developed his own methods by using intelligent interpretation of barometric changes in conjunction with the indications of other weather elements such as wind and temperature. To utilize simultaneous reports of these indicators must have seemed no more than a logical extension of the same idea, the

corresponding synoptic chart being seen, in effect, as a research tool for retrospective investigation rather than an operational facility for immediate interpretation and extrapolation.

FitzRoy's methods of forecasting, with the theories of Dove as a background, are described at length in The weather book and in his 1862 Report (147). Essentially they were based on the assumption of a more or less steady west to east movement of weather systems and a consequent expectation that a storm at a locality would affect locations to its eastwards after an appropriate interval of time. The basic idea was simple, although FitzRoy's explanations certainly were not. His model of the atmosphere in middle latitudes showed two contrary currents of air, one warm and moist from the south or southwest carrying a negative electric charge and with a falling barometer, the other cold and dry from the north or northeast carrying a positive charge and with a rising barometer. Gyrotory movements, or cyclones, with low pressure at the centre were seen as eddies between the two main currents, existing only briefly and never persisting for more than four days. FitzRoy regarded reports of cyclones lasting for longer than this as fallacious and due to successive cyclones having been mistaken for one and the same. The whole body of the atmosphere was considered to be moving eastwards, an idea that FitzRoy claimed as his own, and all cyclones in the latitude of the British Isles thought to have, by virtue of their method of formation, a warm wet side and a cold dry one. An appendix of The weather book includes two schematic charts depicting FitzRoy's concept of typical windflow patterns around the British Isles, and these show a remarkable similarity to present day satellite pictures (148). Not unreasonably he came to regard the preparation of forecasts as a necessary step in making decisions about the issue of storm warnings and in his view, if not that of his critics, the problems were synonymous. The work of Loomis and Ferrel in America does not appear to have affected FitzRoy's thinking in

any way although he was undoubtedly aware of those developments and he certainly met Loomis, at least, personally (149). Dove was the leading meteorological theorist in Europe during the middle years of the nineteenth century and his ideas dominated eastern Atlantic thinking in the 1830s, 40s and 50s. Refusal to modify these theories in the light of new discoveries led to his becoming isolated in later years (150).

5.2 Criticism and controversy

A developing debate on the merits of weather forecasts and their justification (or otherwise) began to generate strong feelings on both sides. FitzRoy claimed that his critics could be divided into three main categories. First were those who thought he failed in scientific method. Second came a group of would be meteorological entrepreneurs, led by Glaisher, who sought financial gain from the supply of weather information and saw the supply of free material by the Department as an obstacle to their ambitions. Last were the profit-seeking ship owners, concerned less with the safety of their crews than with the loss of revenue caused by captains keeping their ships in harbour when storm warnings were in force (151). The first category included a number of eminent scientists, including Francis Galton the General Secretary of the British Association (152). There were also the astro-meteorologists, lunarists and others who advocated theories of weather change based upon planetary and lunar influences whilst denying links with astrology. They approved strongly of prognostication, disapproved of FitzRoy's methods, and did not really regard looking at a period a mere two days ahead as true forecasting anyhow! Astro-meteorologists and lunarists thought in terms of months if not years into the future, and worked out their forecasts from the positions of moon and planets (153). Glaisher's inclusion in the second category was due to his attempt, in association with others including Symons, to float the Daily Weather Map Co Ltd in

1863. The proposal was to sell a daily paper devoted in large degree to the reproduction of weather maps and data. The venture never got off the ground despite publication of an attractive and remarkably optimistic brochure (154). Of the final category it is, perhaps, not too cynical to suggest that they represented the unacceptable face of the so called "Victorian values" that some people, once again, are thinking it fashionable to espouse.

But there was strong support for FitzRoy from many sides. His 'customers' - the seafaring men who made use of his warnings - overwhelmingly expressed themselves as appreciative of their value (155). Continued backing was also evident in high scientific circles, as shown by an exchange of letters between the Royal Society and the Board of Trade in 1863. The Board indicated their concern at the rising costs of the Meteorological Department and queried the utility and scientific rectitude of the warnings and forecasts that were being issued. In reply the Society expressed its confidence in FitzRoy, quoted Herschel's evidence to the Royal Commission on Lights, Buoys and Beacons as to the desirability of giving telegraphic warnings (see p. 40), and indicated that this statement should be regarded as

"... applicable to cyclones in and near our islands, the existence of which has been made known by the system of telegraphy which Admiral FitzRoy has established".

Regarding actual forecasts, as opposed to warnings, the Society made no reply on the grounds that FitzRoy had advised them that they occasioned no additional cost - over and above that of the warning system - and they were therefore scarcely relevant to the query (156).

Articles supporting FitzRoy's work are readily found in contemporary papers and magazines, and The Times dealt in a sympathetic if at times tongue-in-cheek manner with the forecasts, never reaching any conclusion

other than that these pioneering efforts were worthwhile (157).

Commendatory reviews of FitzRoy's publications also appeared in the Athenaeum whilst the President of the British Meteorological Society, N. Beardmore, showed evident approval of the Department's work in his 1861 Presidential address (158). Further recognition of FitzRoy himself came from the Paris Academie des Sciences when he was elected a Corresponding Member in succession to Sir John Ross in 1863. This however was not related to his meteorological work but it is indicative of his high international standing. He also enjoyed royal patronage (159).

Despite this wide ranging support FitzRoy clearly felt under pressure to justify himself. Doubtless he was conscious of his lack of professional scientific attainments, and any hint that his methods were wanting in scientific respectability was probably magnified in his own mind (160). Many of his explanations were verbose and difficult to follow and, indeed, The Times berated him for "... the singularly uncouth and obscure dialect ..." that he used in his articles. Yet even here there was disagreement because the Athenaeum went out of its way to praise FitzRoy's literary style (161).

The Meteorological Department carried out checks on the accuracy of its warnings, but a separate monitoring system was set up within the Wreck Department and outside FitzRoy's control. Not surprisingly FitzRoy resented this. The Wreck Departments' surveillance began on 1 Jul 1861 and involved observations by some 74 coastal observers, mainly coastguards, for periods of 72 hours (the validity period) following the issue of each storm warning. The results were eventually published as a Parliamentary Paper (162). The senior officer responsible for instituting this 'rival' observational network is unknown. Head of the Marine Department was, of course, Sullivan - but he was an ally of FitzRoy's, and most unlikely to have acted in a manner so clearly to the

latter's detriment (see p. 36 and note 113). One possibility must be T.H. Farrer, joint Secretary of the Board of Trade and former Secretary to the Marine Department, whose doubts about FitzRoy's work were evident in his Feb 1863 letter to the Royal Society (see p. 50). Certainly FitzRoy's own verification was scarcely systematic. It consisted of a register of warnings issued, the record of observations from coastal stations (made, at most, twice daily) and an ad hoc collection of extracts from newspapers, statements concerning weather at ports, etc (163).

A number of storm warnings issued outside Britain were falsely attributed to FitzRoy, although whether they originated from unofficial groups having pretensions to rival his work, such as the astro-meteorologists, or came from persons wishing to discredit him is not clear. During late 1863 two of these warnings caused public alarm in Portugal and Gibraltar and FitzRoy was prompted to write to The Times disclaiming responsibility. He lacked firm proof to enable him to identify the culprit but commented that "... To whom these absurd but injurious predictions are traceable I am not certain, however suspicious ..." (164). There is some evidence to link S.M. Saxby, a prominent lunarist, with the warnings. If Saxby was, in fact, responsible then the warnings might well have been mistaken, but the intent was almost certainly not malicious (165).

FitzRoy came under attack in the House of Commons from Augustus Smith, M.P. for Truro, who launched a furious assault on all forms of Government spending, and then went on to refer to the Board of Trade as

"... a department which had greatly expanded, and in reference to railways, it affected the powers of Pluto, and that of Neptune as respects the Mercantile Marine; but he did not think it should undertake the functions of Aeolus ..." (166).

FitzRoy responded with another letter to The Times in which he first defended his own position and then closed by asserting that since the warnings system had been instituted the harbours of the Isles of Scilly had become much less frequented by vessels in distress. Smith was the lessee of Scilly and FitzRoy was clearly implying that his real concern was a loss of revenue from harbour dues (167). A greater blow came when Maury apparently repudiated the forecasting system in two magazine articles (168). FitzRoy's response, as ever, was to launch into lengthy letters and articles explaining his methods, but these increasingly took on the defensive tone of a man seeking to justify himself. There was some encouragement and support to be derived from the interest that his work had stimulated abroad and FitzRoy lost no opportunity to bring this to more general attention (169).

5.3 Climax and tragedy

The pressures upon FitzRoy were mounting. He had suffered a severe blow to his pride when he failed to obtain the position of Professional Officer to the Marine Department in 1857 (see p. 36). He had overcome this reverse by throwing himself into the work of the Meteorological Department, and his rising status was shown by his promotion to Rear Admiral in the same year and, later, by a substantial rise in salary and promotion to Vice Admiral, both granted in 1863 (170). But other factors were intervening. One was his religion. Charles Darwin had built his evolutionary theories largely around observations made during the voyage of the "Beagle" between 1831 and 1836, under FitzRoy's command and at his invitation. FitzRoy had always been a devout Christian with conservative views. He accepted a literalist interpretation of the Bible and in 1839, in his account of the "Beagle" expedition, he had given an explanation of the extinction of the larger reptiles as being due to their inability to get through the door of the Ark (171). His opposition to the developing

ideas of Darwin was absolute. He was a man of moods and at times was apparently able to take a relatively relaxed view of the affair, but there were moments when he found his own part in the formulation of the theories hard to bear (172). Nor was this all. In order to ensure the success of his voyages FitzRoy had expended substantial sums of his own money. Much of this was spent in anticipation of eventual re-imburement by the Admiralty, and when this was not forthcoming he found his private funds severely depleted. He was now in some financial difficulty and his only sources of income were his salary and his naval pension (173). His health was failing, partly due to overwork, and his hearing was deteriorating to the point where he feared total deafness. The forecasts he provided were, in his view, being attacked unfairly by people who should have known better, and he was obsessed, whatever their differences, with anxieties over Maury and his family who were heavily involved with the Confederate cause in the American Civil War (174).

By late 1864 most of the actual work of forecasting was being carried on by Babington who had succeeded Patrickson as deputy in 1863, on the latter's transference as a junior clerk within the Board of Trade, and FitzRoy, who had aged visibly in the last two to three years, was forced to take a less active part in affairs. He was always liable to fits of depression and in early 1865 his wife was deeply concerned for his health and state of mind. The family moved for a few weeks away from the strains of central London to the pleasant and prosperous suburb of Norwood. His mental and physical condition fluctuated but on the morning of 30 Apr he got up earlier than usual, went into his bathroom, and cut his own throat with a razor. He was still alive when found by his family but died shortly afterwards. The first episode in the history of the Meteorological Office had ended in tragedy (175).

FitzRoy's suicide has been attributed to feelings of guilt over the 'heresies' perpetrated by his former friend and shipmate Charles Darwin, but it would be facile to think that this alone was sufficient to cause his final act of despair. He was no stranger to suicides. His uncle, Lord Castlereagh, had ended his own life in a similar manner, and he had himself succeeded to command of the "Beagle" after her former captain shot himself, and then lived for years in the cabin where that event had occurred. Several contemporary accounts suggested that concerns over his meteorological work finally overcame him, but again this seems too simple an explanation, and it is probably more realistic to regard the motives for his action as complex and multi-causal (176).

5.4 The aftermath: investigation and report

The immediate successor to FitzRoy as head of the Meteorological Department was his deputy, Thomas Henry Babington, although the latter's temporary appointment on full salary was not approved until 9 Jan 1866 (177). Moves to find a successor were mentioned in the Athenaeum, which reported that active canvassing was going on in favour of several candidates and commented (misleadingly) upon the probability of the position again being filled by a naval officer (178).

Babington is a little known figure but he came from a relatively prominent family that could trace its origins to the Norman invasion. Thomas Henry was a grandson of Thomas Gisborne Babington (of Rothley Temple, Leics) and Jean Macaulay. His family had close connections with Cambridge University, Thomas Gisborne and his three brothers all being members of St John's College, whilst one (Joseph) was the father of Charles Cardale ('Beetles') Babington the successor to Henslow as Professor of Botany at Cambridge. One of his grandmother's nephews was Thomas Babington Macaulay (later Baron Macaulay) the historian, who was

born at Rothley Temple, and another (Hannah) married Sir Charles Trevelyan, one of the authors of the Northcote-Trevelyan report on the Civil Service. Thomas Henry himself read mathematics at Trinity College, Cambridge (179).

Meanwhile the Board of Trade instigated an enquiry into the work of the Department. They sought Royal Society advice and a small investigating committee was appointed consisting of three members: Francis Galton F.R.S. (chairman), nominated by the President and Council of the Royal Society; Thomas Henry Farrer, nominated by the Board of Trade; and Staff Commander Frederick John Evans R.N., F.R.S., Chief Naval Assistant to the Hydrographer, nominated by the Admiralty (180).

The Committee laid its report before Parliament on 13 Apr 1866 (181). Its conclusions were devastating. Whilst paying nominal tribute to FitzRoy it virtually demolished everything he had accomplished. The statistical compilations and their method of presentation were severely criticized. The method by which Maury's data had been combined into ten degree squares was described as "... an imperfect rendering of Maury's charts ...". The near cessation of work on statistics was strongly attacked, and the long list of publications produced by the Department found to "... have been selected or published without any plan ...". FitzRoy had thought that the accumulation of marine observations was near saturation point as early as 1862 (see p. 47), and the Committee did not query the principle that the number of observations required could reach a ceiling, but they set their ceiling much higher than FitzRoy. Galton calculated that approximately 100 observations per month for each five degree square in every one of 330 ten degree squares (i.e. 400 observations per ten degree square), with more observations in highly variable and fewer in less variable (e.g. tropical) areas, were necessary in order adequately to define the wind field. He estimated the overall

number of observations required was around 1,650,000; FitzRoy had obtained 500,000. The presentation of storm warnings was described as ambiguous and the Meteorological Department's methods of monitoring as unsatisfactory, the Wreck Department's being thought preferable. The Report noted FitzRoy's objections to the Wreck Department's figures which were on the grounds, firstly, that the observations were made by landsmen, secondly that "... it was not fair, when a storm signal had been hoisted throughout a district, to take the weather at each place separately as a measure of correctness ...", and thirdly that the reporters did not seem to be aware that only two directions were indicated by the warnings (the direction was only differential between southerly, meaning NW through S to SE, and northerly, taking in the opposite half of the compass); but it rejected them all claiming (i) that most of the observers were seafaring men (in the Coastguard), (ii) that "... if a whole district is warned, the gale must, unless the warning is wholly untrustworthy, reach most of the places in the district ...", and (iii) the misunderstandings as to direction were examples of the ambiguity criticized elsewhere in the Report. The warnings themselves were considered sufficiently correct regarding force (but not direction) of wind "... as to be of some use ...", but the daily forecasts as published in the newspapers were not thought to be of value (182). In fact before he instituted his warning system FitzRoy had decided that he could only make "... tolerably sure ..." as to whether the coming wind would be polar or tropical "... that is northerly or southerly (following Dove) ..." and he had never been sufficiently confident to attempt greater differentiation (183).

The principal recommendations made by Galton were: (i) that the method of extracting and discussing observations should be terminated and the whole of the data re-worked and presented in a better way; (ii) that full scale collection of observations be resumed; (iii) that issue of daily

forecasts be terminated forthwith; and (iv) that the storm warnings be continued but the principles upon which they were based should be properly defined and tested. In addition the Report called for an investigation into the laws governing weather changes in the British Isles and proposed the establishment of six stations equipped with self-recording instruments for the purpose, a recommendation considered so important that it was italicized. Most important of all the Committee thought that the work of the Department would be better carried out "... under the direction of a scientific body ... than ... if left to a government department ..." suggesting the establishment at Kew might be developed for the purpose. The estimated cost of all this work was £10,450 per annum, of which £3,200 per annum would cease after 15 years because enough oceanic observations would have been collected. This sum was, of course, appreciably larger than the current expenditure of the Department (184).

In a private letter to Sabine, who was now President of the Royal Society, Galton enlarged upon his reasons for recommending that the Department's work be placed under the management of the Kew, and hence within the sphere of the British Association (185). The Committee had considered four alternatives: (i) the whole organization to be placed under the Royal Observatory at Greenwich; (ii) the existing Meteorological Department to be continued and re-inforced; (iii) the Meteorological Society to be given control, with Glaisher at the head; (iv) Kew to undertake the task. Galton himself strongly favoured the last alternative and persuaded his colleagues to accept this solution. His idea was that Kew should open a "branch office" in London which would handle the telegraphic reports and issue warnings; the spare time of the clerks would be occupied with the other work detailed in the Report, notably the ocean statistics. The superintendent of such an office would need to be "... of sufficient character and intelligence ..." to keep the

clerks at their work and to issue warnings "... but he would act entirely under the orders of Kew". If the Department were to maintain a completely separate identity, and to fulfil the additional functions that were proposed, then it would require the superintendence of a "... really good meteorologist ...". As such it would be an expensive department and, due to its special scientific character, difficult for an umbrella Civil Service department to control. Despite his opposition to forecasting in the FitzRoy manner, and his scepticism as to its scientific respectability. Galton had no qualms about the issue of storm warnings coming under the control of a scientific body because it was "... to be conducted on definite maxims ... and a strict comparison of the prediction with the result to be in every case made ...".

5.5 Reaction and assessment

The Galton Report was a substantial document. It comprised 43 pages in 3 parts plus 18 appendices containing a wealth of information, and it provides an excellent reference to the workings of the Meteorological Department at this time. In his new meteorological periodical G.J. Symons, who had worked under FitzRoy for three years (see pp. 46-47), gave a warm welcome to the proposals for streamlining the recording of statistical data, and it is difficult to quarrel with the wish to terminate FitzRoy's ponderous methods in this respect; but the remainder of Symons's article was sympathetic to his former chief and he quoted with approval from a leading journal (unnamed) that "He (FitzRoy) is gone to his rest, and many a storm-sheltered mariner will look to the signal drum, and grieve with a manly sorrow for the loss of Robert FitzRoy". Symons confined his coverage of the rest of the Galton Report to verbatim quotation of its recommendations and significantly refrained from further comment (186).

A detailed critique of the Report would be too lengthy to attempt here, but an outline of the method used to obtain the unfavourable figures quoted in appendices 13, 14 and 15, comparing warnings issued with weather subsequently experienced, is an illuminating exercise. Consider, for example, a stretch of the northeast coast of England. There were Wreck Department observers at Scarborough, Whitby, Redcar, Middlesbrough, Hartlepool, South Shields, North Shields, Bedford and Berwick (187). When FitzRoy issued a gale warning for this stretch of coast it was recorded as nine warnings issued (one for each station). If one of the stations recorded a wind of force 8 (gale force) or more during the 72 hours following the warning, whilst the others observed maxima of force 7 or less, then this was counted as one warning correct and eight incorrect, i.e. 11% of warnings were considered correct. If the same verification was carried out using present day sea areas then all the stations would be combined into one sea area, Tyne, and the record would show one correct warning issued, i.e. 100% of warnings correct. FitzRoy had protested about this method of counting in the first draft of his 1862 Report (a fact acknowledged by Galton) but he withdrew his criticisms following a letter from the President of the Board of Trade (188). Galton peremptorily dismissed FitzRoy's objections (189). Further, however, the observers were situated on land where the wind, especially if it were offshore, would almost certainly be appreciably less strong than out at sea due to the greater frictional effect of the rougher land surface. This rather obvious point was made several years later when the same monitoring system was re-instituted in order to test the accuracy of a new system of storm warnings (see p. 91). Objections were raised to the checks, largely on the grounds quoted above, and they were terminated, but seemingly without comment as to the fundamental doubt this threw on the earlier criticisms of FitzRoy's work (190). It must also be remembered that the observed wind speeds were only estimated.

Limited comparisons of the figures obtained using Galton's assessment, taken from all observations (referred to as the "Galton number"), and those obtained by using sea areas (as would be present day Meteorological Office practice), are given in Tables 3 and 4. In Table 3 figures for three days in 1863 are given, the dates being chosen at random, the only selection being that at least one of the days should have a less than blanket cover of warnings over the whole of the British Isles, and that one should be notably unsuccessful as regards its outcome of the warnings. In Table 4 similar figures are given for all warnings issued during the month of Dec 1863.

Table 3 shows that Galton marked 84 warnings as correct out of 193 issued (44% correct). Use of sea areas would give 28 correct out of 37 (76% correct). Table 4 shows corresponding figures for Galton of 236 correct out of 387 (61% correct), whilst use of sea areas shows 68 correct out of 76 (90% correct). It should be emphasized that the observations were made at shore based stations and these figures would almost certainly be significantly more favourable to FitzRoy had they been obtained from observations made at sea although, of course, the allowable validity period was for 72 hours, which is very long and doubtless resulted in some warnings being counted as correct by virtue of the wrong gale! But, taking Galton's assessment on its own terms, it is clear that a present day assessment, using the same figures, would give a far more favourable result to FitzRoy.

Nor was this the only weakness in Galton's conclusions. In appendix 7 of the Report he derived a list of what he considered to be the principal maxims employed by the Meteorological Department when determining their forecasts, and then followed it with an elaborate critique of their use. Galton treated each of the maxims as an independent variable and, according to the way he expressed the argument, the more maxims

applicable to a particular forecast then the smaller were its chances of success. He worked out an example, postulating a forecast based upon three maxims. It was not difficult to show that, given a probability as high as 80% for each maxim being correct, then the overall probability of a correct forecast was barely more than even ($8/10 \times 8/10 \times 8/10 = 512/1000$). He consequently rejected the use of maxims - that he had himself derived - but failed to comment on the possibility of any of the maxims actually having relationships with the others, so that the use of a number of indications would actually increase, rather than decrease, the chances of success (191). It may be pertinent to note that Galton's work on bivariate distributions was not carried out until some fifteen years later (192). That he went to the lengths of himself deriving the maxims, upon the supposed use of which he then based his criticisms of the Department, was due to his thinking that Babington had withheld information from the Committee (193).

Galton was preoccupied with the power of statistics, his judgment was erratic and he lacked the imagination necessary to look upon FitzRoy's work as more than an academic exercise being attempted by someone lacking in scientific expertise (194). He did useful work for the science of meteorology but it is difficult to see him as other than an unfortunate choice as Chairman of the Committee, and his scientific reputation was probably sufficient to sway its other members. His own retrospective view was that the Galton Report had not been critical enough (195).

5.6 FitzRoy and meteorology

Galton's opinion notwithstanding, the Report's figures were simply not fair by even the crudest of assessments, but they were official and were quoted widely, the general view of FitzRoy's work suffering in

consequence. Following upon the official findings of the day, FitzRoy's work has been criticized by a number of authoritative writers. Thus Cleveland Abbe commented that

"... The British (Meteorological) Office, under Fitzroy (sic) ... began boldly with predictions, but was obliged to modify its plan until further study had shown how to make these more acceptable".

Napier Shaw thought FitzRoy had been "... overpowered by the glamour of a telegraphic synoptic map ...", and Simpson talked about "... the slippery slope of forecasting down which FitzRoy had so disastrously trodden ..." although he also saw him as "... a true pioneer ..." and wondered whether "... his failures were so real as made out by the (Galton) Committee ..." (196).

That FitzRoy's sense of organization was somewhat shaky is beyond doubt (197). He was a man of action. That his methods were empirical he would not have denied, but was empiricism out of place? It could well be argued that it was not only desirable but essential. He also added to the vocabulary of meteorology (198). And he undoubtedly brought the science to the notice of the public. Doubtless his work will continue to be seen as controversial but it has been strongly defended by at least one eminent figure of more recent days. The Swedish meteorologist Tor Bergeron has forcibly expressed the view that significant progress in meteorology was halted for several decades after 1865. Bergeron held that the understanding of weather systems had at that time reached

"... the very peak of an evolution that was then unfortunately interrupted by FitzRoy's untimely death ... and by the overwhelming pressure from the followers of the new isobaric-synoptic method.

That evolution was not then continued until about 1905 by Shaw and Lempfert, with their Lagrangian air trajectories and ingenious cyclone model, and by the works of the Bergen school from 1918" (199).

The contemporary verdict upon FitzRoy the man was gentle, and the chroniclers of his passing went beyond the normal requirements of the proprieties on such occasions in praising his achievements and his character. That he worked himself to the limit and sacrificed much for the good of others was stated implicitly and explicitly by a multifarious selection of writers. His judgment might have been considered faulty by some, but his sincerity and devotion to duty as he saw it does not seem to have been questioned (200). He laid the foundations of the Meteorological Office in a characteristically controversial manner, and he placed the priority of a meteorologist's freely given service to the public firmly ahead of a more academic or commercial role in society.

CHAPTER 6

TRANSITION - FROM THE BOARD OF TRADE TO THE "COMMITTEE APPOINTED BY THE ROYAL SOCIETY AT THE REQUEST OF THE GOVERNMENT"

6.1 Preparing for a change

The dust raised by Galton took some time to settle and the work of the Meteorological Department continued without significant change for several months. Babington remained at the helm throughout this period although, as has been noted above (see p. 55), his temporary appointment as head was not made official until Jun 1866 a date more or less coincidental with the first noticeable step towards implementation of the Galton recommendations, namely the dropping of the issue of routine forecasts to the newspapers (201). Some three months later a more decisive move was made in a letter from the Board of Trade to the Royal Society which intimated that the Board was prepared to accept Galton's ideas in principle, but sought the advice of the Society before submitting a formal case to the Treasury. The letter also asked for estimates of probable staffing and expenditure levels. A copy was passed to the Admiralty who concurred in thus seeking Royal Society guidance (202).

There was an appreciable delay before any reply was forthcoming - the President of the Society and many members of Council were absent during the recess - but when it eventually did arrive it gave broad support to nearly all the Galton proposals, and in particular for the idea that work on digesting and tabulating the results

"... would be much better, as well as more economically, performed under the direction of a scientific body, furnished with requisite funds, than ... if left to a government department ..." (203).

The Royal Society also agreed with Galton in thinking that the actual collection of oceanic observations would be best performed by a government office. As regards staffing and finance there was thought to be "... no reason to question ..." Galton's estimates. Galton had actually quoted a total of £12,950 for the first year, which included £2,500 initial outlay. Of the remaining £10,450 it was estimated that this running annual cost would decrease by £3,200 after fifteen years, when sufficient oceanic observations would have been collected (204). Finally the President and Council stated their willingness to nominate the members of a superintending committee if the appointment of such a body was thought desirable. Galton was himself a member of the Royal Society Council at this time, but the Council's proposal ran contrary to his earlier suggestion to Sabine that the new organization should be put under the supervision of Kew (see p. 58). Presumably, now that he was President of the Royal Society, Sabine wished to build up its influence, and there was still to be a prominent role for Kew under the new arrangement.

There was, however, a major disagreement with the Galton Committee on the subject of storm warnings. Galton thought the warnings "... too important, too popular, and too full of promise of practical utility to be allowed to die". He also recommended that their issue should be placed "... under the same scientific body which superintends the discussion of (British Isles) ... observations" (205). Galton considered it perfectly proper to place this task "... within the province of a scientific body ..." because it would be "... conducted on definite maxims ..." (206). The Council's view was diametrically opposite and held strongly that the issue of warnings should not be undertaken under the superintendence of a scientific body until their empirical character had been rendered more strictly scientific. If the Government wanted warnings then the Government could consider the means of carrying them

on. The Royal Society did not want any part of it. Clearly the Society did not consider that service to the public was their responsibility and, not unreasonably, they were putting the onus for providing that service on to the Government of the day. Although they could, perhaps, have been accused of wanting to have their cake and eat it - receiving public money for carrying out observations in order to pursue their own "strictly scientific" studies of meteorology, but neatly stepping out of any commitment of service to user interests that had figured so highly on FitzRoy's list of priorities. This basic difference of approach between the "pure" scientist, unable to see merit in the application of techniques without mastery of the relevant theoretical background, and the more pragmatic practitioner who is prepared to operate a system of proven value whilst still lacking a full understanding of the causative phenomena involved, is a dichotomy which runs through this story and will be considered more fully in the closing chapter. It comes down to the present day in the differences between "research" and "services" or, in meteorology between "atmospheric physicists" and "meteorologists" (207).

The Board of Trade accepted the Royal Society's suggested modifications to Galton and sought broad approval for the proposals from the Treasury before more detailed work on the re-organization was put in hand, and a sanction was requested for the preparation of an estimate incorporating the new framework (208). Events were beginning to jump ahead of the authorizations that nominally permitted them to take place. For one thing R.H. Scott, the eventual head of the newly constituted office, received a proposal from Sabine concerning that position which pre-dated the Royal Society letter to the Board of Trade concerning the suitability of Galton's proposals (209). For another the Board issued an official circular withdrawing the storm warning service from operation (at just eight days notice) without waiting for a Treasury response to its proposals (210). Implicit in this withdrawal was a decision that the

Board did not deem the warnings to be of sufficient importance to warrant the expense of continuing their issue (see pp. 66-67). The official Treasury line soon followed in a letter dated one day after the Board of Trade's circular and was quite explicit, commenting that "... a very strong case ... for the utility of the warnings ..." was needed otherwise the Treasury were "... not disposed ... to sanction any expenditure ..." on that account (211). The Treasury letter also indicated that all meteorological costs should be included in one vote so that, were the Hydrographic Office of the Admiralty involved in any ancillary work then the requisite finance would have to come out of the same money allocation. Further concern was expressed that all the current staff of the Meteorological Department should be re-employed within the new meteorological organization, or else absorbed into other departments within the public service, so that no possible claims for compensation might arise.

The Board of Trade and the Treasury, concerned about the level of public expenditure, and the Royal Society, concerned about its scientific "purity", had between them all either failed to spot the emergence of a very hot potato indeed or more probably, in a classic piece of buck passing, had ignored consequences which each thought they could unload upon the others. The storm that was to follow would have justified the hoisting of one of Admiral FitzRoy's drums high above the re-organized Meteorological Office. The effects of the resulting hiatus in the storm warning service will be considered below (see pp. 83-89) but, before looking at the problems that were caused, it is necessary to take a look at the way the financing and management of the former Department were to fare under the new regime.

6.2 The Meteorological Committee

The Treasury gave ready approval for the preparation of an estimate based upon the recommendations of the Galton Committee. On receiving this sanction the Board of Trade immediately approached the Royal Society requesting the President and Council to nominate the members of the proposed Meteorological Committee as quickly as possible, in accord with the offer contained in the Society's earlier letter (see p. 66). The Council met on 13 Dec, with Sabine in the chair, and named the following members (212):

Lieut-General E. Sabine)

Mr J.P. Gassiot) Members of the

Dr W.A. Miller) Kew Committee

Mr W. De La Rue)

Mr F. Galton) Officers of the

Mr W. Spottiswoode) British Association

The Hydrographer

Col W.J. Smythe (213)

All the members of the new Committee, with the single exception of De La Rue, were also either current members of the Royal Society Council or had been so the year previously. This might account for the promptness with which the appointments were made, although the possibility that the whole arrangement had been agreed privately beforehand is not to be discounted.

In the meanwhile Babington had resigned his temporary position as head of the Meteorological Department on 7 Dec 1866, the day on which the Board of Trade suspended FitzRoy's storm warning system. The coincidence seems too great for this to have been chance, and there seems little doubt that Babington left his post in protest at the dismantling of the organization that had been set up by his former chief. Unfortunately no positive confirmation for this hypothesis has been found, so it must remain in the realms of speculation, and no further traces of Babington's career are available so he must fade from the story at a rather poignant moment. His immediate successor was G.N. Simmonds, one of the clerks employed on meteorological telegraphy, who was given the task of supervising the routine work until the new arrangements were complete (214).

The first administrative task of the Meteorological Committee was to appoint a permanent head and the senior officers for the re-constituted establishment. The principal officer was named as Robert Henry Scott, whilst the new senior officers were Balfour Stewart, the Director of Kew Observatory, who became Secretary to the Committee on a salary of £400 per annum, and Captain Henry Toynbee, of the mercantile marine, as Marine Superintendent on £350 per annum. Scott's salary was to be £800 per annum, the same as that paid to FitzRoy and Babington when in charge of the former Meteorological Department (215).

6.3 The new Director and his senior officers

Scott almost certainly owed his appointment to a close acquaintanceship with Sabine. Both men came from Dublin and there may well have been a family connection. Certainly the relationship between the two men was an intimate one and Scott became an executor of Sabine's will when the latter died. At the time of his appointment Scott was Keeper of Minerals to the Royal Dublin Society (216). In contrast to Robert FitzRoy he was

a comparative unknown and details of his early career are sketchy so it is necessary to supply a little background information (217). Scott was born in Dublin in 1833, the son of James Smyth Scott Q.C. His mother Louisa was a member of the powerful Irish Brodrick family, a daughter of Charles Brodrick, the Presbyterian Archbishop of Cashel, and sister of both Charles Brodrick, the 6th Viscount Midleton, and William Brodrick, the 7th Viscount, who succeeded his brother (218). In addition to extensive possessions in Ireland the Brodrick's also held estates near Godalming in Surrey (219). Robert Henry was the second son in a family of five sons and one daughter, his elder brother being Charles Brodrick Scott who became headmaster of Westminster School from 1855 to 1883. Robert was educated at Rugby School under A.C. Tait, the immediate successor to Arnold as headmaster and a future Archbishop of Canterbury. On leaving Rugby he studied at Trinity College, Dublin, where he was a classical scholar in 1853, but two years later attained first place in the experimental physics examination. This was followed by the gaining of a diploma at the School of Engineering in Dublin. Scott next went to Germany, studying in Munich under Liebig (presumably chemistry), and also in Berlin, and gaining a thorough knowledge of German (220). In Berlin he met Heinrich Dove, and when that eminent meteorologist sought a translator to bring out an English edition of his celebrated Das Gesetz der Sturme it was to Scott that he turned (see p. 35 and note 110). Scott also translated the second, and much enlarged, edition of Dove's work which was published in English in 1862. Part of the cost of publication was borne by the Meteorological Department of the Board of Trade, and this brought Scott into communication with FitzRoy (221). Scott acquired a M.A. degree in 1859 and three years later took up his post with the Royal Dublin Society, initially on a temporary basis, but the appointment was made permanent in 1866 with a salary fixed at £100 per annum. A year earlier he married Susan Louisa Stewart, a daughter of the Island Secretary of Jamaica and a descendant of Alexander McKenzie, a younger

son of the baronial house of Kintail, who had joined Paterson's ill-fated Darien settlement scheme in 1698. Following the scheme's failure he had moved to Jamaica where he acquired considerable wealth in the form of land and slaves (222). Despite his notable antecedents, and his subsequent election as a Fellow of the Royal Society, Scott never appears to have been considered as more than an efficient journeyman in scientific matters and a competent administrator. His links with meteorology before 1867 were tenuous, and apparently confined to the translation of Dove's works as mentioned above. But Sabine was not looking for an innovative scientist - the scientific thinking under the new regime was to be done by the Committee - and Scott's other qualifications fitted him admirably for the projected task (223). Anyway, Sabine was doing a good turn for a valued friend and fellow Irishman, the days of patronage were not dead (are they yet?) and, doubtless, he also saw Scott as a useful satellite who would follow the line he himself wished to pursue. Sabine's approach to Scott was made at the time that the Royal Society's reply to the Board of Trade request for advice on the Galton recommendations was being drafted, and actually preceded the date of the official letter (see pp. 107-108). Sabine had not fully comprehended the implications in the removal of the Meteorological Office from the public service, and his invitation was couched in more optimistic terms than later proved to be justified. Not surprisingly the young (he was then 33) and newly married Scott had little hesitation in accepting a substantial rise in salary and personal influence. He was to become the longest serving head in the history of the Meteorological Office.

In view of the appointment of Scott as Director the position of Stewart as Secretary was a strange one. Five years older than Scott he had already laid the foundations of a distinguished scientific career and was a F.R.S. of some four years standing. Yet he was placed in a nominally subordinate position on half Scott's salary, although still retaining a

separate income of £200 per annum as Director of Kew and eventually getting a further £200 per annum as an allowance for superintending work associated with the Meteorological Committee (224). The nominal designations of the two officers were also misleading. Stewart, the Secretary, was not concerned with correspondence, which was all dealt with by Scott, but he did have the major task of getting the proposed network of observatories into an operational state. Scott, the Director, was in day to day charge of the Office's work but he was not in a position to inaugurate changes to the operational programme without prior referral to the Committee. The status of Toynebee, the Marine Superintendent, was more clear cut. As his title implied he was specifically concerned with the collection of maritime observations and his work was therefore in direct line with the original function of the Meteorological Department. His appointment as an officer of the new meteorological organization obviously meant that the idea of transferring the marine function of the old Department to the Hydrographical Department of the Navy had been shelved, although there appears to be no record of a firm decision on these lines being taken. Admiralty opinion was in favour of such work being under the Hydrographic Department, but raised no objection to the Hydrographer being appointed as an ex-officio member of the Meteorological Committee (225). Toynebee himself was a former master mariner and had been one of FitzRoy's first "excellent" observers. His observation books were, apparently, works of art being illustrated by coloured sketches of marine animals drawn by his wife, who often accompanied him on his voyages (226).

6.4 Financing of the Meteorological Office after 1867

Notification of the senior appointments was made by the Committee to the Board of Trade in a letter dated 21 Jan 1867 (227). Accompanying the letter was an estimate for forwarding to the Treasury. This envisaged an

expenditure £150 less than the overall figure quoted by Galton and which both the Committee and the Board were assuming to have been approved in principle by the Treasury (see p. 68). The letter also suggested that Simmonds be informed of these happenings and "... desired to give over the charge ..." of the Office. Scott took over on 7 Feb and Simmonds resigned a fortnight later. The actual title of the new establishment was not decided until a meeting of the Committee on 25 Feb 1867 when the official name of "Meteorological Office" was adopted (228).

The Board accepted the Committee's figures and forwarded them to the Treasury on 8 Feb, with a covering letter, for formal approval. The estimate was described as "... reasonable ..." and, as it was "... within the Estimate ... provisionally sanctioned by the Treasury ..." it could "... properly be approved ...". The letter gave special mention to the discontinuance of the storm warning system but stated that it was "... proposed to transmit facts ... by Telegraph ..." although requiring "... payment of a large part ... of the cost of transmitting ..." by the recipients. Also noted was the proposal to instal eight permanent observatories, one more than had been suggested by Galton. Finally the status of the staff was mentioned and it was made clear that they were "... not Civil Servants of the Crown, and ... not entitled to superannuation or compensation in case of abolition of Office ..." (229).

The Treasury role vis-a-vis the expanding claims of science upon the nation's purse strings during the latter half of the nineteenth century was a difficult one. The dilemma of the classically trained official confronted with the task of sanctioning financial provision for projects about which he had little knowledge, and even less understanding, was a by-product of an educational system geared more to the production of imperial administrators than controllers of new science and technology (230). The problems thus caused by the exercise of Treasury power have

been well described by Roy MacLeod, although it must be noted that his assessment of this power as limited in practice to being able "... to remonstrate, to exhort and to recommend ..." was seemingly far exceeded in this particular instance (231). The margin notes and informal memoranda contained in the relevant Treasury file give a good insight into their reactions to the new organization (232). On the actual Board of Trade letter itself, against the passage on non-entitlement to superannuation, a pencilled margin note states "There is something anomalous about this. These persons are paid out of public money". This was presumably written by R.E. Welby, the Private Secretary to George Ward Hunt, since exactly the same phrase occurs in a much longer note written by Welby to Hunt. Welby thought the proposals represented a "... heavy Estimate ..." and expressed the fear that "... the arrangement will be a source of expense and irresponsibility .." (233).

Concern was felt at the Treasury about the whole method of financing the new Office. As the file bounced from one desk to another it accumulated a collection of worried notes (many of them nearly illegible) and there was an appreciable delay before any firm decision was forthcoming. In fact the time lag became prolonged to the point where the matter of the senior officers' quarterly salaries obtruded. Another letter from the Board of Trade, dated 12 Mar, sought clarification on the tricky point of who was to pay them. The salaries were due on 31 Mar but no reply was forthcoming from the Treasury for nearly a month. When it finally arrived, in a letter signed by George Hamilton, the Permanent Secretary, its contents were unwelcome in the extreme and cast a dark shadow upon the immediate aims of the Committee (234). The latter pointedly declined "... to express any opinion upon the establishment ... required ..." because the officers involved would "... not be in any sense in the Civil Service of the Crown". The sting came in the next line which referred to the Treasury "... assenting to insert in the Estimates a lump sum of

£10,000 ..." on the understanding that no claims "... over and above ..." this amount would be made on public funds "... and that any saving out of that sum will be surrendered to the Exchequer ...". No direct reference was made to the payment of salaries and, up to this point, there had been a tacit assumption that they would be paid out of the existing Board of Trade vote until the end of the current financial year. Further disillusion was to follow. A week later another Treasury letter arrived, this time signed by Hunt (235). This again insisted that the officers appointed by the Committee were "... not in any sense servants of the Crown ...". It also stated flatly that "... any salary ... must be defrayed out of the sum of £10,000 inserted in the Estimates ... as a contribution towards ... the meteorological researches ... undertaken by the Royal Society ...". The initial knife thrust had been pushed deeper.

The Treasury were to add a little twist. The official office seal, two register stamps and a franking stamp had been returned to the Board of Trade on 30 Mar with a request for the issue of a frank to the new Meteorological Office. This was referred to the Treasury and so it also went the round of that Department's officials, accumulating discouraging comments as it did so. Welby continued his fastidious approach and commented that "... this body ..." should not be assigned "... any of the characteristics of a Public Department ..." otherwise he foresaw "... great trouble ...". The inevitable refusal was sent from the Treasury on 20 Apr, being forwarded by the Board of Trade to Scott nine days later (236).

These events hit the Committee one by one during its early months of existence and must have come as a series of hammer blows to the hopes that had been entertained at the start. Sabine called a special meeting on 22 Apr, at his own home, to consider the new situation (237). Miller, Richards (the Hydrographer), Gassiot and Smythe of the Committee attended

in addition to Sabine, with Scott and Stewart also present, and a very carefully worded letter was drafted. The complications of the correspondence were manifested in the complex of references with which the letter opened. The Committee next registered its protest about the constant referral by both Board of Trade and Treasury to the "Royal Society" being involved in its meteorological work, pointing out that the money provided for meteorology in no way benefited the Society who "... contribute nothing to this object". The letter went on to take issue over disallowance of the estimate for £12,800, which had been given tacit approval by the Board, and also pointed out that the clerks' wages had been paid up to 31 Mar by the Board and it was "... distinctly understood that the salaries of the officers would be paid by the Board of Trade up to the end of the Financial Quarter and subsequently out of the annual grant" (238).

6.5 The Treasury in action

The response was rapid, although scarcely constructive, and it ignored the question of funding completely. At the next meeting of the Committee on 29 Apr Scott was able to report only that the Treasury letter of 10 Apr had been modified to the extent that a mention of "the Royal Society" now referred to "Committee appointed at the request of the Government by the Royal Society", the remainder of the letter being unaltered (239). By 6 May the Committee were further informed that the Board of Trade letters of 15 and 17 Apr and the Treasury letter of 17 Apr had been modified similarly (240). The dispute was becoming increasingly pedantic. With the amended 17 Apr Treasury letter in front of them the Committee now amended their own letter of 23 Apr (241). The point at issue this time being Treasury reference to the £10,000 as "... a contribution ..." to the meteorological researches undertaken by the Committee. It was in

fact almost the whole of the income that the Committee had at its disposal and the inference that it was anything less was firmly corrected.

The feeling amongst the Committee at this stage must have been one of increasing frustration, with the Treasury letter about the frank as the last straw. They had started with an apparent budget of £12,800 to play with. This had been whittled down first, brutally, to £10,000, then to £10,000 less the senior officer's salaries. Now it was also less postal charges; but there was some relief on the way. Farrer took up the issue of the Office's financing in a very long letter to the Treasury dated 23 May (242). The whole of the relevant correspondence was reviewed, the points raised in the 23 Apr Office to Board letter (which was enclosed) were emphasized, and the plea that the £12,800 estimate might be approved was re-iterated. Doubtless all this was more a token gesture of protest than a serious attempt to change the rigid thinking of the Treasury, but Farrer did hold one final card. Noting that the estimate had included a sum of £570 for meteorological services to the Admiralty he commented that this sum, as far as the Board were able to judge and in the absence of special application by the Admiralty, would not now be required. Faced with a Navy bereft of meteorological equipment the Treasury gave way to that extent at least. Their final response noted brusquely that in assenting to a sum of £10,000 the Lords Commissioners were aware of the reduction they were proposing to the sum estimated and intended "... that the arrangements ... should be curtailed accordingly ...", although they now accepted that an additional £570 should be made available for meteorological services under the Admiralty (243).

On being received at the Board of Trade this latest Treasury letter was promptly returned by Farrer who insisted that all references to the "Royal Society" (there were five) should be altered to "a Committee

appointed by the Royal Society at the request of the Government". In a note to Spencer Shelley, one of the principal clerks at the Treasury, Welby commented wearily that he supposed they "... must respect their susceptibilities ...", and the appropriate corrections were made (244). But the importance of this alteration as viewed through Royal Society eyes was still quite lost on the Treasury officials. Several months later the same file acquired another protest from the Committee. In the 1867-8 Estimates the sum required for their work was described as being "For Meteorological Observations and Experiments formerly under the Board of Trade to be conducted in future by the Royal Society". An accompanying letter from the Board to the Treasury reinforced the point and the correct title was quoted, this time using the definite article, as being the cumbersome one of "The Meteorological Committee appointed by the Royal Society at the request of the Government" (245).

The reason for the Treasury's apparent change of mind about the sum that should be authorized is not clear. The earlier correspondence had not shown any hesitation in the Treasury's seemingly relaxed acquiescence to the estimate of £12,800, and this was itself within the original Galton projection of £10,450 plus £2,500 for "setting up" expenses that had been thought necessary. In fact the £12,800 included £2,900 for "setting up" expenses in the first year, and so envisaged an annual cost of only £9,900. Certainly both the Meteorological Committee and the senior officers of the Board of Trade seem to have taken Hunt's letter to the Board of 30 Nov 1866 (see p. 68) as tacit approval for the level of funding contemplated by Galton, and presumably the Board's officials were familiar with normal Treasury practice in the giving of consents. When the eventual authorization for £10,000 was received in April the Committee had already started a major development programme for the new observatories and this had to be drastically amended in order to keep within the new spending limits. Whether the eventual Treasury response

was due to an actual change of policy or whether it was merely a case of dilatoriness accompanied by lack of sensitivity (or, perhaps, sheer bloody mindedness) is not clear. There is no evidence that the former was the case. No change of Government took place between November and April nor were any of the senior Treasury officers altered. The most intriguing piece of evidence is a nearly illegible note contained in a Treasury file. This was written by Welby to Hunt between 8 Feb, the date of Farrer's letter to the Treasury, and 10 Apr, the date of Hamilton's reply. Unfortunately some of the note is quite unreadable and its full impact can only be guessed at, but it does appear to show some signs of departmental readjustment of attitude within the Treasury as the new situation of the Meteorological Office began fully to be realized. The entire note is quoted below with queries inserted where the wording is indecipherable.

"Mr Hunt

-?- has been here - he fully agrees to the inexpediency of our committing ourselves in estimates or otherwise to a list of officers and salaries.

He says the (?)whole(?) is experimental from year to year, and he -?- on thinking that a lumped sum of £10,000 to be placed at the disposal of a Committee which has been nominated by the R. Soc for the purpose (-?- them) will be the best form for the Estimates.

R.E.W." (246)

It is unfortunate that the name given at the start of the note cannot be made out. The Chancellor of the Exchequer was Benjamin Disraeli, but this was surely too small a matter for his attention. Hamilton, who was

the Permanent Secretary, appears to be the only other possibility from within the Treasury itself. Perhaps the Board of Trade had been contacted privately. Farrer, for example, might have been asked to attend the Treasury and persuaded that the reduction in grant was acceptable. If so then no attempt was made to inform the Committee before Hamilton's 10 Apr letter reached them. The note also emphasized the Treasury's view of the impermanence of the arrangement. It was to be some years before it became accepted that the Meteorological Office as an institution was there to stay.

The position now occupied by the Office was anomalous in the extreme.

Some years later Scott reviewed the situation that existed, noting that

"... the Government considers us under the Royal Society, and only lately the senior Secretary of the Royal Society has told me that he has always considered us under the Board of Trade; but the Government disclaims all connexion with us, whilst the Royal Society disclaims all control over us, except merely the nomination of the members of the committee" (247).

The unusual status of the Office was highlighted at the end of its first financial year. Hamilton's intention had been that any operating surplus arising out of the £10,000 annual grant should be returned to Treasury funds (248). However, when Scott asked for the appointment of auditors to whom he could submit the accounts for inspection he was told that as the money provided was "... considered as a contribution towards the expenses of the researches undertaken ... at the request of H.M. Government ..." then it was unnecessary for it to be subjected to public audit (249). The obvious corollary was that there could be no question of returning to the Exchequer a surplus that had not been subject to an

official audit. So, in fact, the accounts were audited by Cassiot and Spottiswoode on an informal basis and the small surplus carried forward to the following year as a credit (250).

Nonetheless a special relationship did continue to exist between the Meteorological Office and the Board of Trade. All communication with the Government took place through the Board and, in Scott's words, the Office remained "... distinctly affiliated to the Board of Trade". He added that this affiliation had the advantage of linking the Office with the prestige that FitzRoy's work still held in the minds of many mariners. In later comment on the response to requests by the Office for marine observations Scott noted that almost every captain showed willingness to observe for the Board of Trade but most knew little about the Royal Society. Had he not been able to point to the indirect link between the Office and the Board then he thought that he would have received even less co-operation than he had (251). It is to these operational matters that we must now turn in order to see how the work of the Office altered to meet the demands of the new organization that had been put in place to run it. The early days under the new regime were far from smooth, especially in regard to the abandoned storm warning system, and the consequences of its discontinuance were to cause severe problems for the unpaid Committee. The way the pure scientists of the Committee and the civil servants of the Treasury and Board of Trade interacted to deal with the problems raised by the joint forces of public finance, private finance, pure science and applied science, together with a whiff of Scottish nationalism, forms the background to the succeeding era in the Office's development.

CHAPTER 7

THE SCOTT ERA - PART I: THE AMATEUR COMMITTEE

7.1 The storm over warnings

The new Committee had not even met for the first time before it was smitten with controversy. As has already been noted, the Board of Trade peremptorily discontinued the issue of storm warning signals on 7 Dec 1866 (see p. 67). The abrupt termination of the service aroused considerable protest. The circular notifying the intended cessation gave just eight days notice, and it must have been impossible for many of its users to know of its impending withdrawal before that withdrawal was implemented. Primary responsibility for this remarkable failure in communication is difficult to allocate. The actual decision to stop the warnings originated with the Royal Society, and the very short period of notice given was at least in part due to their disinclination to have anything to do with them. But the recommendation by the Galton Committee that the warnings should be continued, and the statement by the Royal Society that it was up to Government to consider the means of carrying them on should they be "... deemed of sufficient importance ...", appear to have been either completely ignored by both Treasury and Board of Trade or, implicit in the two department's inertia, to have indicated their assessment of a lack of utility, in opposition to the views of Galton. That there was protest by the man in immediate operational control seems almost certain, otherwise the simultaneity of Babington's resignation and the end of the warning service, both of which took place on the same day, would have been a remarkable coincidence indeed (see p. 70).

Whomsoever's was the responsibility there were no doubts about the subsequent chorus of disapproval. Four days after the warning service ended a strong attack on the Board of Trade and the President and Council of the Royal Society was delivered at a meeting of the Manchester Literary and Philosophical Society by one of its joint secretaries, Joseph Baxendell (252). In particular he criticized the principle of refusing to issue storm warnings because of limited comprehension of the atmospheric processes involved, and cited various instances where empirically based knowledge was utilized in the absence of a full theoretical understanding - for example some of the predictions given in the Nautical Almanac, laws on the strength of metals and the way in which the laws of magnetism were used to correct compasses in iron ships (253). Baxendell commented that

"... in a science which aims at prediction, its progress will be best and most surely advanced by a continuous and systematic comparison of the phenomena as they actually occur with the phenomena as predicted ...".

He followed up his attack some three months later with an open letter to Sabine in which he criticized the policy of the Committee towards the opening of new observatories; praised the work of FitzRoy and Babington, who had shown that meteorology was "... sufficiently well understood to be made the means ... of saving ... many valuable lives and ... property ..." and inferred political motivation behind an apparent change of heart by the Royal Society over the issue of storm warnings, which he claimed had co-incided with "... the accession to power of the present ministry ..." (254).

Baxendell's first attack was followed, and in some cases preceded, by a welter of protest from a very mixed chorus of protesters. This included such diverse persons and bodies as the Rev. Francis Redford, F.R.S., of Silloth; the Astronomer Royal for Scotland (C. Piazzi Smyth), the

Manchester Chamber of Commerce and the Provost, Magistrates and Council of the Burgh of Leith (255). Feelings seem to have run especially high in Scotland and Col W.H. Sykes, F.R.S., M.P. for Aberdeen (City), Chairman of the East India Company and an amateur meteorologist, placed himself at the forefront. He raised a Parliamentary Question concerning the warnings on 25 Feb 1867 in which he drew attention to the correspondence received by the Board of Trade on the subject of the suspended warnings (256). Some months later he delivered a blistering assault on the Meteorological Committee at the 1867 meeting of the British Association in Dundee. He railed against "... the pedantic affectation of science - literally a coxcombry of science ..." that had been responsible for the stoppage. Cassiot and Balfour Stewart were present and tried to smooth the voice of protest, but Sykes received strong support from Milne Home the President of the Scottish Meteorological Society, the Duke of Buccleuch, who was the Association's President, Belcher, Don and, perhaps surprisingly, Glaisher, amongst others. A resolution urging resumption of the warnings was proposed by Home and Buccleuch and was passed unanimously by an assembly which included Prof. A. Herschel, Sir Henry James and G.J. Symons in addition to those named above (including, apparently, Cassiot and Stewart) (257).

The debate on storm warnings was again resolving itself into the recurrent argument that runs through the fabric of society between "doers" and "thinkers". In this case practical application of meteorological information had provided results that were accepted as having been of value to society. That FitzRoy had developed his techniques by empirical means, and lacked a full understanding of the causative phenomena behind the storms that he forecast, was seen as less important by Sykes and his supporters than the simple fact that FitzRoy's method saved lives. The more academic arguments favoured by the President and Council of the Royal Society were concerned with the purity

of their scientific reputations and eschewed the empirical approach, despite the support even of Galton himself for the continuance of storm warnings. The effects of this asceticism was, of course, rendered more unfortunate by the failure of the Treasury to equate the twin aims of economy in using the public purse and profitable trading with that of safety (258). The form of this argument between the "pure" and the "applied" scientist has already been noted and still persists today (see pp. 66-67) (259). It will be considered more fully later.

Perhaps the most important factor that eventually moved the Committee to action was the attendance of a deputation upon the President of the Board of Trade (the Duke of Richmond) on 31 May 1867. No record has been found as to the composition of the deputation although it was described as "large" (260). It was also, clearly, influential and the Committee were told that unless they agreed to add storm warnings to their duties then their grant would be discontinued (261). Faced with the loss of their whole operation, the Committee gave way by stages. They had already made a limited response to the early storm of protest, and in March had approved a standard reply to the protesters. In this was offered, to any port requesting it, a regular copy of the Daily Weather Report, free of charge; also "... regular or occasional telegraphic intelligence ...", provided an application was received stating the precise information required, with half the cost of transmission to be borne by the applicant (262). When Farrer's 31 May letter concerning the deputation arrived (see note 260), the Committee responded by declining to "... prognosticate weather or to transmit what have been called storm warnings ..." but drew attention to their earlier circular and went on to accept responsibility for forwarding telegraphic information of storms already occurring along the coast, as long as this remained within the limit of £3000 that their budget allowed for telegraphic purposes. The form of message proposed was quoted as being, for example, "Storm from west at

Penzance and South Coast. Hoist signal". (263). On receipt of such a message the station concerned would hoist an appropriate signal that would be uniform along the coast and mariners might then apply to know the nature of the information received. The Board of Trade approved this scheme in principle but thought that special provision should be made for sending messages free to poor fishing villages, to which suggestion the Committee agreed provided the Board supplied a list of such recipients (264).

The question of the actual visual signal that should be displayed to indicate the existence of a storm was now to prove a difficulty. FitzRoy had been concerned to give warning of expected future conditions at the place displaying the signal. *The information that was now intended to be given pertained not to expected weather but to that actually occurring at some, possibly distant, location along the coast.* Toynbee attempted to devise a system using an apparatus like a railway semaphore but "... the experiment fell perfectly flat owing to the difficulty of instructing our coasting seamen ... in the use of a totally novel system" (265). Even before Toynbee's system was proven to be impracticable there were problems regarding the funding of new signal gear. The Committee could not meet this commitment out of their resources and suggested that the Board of Trade might present each station with a complete set of signalling equipment, provided the stations were thereafter responsible for the maintenance and displaying of the signals. The Board responded by noting that each station still held the original FitzRoy signals and that they did not have any funds for the purchase of new ones (266).

Procrastination continued and nothing further happened for some two or three months. Eventually a letter from Sir J.D.H. Elphinstone to the President of the Board of Trade prompted a query from the Board as to what action was being taken (267). Spurred into activity Scott prepared

a report which he presented to the Committee on 6 Nov outlining the steps that were necessary before a satisfactory system could be introduced. He sought more observations and more staff, and suggested that if Toynbee's signals were not to be used then perhaps FitzRoy's drums might be made operational once more (268). The report was "received" rather than adopted, but a reply was sent to the Board on the following day confirming that work to institute the new system was proceeding and that the signal to be used, for the time being at least, would be the drum. It also proposed to move further towards FitzRoy's methods by suggesting that the Office might defray the full costs of transmission (269).

The Board were getting impatient at last. Farrer replied within a week assenting to use of the drum and indicating that it should be brought into use with "... the least possible delay ...". The idea that the Office should meet the entire costs of transmission of warning messages was also approved (270). The Committee were now moving rather more quickly and by 26 Nov they got as far as approving a draft circular to be issued to ports by the Board, giving notification that the new service was ready for introduction but requiring individual authorities to make application for the receipt of "... notices of serious atmospheric disturbances ..." (271). The Committee had earlier requested the Board to re-introduce their former method of checking the accuracy of the warnings (272).

By 28 Dec 1867, nearly 13 months after FitzRoy's service was abruptly terminated, the first stations were placed on the Committee's list and by the end of Mar 1868 more than 60 stations were in receipt of the notices (273). For effectively the whole of 1867, therefore, Britain was without the storm warning service that existed in one form or another during all the other years of the decade 1861-70. Obviously too much should not be read into a very small statistical sample, but the figures for loss of

life in British coastal waters during this period certainly do nothing to dispel the charge that the purity of the Committee's devotion to "true", as opposed to utilitarian, science, coupled to the Treasury's caution with the public purse, were together bought at the cost of seamen's lives, and that the latter were rendered more secure once again when these principles had allowed themselves to come to terms with the idea of providing a free public service in the FitzRoy tradition. See Table 5, in which the figures were compiled for purposes unrelated to the Meteorological Office (274).

7.2 Aftermaths of the FitzRoy era and the re-introduction of warning messages

It would be difficult not to conclude that the chain of events leading to the peremptory cessation of FitzRoy's warning system, followed by the prolonged delay involved in the re-introduction of a less ambitious method of notification, were both unfortunate in the extreme. The susceptibilities of the "pure" scientists, and the sheer blindness or lack of imagination (or both) of the Government administrators, had combined against the interests of the maritime population. But, although FitzRoy's greater breadth of vision and capacity for driving through the enmeshing webs of bureaucracy had given the country a pioneering service that was admired and emulated elsewhere, his neglect of the more mundane details was revealed in a less favourable light as the new, more "strictly scientific" direction of affairs took over. Once he had fairly settled into post Scott proceeded on an inspection of the telegraphic reporting stations that continued to provide observations for the routine Daily Weather Report issued to newspapers and others, even during the hiatus in the storm warning system although, of course, without the embellishment of the forecasts of earlier times. The results of this

inspection made the relative success of FitzRoy's work seem even more remarkable. The deficiencies of the telegraphic reporting network are probably best described by quoting Scott's annual report verbatim:

"Up to the date at which the Committee assumed superintendence of the Office, no inspection of any kind had been undertaken with the view of ascertaining either the position of the instruments at those stations, or the capability of the observers to report correctly. The stations were all visited in the course of last summer, and were found to be in urgent need of inspection. In three instances the thermometers were kept under the roof of a railway station, and in one case in a box which was almost completely closed. Thermometers were found coated in dust, and as for the wet bulb thermometer it was only properly managed at one station. In one case this latter instrument was found completely coated with carbonate of lime, and in another with its bulb totally immersed in water. The wind reports were given sometimes by true and sometimes by magnetic bearings, while the force was estimated by the merest guess work. In several instances, the clerks stated that they had never received any instruction in this special duty of reporting, and were totally unaware that their reports were necessarily untrustworthy owing to the situation of their instruments" (275).

Attention to what he saw as details (such as prosaic matters like the inspection of stations that had been issued with clear instructions!) might not have been FitzRoy's strongest point, although he certainly came out much better when it came to the bolder concepts. His storm warning service was now to be operated in a kind of limbo for some six years with the Committee, and Galton in particular, maintaining their distaste for prognostication. The compromise arrangement to which they had agreed merely provided information on the existence of storms actually in progress. When a report indicated the presence of storm conditions a

message would be sent to telegraph stations along the coast giving notification of its occurrence, although a degree of prognostication was clearly required in deciding which stations to inform. On receiving a warning message the telegraph station would fly one of FitzRoy's old drum signals, which would then be repeated along the coast. Mariners seeing the drum, and wishing to know its meaning, were expected to go to the respective telegraph office where the full text of the warning would be posted up for all to read. The message would only provide information about the observations of a storm in progress and included no indication as to probable movement or development, these having to be inferred by the individual mariner from his own readings of the barometer and observations of winds and weather changes at his locality (276). The monitoring system used by the Board of Trade to check the validity of the messages, and which had been used with devastating effect by Galton to support his criticisms of FitzRoy's work (see pp. 51-52), was itself discontinued for the rather obvious reason, inter alia, that the observations obtained were from relatively sheltered localities and therefore not representative of conditions prevailing over the open sea (277). Despite this acceptance of FitzRoy's own view of the system there seems to have been no attempt to review the conclusions of the Galton Committee that had been based upon it.

Not until Jan 1874, prompted by opinions expressed at the International Meteorological Congress held in Vienna the previous year, did the Committee at last decide that enough experience had been obtained in dealing with weather changes on a daily basis (278). A decision was eventually taken that, in effect, resulted in the full restitution of FitzRoy's warning system in mid-March of that year (279). The only significant changes to the indications given by FitzRoy were (a) that the drum was no longer used alone to indicate dangerous winds probable from different directions successively; and (b) the period of the warning was

altered from FitzRoy's 72 hours (with the warning signal shown only on the day of issue and then taken down) to one where a signal was flown when the danger of a storm became quite apparent (usually within 24 hours), and was kept up until either the storm had passed or the danger no longer existed (280). No comment from Galton or Sabine as to their views on this reversion to the essentials of the earlier practice is to hand, although they would doubtless have argued that six years of study had resulted in a greater understanding of the ways of the weather systems. They had been instrumental in the peremptory cessation of the warnings. Now the warnings were to be resumed, partly because of pressure from the international world of meteorology and partly because the prevailing practise of expecting an individual mariner to interpret possible weather developments (from a brief message coupled to the readings of his own barometer) better than a relative specialist with information from the whole country at his hand, was becoming a growing monument to its own absurdity and could scarcely retain its credibility any longer unless some positive advance were made (281). Scott, the man in charge of the restored system was in no doubt that it was in the same mould as that of FitzRoy and, indeed, that advances in meteorological knowledge in the interim had not resulted in any significant change of method. As late as 1887 he stated quite specifically that the principles of forecasting then in use were "... mainly the same as the principles ... devised by the Admiral ...:" (282). Over seven years had passed before a service that had been terminated almost overnight, due mainly to its supposed lack of scientific "respectability", was restored in essentially the same form by the same people who stopped it. The way of the "academic" and the "practical" approaches to science were indeed divergent.

7.3 Progress in marine meteorology

Whatever success might have been achieved by FitzRoy in the sphere of storm warnings, there can be little doubt that his emphasis on forecasting had allowed the earlier activity over the collection of marine statistics to run down to the point of near extinction (283). The brief of the new Marine Superintendent, Toynbee, was to resume the systematic collection of marine observations and to maintain the statistical record in accordance with the recommendations made by Galton (284). His first action was to review the data already acquired by FitzRoy and to relate it to the requirements that had been laid down. Much of the administration had fallen into arrears and the port agencies had become moribund. Galton had also proposed a different method of recording the observations, using cards rather than data books, and had estimated that less than a quarter of the collected data was fully worked up (285). Toynbee submitted a report containing his detailed recommendations for action. It dealt with straightforward technical matters and was in no way controversial but its consideration was postponed at three successive meetings; eventually a circular memorandum to ship's masters was approved requesting observations and offering to supply instruments very much in the original manner used by FitzRoy (286). There were problems in re-instituting the port agencies. Without the cachet of FitzRoy's name it was not easy to obtain agents who were prepared to carry out the duties efficiently, but Toynbee persevered and eventually achieved a satisfactory coverage. He also started an incentive scheme so that some of the agent's payment for servicing a ship was withheld until satisfactory observations were received, and extra payments were made on the receipt of "excellent" returns (287).

Galton's method of recording observations on cards was given a prolonged trial but proved unsuccessful. The cards were replaced by data books ruled into columns and closely corresponding to the registers used for recording observations. The data books were arranged with each page corresponding to a one-degree square, so that FitzRoy's ten-degree squares each required 100 pages. One book corresponded to a month's observations for one ten-degree square (288). It was decided to concentrate effort towards specific areas of the ocean. The Equatorial Atlantic was selected for first attention and this was initially concentrated on Marsden Square 3 (0-10 N; 20 -30 W). This lies athwart the sea lanes between Africa and South America encompassing the region of variable winds, known as the doldrums, that had proved so disastrous to sailing ship's passages in the past. It was widely thought that no area of the open ocean was "... so frequently ploughed with keels as this ..." (289). The selection of area was clearly appropriate and the work was carried out in scrupulous detail, each one-degree square being examined individually so that figures for 100 separate squares were eventually published, but it also carried with it a very long gestation period and Square 3 dominated the efforts of the Marine Department of the Office from 1867 until 1873, when attention was transferred to the squares immediately surrounding (290). Diagrams of the Square 3 data were lithographed and submitted for comment to some 35 experts ranging from mariners, through members of the Office staff, to leading scientists, for appraisal and comment (291). Reaction was mixed and praise came from some practical seamen as well as from most of the academic men of science. But a large body of opinion thought the detail was more than the average mariner would be prepared to study. A rough "score" of the 35 opinions given shows 19 as favourably disposed towards the usefulness of the charts for seamen, 10 broadly unfavourable mainly on the grounds of over-complexity and 6 neutral, ambivalent or of no opinion. Once again conflict was evident between what was thought suitable by a panel

of "pure" scientists - supported by a former "practical" seaman (Toynbee) who nevertheless had an aesthetic and fastidious outlook - and that thought likely to be utilized by many of the latter's more rough-hewn colleagues. The conflict is the same as that already noted as running through the whole story of meteorology and, indeed, of any academic discipline that possesses a practical or utilitarian value. It was remarked upon above, especially in relation to FitzRoy's introduction of weather forecasts and storm warnings (see p. 67); it continues to the present day; and doubtless it will persist until, and if, an educational system is devised which enables people to be made more aware of those outside their own closed community.

The work on marine statistics was extended to waters around the Cape of Good Hope in 1875 (292). The immense backlog of untouched registers had gradually been worked off and the Marine Department was setting into a steady routine. Another legacy from the less ordered days of FitzRoy had been tackled earlier. There had been no proper record of many of the instruments issued in the early years. Separate issues had supposedly been made to the Admiralty and the Mercantile Marine, but this was not done systematically and "... a considerable number ..." of nominally Admiralty instruments had found their way to merchant ships, telegraph agencies, etc. Toynbee did his best to trace both these and instruments from out-of-commission ships that were still on loan and many were recovered, although others had to be written off. A liberal attitude was adopted and a number of recipients were allowed to retain their instruments, including various Training Colleges and also the Scottish Meteorological Society, the latter being permitted to keep instruments to the value of £100 that had originally been supplied on loan (293).

Besides his direct work on the compilation of meteorological statistics Toynbee also produced a number of papers on marine meteorology (294). These were mostly studies of wind and weather over specific areas of ocean resulting directly from his routine work, but he went outside his normal duties when he produced a paper on the use of isobars. Isobars were by no means universal in the preparation of weather charts at this time and they had been eschewed by FitzRoy in his synoptic charts - instead he delineated pressure by means of lines drawn from west to east across the chart with the separation between the pressure line and the appropriate line of latitude being representative of the pressure at that place (see p. 47). The rate of decrease of pressure with height had been understood since the time of Laplace but there was no firm agreement on the practice of reducing pressure to mean sea level for ready comparison (295). Buys Ballot proposed the law linking wind direction and pressure field in 1857. Ten years later the influential Alexander Buchan, Secretary of the Scottish Meteorological Society, advocated the use of "isobarometric lines" in the first edition of his best known book, and expanded his ideas in the much enlarged second edition a year later in which he included "isobarometric charts" showing the mean distribution of atmospheric pressure throughout the world (296). The idea of drawing isobaric charts was suggested to Toynbee by W.W. Rundell, secretary to the underwriters of Liverpool. In his paper Toynbee also advocated drawing a straight line joining the two stations with lowest and highest pressures ("the line of greatest difference"), with an arrow about its centre at right angles indicating the direction of the wind, and a dotted line between the stations of greatest rise and greatest fall of pressure during the previous 24 hours ("the line of greatest change"), with a dotted arrow at right angles to its centre indicating the line of coming wind. He laid down rules for using these lines to forecast changes of wind.

Toynbee submitted his paper to the Committee on 26 Oct 1868 but it was not until the following January that any reaction was forthcoming. When it came it was not encouraging and it was clear that the Marine Superintendent was thought to have gone beyond his brief, and probably beyond his competence. The paper was thought to be "... of a speculative nature ... (leading) as yet to no practical results ... (and so) scarcely fitted for publication ... as emanating from an officer belonging to their staff" (297). It was returned to Toynbee but the latter was not prepared to see his work go unrecognized and, after what must have been a personal investigation into its applicability, he wrote a letter to the Committee in which he detailed his own conclusions. *This was considered* by the Committee on 6 Jul 1869 and the arguments he used must have been persuasive (no copy of the actual letter has been found) because the initial decision not to publish was shelved and a sub-committee consisting of Miller and Richards was set up to recommend whether further action should be taken. The paper was eventually published as non-official publication no. 3 (298).

Toynbee's publications were not confined solely to meteorological topics. In the tradition of FitzRoy he was also deeply religious and he wrote a number of evangelical pamphlets which he used to distribute to the staff from time to time, and several of these were published and distributed more widely (299).

7.4 Expanding services

In addition to the rationalization of the work of the Marine Department, the Office also sought to widen the exchange of information with other countries, a task inaugurated under FitzRoy. The most obvious gap in the telegraphic reporting network was the vast ocean to the west of the British Isles, from which information was only available retrospectively

after ships had completed their voyages. The final laying of the trans-Atlantic cable in 1866 had brought with it the opportunity for obtaining current observations from North America. The possibility of extrapolating weather changes from the east coast of Canada and the United States to the west coast of Europe was seen as a chance to extend the range of any warning network, and hence the accuracy of the warnings. An initial approach was made to the Office by the Anglo-American Telegraph Co., who undertook to supply daily weather observations from their station at Heart's Content in Newfoundland for a payment of £200 per annum (300). The Committee accepted this arrangement for a trial period but, with the financial constraints of their first year hard upon them, they sought to terminate their commitment to paying such a sum. The Telegraph Co., either through sheer generosity, the possibility of good publicity, or the hope that after an extended period the Committee might change its mind, promptly offered to supply the observations gratis (301). This offer was accepted and the observations continued to be received until Oct 1871, when the Telegraph Co. sought to impose a charge. The Committee declined and the information ceased (302). The possibility of obtaining observations from a permanent station to the west of the British Isles was similarly pursued with the idea of anchoring a ship several hundred miles out in the Atlantic and connected to the shore by telegraphic cable. Indeed, trials with a ship stationed in the Channel approaches were held as early as 1869, but the results were not encouraging and the idea was dropped (303).

A completely different type of public service inaugurated by the Committee was the notification of rapid pressure falls to collieries. This originated from a letter written by an Aberdare colliery manager, Mr W. Thomas. The letter was referred to Prof. John Phillips of Oxford who gave his opinion that pressure falls could be a possible source of hazard due to a consequent increase in the efflux of dangerous

gases. He suggested that appropriate warnings might well be sent to colliery inspectors. Scott promptly referred the matter to the Board of Trade, offering to supply the warnings if required. This was passed on to the Home Office, who showed their level of concern for the safety of miners by flatly declining to take any interest (304). Matters lapsed for almost a year, but in Jan 1869 Scott reported himself in correspondence with the Board of Trade and with a civil engineer, Mr J.T. Woodhouse, regarding proposed telegraphic warnings to collieries. Woodhouse favoured the idea and the Committee resolved to seek the views of a number of colliery inspectors, although stating that the Office would not be prepared to incur significant expense unless the benefits would be great (305). Nothing appears to have come of this exchange at the time, but in Feb 1876 Scott reported that telegraphic notifications of rapid pressure falls were being given to a small number of colliery authorities (306).

7.5 The observatory network

The main recommendation contained in the Galton Report was the proposal to establish a relatively small network of observatories, strategically placed throughout the British Isles so that they would be capable of detecting and tracking any weather system moving within their vicinity (307). This was very much in the line of Forbes's recommendations (see p. 23) and followed directly from a letter by Sabine to the Board of Trade written some months before the Galton Committee was appointed (308). Sabine proposed Falmouth, Kew, Stonyhurst, Armagh, Glasgow and Aberdeen as being "... distributed at nearly equal distances in a meridional direction ...", which was a somewhat hopeful statement if one actually looks at a map, but certainly the proposed spread of stations was a reasonably even one. The proposal included use of the British Association establishment at Kew as a central observatory and one of the

first acts performed by the Meteorological Committee was to appoint Balfour Stewart, the Superintendent of Kew, as Secretary to the Committee at a salary of £400 per annum (see p. 70) with "... the Secretary not undertaking any other work except that of Kew Observatory ..." (309).

The original proposals by Sabine appear to have been accepted without question by the Meteorological Committee. Inherent in the proposals was the existence at each locality of a suitable institution capable of undertaking the work of a meteorological observatory. He was quite specific in naming the institutions involved, and presumably he had their prior agreement before doing so although evidence is not to hand. Sabine listed them as: Falmouth - Polytechnic Institution; Stonyhurst - College (already a magnetical and meteorological observatory); Armagh - Observatory; Glasgow - University and Observatory; Aberdeen - University. In the event Valentia, where no parent institution existed, was added to the list - its unique position in the far southwest of Ireland making it invaluable for the Committee's purposes. Each will be briefly considered in turn.

The central observatory at Kew was, of course, already established under the British Association as a meteorological and magnetical observatory (310). The Galton Committee had noted the need for "additional buildings" at Kew if it were to perform a central role under the Meteorological Office, and these were costed at £1,200 by the Meteorological Committee as a part of the £2,900 they estimated would be required to set up the observatory network (311). The estimate and covering letters to the Board of Trade were all drafted by Capt. Richards, the Hydrographer, although signed by Sabine as Chairman of the Meteorological Committee (312). By 1 Apr 1867 plans for the new building had been drawn by the architects, its site had been staked out and the Committee had approved an estimate of £880 - higher than originally

envisaged, although total costs were not expected to rise. The Treasury letter to the Board of Trade intimating that the total grant to the Office would be only £10,000 (instead of the £12,800 expected) was dated just nine days later and caused an immediate re-appraisal. Construction of the new building was abandoned before it had begun and arrangements were modified in line with the more straitened circumstances in which the Committee found itself. At Stewart's suggestion an outhouse was adapted as a workshop for the verification of the self-recording instruments, and a small building was erected containing a work room and carpenter's room in place of the larger building originally planned (313).

The self-recording instruments that were to be used in all the observatories were developed at Kew by the mechanic, Richard Beckley, under the supervision of Stewart. They consisted of a thermograph (for both wet and dry bulb thermometers) and barograph, which all recorded photographically, and a mechanically recording anemograph based on the Robinson hemispherical cup anemometer and adapted by Beckley (314). Of necessity the recording apparatus for the thermograph was located indoors, but the thermometer bulbs themselves were housed in a thermometer screen attached to (and at least two feet outside) the wall of the observatory, and the stems of the instruments were exceedingly long in consequence. On 25 Jan Stewart had been authorized to place orders for five sets of instruments, and on 5 Aug he was able to report that all the anemographs were ready, with the other instruments likely to be available within a few days; by 16 Dec Kew Observatory was complete and in regular operation (315).

Financial arrangements for Kew were complicated due to its being a joint establishment of the Meteorological Office and the British Association. There were never likely to be any serious difficulties arising out of this partnership. Four of the eight members of the Meteorological

Committee were specifically nominated as representing the Kew Committee and two others as officers of the British Association (see p. 69). The opportunity for gaining additional income must also have come as something of a boon to the Association's coffers (316). In the first year (from Apr 1867) Kew received £250 from the Meteorological Office for expenses as the central observatory and a further £70 for assistance in examining the "... results from outlying observatories ..." (317). During 1869 the Committee extended these arrangements offering to Kew the choice of either (i) continuing as an ordinary self-recording observatory for an allowance of £250 per annum, or (ii) in addition to (i) also being retained as the central observatory with a supervisory role over the records from the other observatories and a further allowance of £400 per annum. The Committee also wished to retain Beckley's services at their expense, when required, and offered to pay all additional costs relating to their work "... according to furnished and accepted estimates ..." (318). Not surprisingly the Council of the Association approved the second alternative (319). The financial relationship between Kew and the Meteorological Committee remained unchanged when the Observatory was transferred from the British Association to the Royal Society in Jun 1871 and Stewart was replaced as Superintendent of Kew by Mr S. Jeffery, a member of the Meteorological Office staff (see p. 106). A new committee was appointed by the Royal Society to manage Kew but good relations between the Meteorological Committee and the new Kew Committee were assured by the simple process of making the two committees identical in personnel! (320).

Falmouth did not possess a suitable observatory but the Polytechnic Institution were willing to erect one assuming that it was paid for out of the meteorological vote. The annual grant was fixed at £250 and the observer, a Mr Squire, was instructed in his duties. The vote passed the House of Commons on 9 Aug. Work on the observatory commenced immediately

and it was completed inside four months (321). Instruments were installed quickly and the establishment was reported operational on 1 Jan 1868 although records did not commence officially until March (322). There were fewer problems at Stonyhurst where the observatory was already in existence. By early Aug 1867 the observer, the Rev. W. Sidgreaves, had been trained and regular observations had commenced by 23 Dec, the annual grant being fixed at £200 (323).

At Armagh the existing observatory was under the superintendence of an eminent scientist, the Rev. Dr T.R. Robinson, a former President of the British Association and inventor of the Robinson hemispherical cup anemometer, the original instrument being still in use at the observatory. It was noted on 12 Aug 1867 that "... a structure ..." would need constructing to house the photographic and instrumental rooms. This work was put in hand and Robinson was later asked to engage an assistant at £100 per annum and prepare for the reception of instruments (324). The observatory was reported as ready to observe on 6 Apr 1868 (325). The only allowances noted against Armagh were staff salaries and any extra expenses specifically related to the meteorological work. Similarly, no major difficulties were encountered at Glasgow where the observatory was under the supervision of Prof R. Grant, who held the chair of practical astronomy at Glasgow University. The annual allowance was fixed at £250 per annum and Grant's assistant was duly instructed in his duties. The observatory was complete and in regular operation before the end of the year (326).

The two remaining observatories presented more obstacles before they were eventually brought into the network. Aberdeen almost never got started at all. The Meteorological Committee had, in fact, envisaged a network of eight observatories in their original submission, one more than had been proposed by Sabine, the eighth to be situated in the extreme north

of Scotland (327). When it was learned that the Treasury were restricting the Committee to a grant of £10,000 per annum (see pp. 75-76) an immediate decision was made to restrict the number of observatories to be established in that financial year to six, and to shelve plans for the two northern ones, including Aberdeen (328). Initial negotiations for siting a meteorological observatory in Aberdeen had been carried on with the University authorities by Sabine, prior to the nomination of the Meteorological Committee. When the Committee now failed to follow up these enquiries Prof. David Thomson, the Professor of Natural Philosophy at Aberdeen University, under whose control the observatory was to be placed and who regarded its acquisition as enhancing the prestige of his department, promptly contacted the Chancellor of the University pointing out the desirability of establishing such an observatory at Aberdeen (329). It so happened that the Chancellor was the Duke of Richmond, who was also the President of the Board of Trade. The Government view that the provision of financial resources for the development of meteorology should be restricted was apparently not meant to apply to areas where influential ministers had an interest. Pressure was put on the Committee to proceed with the observatory and they "... relaxed their resolution respecting retrenchment ... and agreed to include Aberdeen ..." in the programme. The consequence was some financial embarrassment and in retrospect it was felt "... that they were scarcely justified in adopting this line of action ..." since annual expenses exceeded the grant by £500 (330). This had to be covered by delaying payment on three items totalling some £536, and the accounts for 1867/8 actually showed a small credit balance (331). The Committee learned its lesson and henceforward always ensured that a substantial balance was held in reserve. Once the financial problems had been settled the installation proceeded smoothly. Thomson made a firm proposal to establish the observatory. This was accepted by the Committee in Oct 1867 and a sum of £250 was agreed to cover all the

annual expenses, although this was only approved as being payable on a year to year basis (332). By the end of Mar 1868 the observatory was in regular operation (333).

Valentia was the only observatory on the Committee's list without an adjacent institution to which it might be attached. Indeed it was not included in Sabine's original list, but the Committee considered its installation in the remote southwest of Ireland to be of major importance. Although it must have been thought of earlier, the first positive reference to Valentia was on 15 Apr 1867 when the Committee resolved to select a suitable person to be put in charge. Three weeks later Scott reported that a Rev. Thomas Kerr, who had been recommended by Admiral Richards, was interested in the position. Scott and Kerr were despatched to Valentia to find a suitable location for the proposed observatory and following an inspection of Valentia island Scott entered into negotiations with Mr P. Fitz-Gerald, the Knight of Kerry, for the lease of one of his houses. A suitable property was secured at a rental of £50 per annum, Kerr accepted the position as Director at a salary of £250 per annum and 10 shillings per week was allowed for an assistant (334). By Mar 1868 the fittings had been completed at a cost of £100 and Kerr, who had remained in Valentia to supervise alterations to the premises, was told to return to London to collect the instruments and receive his final instructions. He attended the meeting of the Committee on 18 May and reported estimated running costs at nearly £21 per month - including £10 for the wages of a clerk and a messenger - significantly more than the 10 shillings weekly that had been envisaged. Scott computed the total annual cost of the observatory at £549, which was approved although Kerr was instructed to reduce expenditure wherever possible. By 3 Aug 1868 the last of the observatories was in full readiness to commence operations (335).

The seven observatories had been brought into operation with efficiency and despatch and their instrumentation was of a very high standard. Uniformity of exposure was considered less important and the height of the thermometer bulb mountings, for example, ranged from 4 feet at Armagh to 41 feet at Aberdeen (336). This brought strong criticism from Glaisher amongst others (337). It was intended to compare records from the observatories to see the effects of weather systems as they moved across the country, and so to find out the nature of the systems by interpolation and interpretation (338). Considerable attention was directed at the means used for permanently recording the observations, and it was decided that the best way to promulgate the information was to publish copies of the actual traces of the self recording instruments. Pantagraphs were devised for the reproduction of traces from the original curves and these were then published in a Quarterly Weather Report (339). Balfour Stewart pressed strongly for hourly values of the observations to be published at the same time. He also disagreed with the method adopted for reducing the observations and was unsuccessful in his attempts to obtain additional clerical assistance. Following an argument with Sabine he resigned, ostensibly as a result of the disagreement, but he left under a cloud and Scott later categorically accused him of fraudulence and theft (340). Despite this unfortunate episode Stewart went on to a well known and distinguished career as Professor of Natural Philosophy at Owens College (341). He nursed his grievance and some years later organized a petition that was signed by James P. Joule and 31 others, entreating the Committee to publish hourly readings for each observatory (342). The strength of the petition, and Stewart's vehemence in pressing the case, clearly implied that the information was required with some urgency by a significant number of research workers and the Committee agreed to compile and lithograph 100 copies of the tabulations, offering them for sale at £1 per annum. Unless the sales were going to be large this was always going to be appreciably less than the cost of production,

which occupied virtually the full time work of one clerk. By mid-March ten people had subscribed to the service, including just 2 of the 32 memorialists. Eight weeks later the total had reached 16 and a list of recipients who would be supplied free of charge had to be drawn up to make the whole exercise seem worthwhile (343).

Amongst the earliest phenomena identified by the new continuous observations was

"... a very sudden fall ... in the temperature of the air (accompanied by a) barometer which had been falling rapidly previous to this instant (and) began then very suddenly to rise. The direction of the wind at the same moment changed from southwest to northwest ..." (344).

The modern meteorologist will have little difficulty in recognizing this description of the passage of a cold front and, as somewhat whiggishly remarked by Napier Shaw,

"If they had 'kept right on to the end of the road' ... (they) might have set out the doctrine of fronts in 1869 instead of 1919" (345).

Ironically Brunt was later to suggest that Shaw himself was guilty of the same failure to carry preliminary findings through to a proper conclusion which would have led, in his case, to the emergence of a "frontal" theory in 1907 (346).

7.6 Staff matters under the Meteorological Committee

The terms of employment of the Meteorological Department's staff underwent a marked change when control passed from the Board of Trade to the Meteorological Committee. They no longer had the status of civil servants and they were not eligible for superannuation. This latter point was made crystal clear when the senior officers were appointed. Sabine had originally told Scott that he would be employed on public

service terms but Farrer quickly pointed out that this could not be so (347). Nevertheless Scott accepted almost without demur, doubtless due to the substantial increase his new salary gave over the £100 per annum which he received from the Royal Dublin Society (348). Toynbee had initially queried his position, pointing out that other ex-merchant navy captains in analogous positions were remunerated on incremental scales, and that several were also entitled to a pension. He was told the Committee would be unable to provide an annually increasing salary, since they were only authorized to provide estimates for the Office on a year to year basis and a commitment to regular increases would imply a greater degree of permanence than could be assumed; but a month later he was informed that his salary would be reviewed at the end of the financial year (349). In the event it was raised from £350 to £400 per annum (350). Later he was also given permission to act as a Trinity House Assessor in the County Courts (351). There were no problems with Stewart who added his salary as Secretary to the Committee to that he already held as Superintendent of Kew Observatory (see pp. 72-73). He held these salaries until his resignation took effect in 1870.

The subordinate positions in the reconstituted Office were all filled by former staff of the Meteorological Department of the Board of Trade all of whom were offered appointment, although the offers were not made until the men involved had queried their position (352). That these appointments were not superannuable was less disadvantageous than might be supposed since, following the resignation of Babington, none of the original members of the Meteorological Department remained on the strength, and most of the staff were employed as supplementary clerks. The salaries of the clerks were decided by the Committee on 25 Feb 1867. Simmonds, the chief clerk who had actually been briefly in charge of the Office, promptly resigned leaving the senior position vacant. The other appointments are shown in Table 6 (353). The position of chief clerk

remained to be filled. The Committee received applications from the second senior clerk, Mr Richard Strachan, and from a naval instructor, Mr William Salmon. The latter was appointed and took up his duties on 1 Apr 1867 (354).

Expenditure on salaries during the first financial year totalled £2,550, and all the staff were re-appointed at the end of the year, including a Mr G. White who had been employed in November to assist with the extra work entailed by the introduction of cautionary notices of existing storms (355). Salmon resigned his position as chief clerk in May 1874 and Mr J.S. Harding was promoted to fill his place. By this time the number of clerks had risen to 10 (1 chief clerk, 3 seniors, 6 juniors) and there were 9 temporary clerks, an officer keeper and an engraver. All the five who originally accepted appointments remained on the staff and, with Salmon's resignation, had all moved up one position. Salaries were still in line with those laid down at the start of the Committee's jurisdiction (356). Appointments remained on an annual basis and Scott thought the clerks had received something of a raw deal as regards their conditions of service. In evidence given to the Devonshire Commission in Apr 1874 he quoted salaries paid for work at a comparable level within the Civil Service, and the figures showed the Office in a distinctly unfavourable light (see Table 7) (357). There can be little doubt that the terms of service for the Office staff were below what might reasonably be considered as compatible with the job during this period.

7.7 Accommodation problems

For the first two years after the reorganization the Meteorological Office continued to enjoy rent free use of the same office premises that it had occupied as the Meteorological Department of the Board of Trade. An exchange of letters in Feb 1868 showed the Committee as being anxious

about their security of tenure, but at this time the Board were neither inclined to be specific about repossession nor prepared to assist in the quest for alternative premises (358). Nothing further happened for more than a year and the first intimation of a notice to move came in a somewhat peremptory note from the Office of Works, asking the Meteorological Office to terminate their tenancy "... as early as practicable ...". The Committee responded promptly. Firstly by asking the Board of Trade if the Office would be expected to meet the rental of alternative premises out of their annual grant, and if they might possibly obtain such accommodation through the Office of Works in the vicinity of their present home. This was important since removal to any distance away from a telegraph office would involve delays in the receipt and despatch of weather observations and warnings. Secondly by asking the Office of Works if they might purchase the furniture that the Meteorological Office had in its possession (359). By a masterpiece of bad timing the same mail that bore with it the letter from the Office of Works also carried a request from the Scottish Meteorological Society to the Meteorological Committee for financial assistance. The implications of this letter will be considered at greater length below (see p. 123) but it is not surprising that the response by the Committee was both rapid and negative.

The attempt to secure accommodation through the Office of Works proved abortive and the Committee immediately entered into negotiations to lease premises at 116 Victoria Street, comprising the entire first and mezzanine floors (8 rooms) and a basement room, at a rental of £370 per annum, with an additional £2-10-0 for gas burners on the stairs. The lease was agreed by 3 May and the move took place at the end of May, the new premises being occupied on 1 Jun 1868. The old office furniture was purchased from the Office of Works for £111 and additional furniture and fittings cost another £550 (360). This accommodation was to be used by

the Office until 1910 when a new custom-built headquarters was erected at South Kensington (361). Until recently both buildings still survived but the Victoria Street site has since been re-developed. The premises that housed the former South Kensington headquarters are now situated above the Post Office that adjoins the Science Museum and there is still (1988) a (redundant) bell push labelled "Meteorological Office" on the Post Office wall! The rooms are used as a store by the museum.

7.8 Changes to the Committee

Throughout this period the composition of the Meteorological Committee itself showed little change. Together they formed one of the "... strongest bodies of scientific men that has ever directed anything, all giving of their services free for the furtherance of the science they wished to see prosper..." (362). Miller, the vice-chairman, died suddenly in 1870 and was replaced by Sir Charles Wheatstone, who died five years later. Meanwhile Spottiswoode had resigned in 1873 due to pressure of business, and the Earl of Rosse and Maj-Gen Richard Strachey had joined the Committee. In 1874 Adm Richards retired as Hydrographer to the Admiralty and so lost his ex-officio place on the Committee; the Committee wished to keep his services and suggested to the Royal Society that they might retain him as a member in his own right as well as appointing Capt Evans, the new Hydrographer, ex-officio. This was agreed and the potential size of the Committee grew again, although it was seldom that more than four or five ever sat down at the same table and sometimes there would be as few as two, the attendance being of course purely voluntary. Finally Cassiot, the benefactor of Kew Observatory, as well as other scientific projects, retired due to ill health almost simultaneously with the death of Wheatstone. He died himself some two years later as the Committee was being reconstituted into a paid Council following a Treasury enquiry (363).

A significant alteration to the working of the Committee came when the Treasury changed their collective minds as to its precise status. When the Committee was formed it was originally instructed to refund to the Treasury any surplus there might be from its annual grant-in-aid but, as has been seen above (see pp. 81-82), this was countermanded on the grounds that the grant was only a contribution to researches undertaken at Government request. In 1873 the Treasury suddenly reversed this ruling and decided that it covered "... the whole of the expenses ..." of the observations and experiments conducted by the Office at the behest of the Committee. In consequence it was necessary to have the relevant accounts and vouchers examined to see if the grant "... had been expended in accordance with the terms of the estimate presented to Parliament ...". The appropriate documents were forwarded as requested, but the Treasury requirement for the refund of any surplus was never revived (364).

CHAPTER 8

CONTROVERSY, INQUIRY AND REPORT

8.1 The Airy affair

The unusual status of the Meteorological Office, financed by an annual grant that was administered by an unpaid Committee nominated by the Royal Society, has already been noted (see pp. 81-82). The situation was open to misunderstanding and the Royal Society was at some pains to distance itself from the Meteorological Committee per se, although it did appoint the Committee's members and the latter were all individual Fellows of the Society. One example of this was the refusal by the Society to allow the Meteorological Office to use its crest on the office seal (365). Yet there remained an impression that it was gaining from the funds allocated for the working of the Office. Certainly this was the feeling of members of the X-Club who wrote a joint letter to the Society expressing their concern (366). This prompted a lengthy letter from Scott to Farrer, the Secretary to the Board of Trade, detailing the exact relationship between the Meteorological Committee and the Government which was published as a Parliamentary Paper (367).

Apart from such extraneous worries the relationship between the Royal Society and the Meteorological Committee remained as harmonious as would be expected between two bodies who both had the same man as their head. But a change came in 1871 when Sabine retired at last from the Presidency of the Royal Society after 10 years in office. He was succeeded by George Biddell Airy, the Astronomer Royal (368). Airy had established a meteorological observatory at Greenwich under the supervision of James Glaisher as early as 1840, and he had already shown himself jealous of its reputation (369). He now saw an opportunity to bring the observational work at Kew under his

direct control and attempted to use his position as President and therefore, he thought, with a measure of control over the Meteorological Committee, to absorb the Kew observations into the establishment at Greenwich. The management of Kew had just been taken over by the Royal Society from the British Association, and the committee appointed to supervise the observatory was identical in composition to the Meteorological Committee itself (see p. 102).

The argument started with a letter from Airy, in his role as PRS, requesting information as to the cost of the Quarterly Weather Report produced at Kew (370). Scott replied informally quoting a rough figure since he did not have to hand the precise cost of publication, the expense of which was borne by the Stationery Office. Nothing further was heard for nearly a month, but on 12 Jan 1872 Scott received a letter from the Controller of the Stationery Office containing the exact information that had been requested by Airy. This came as something of a surprise since Scott had not asked for it - but clearly Airy had, because the following day (13 Jan) Scott received a letter from him seeking the information that the Stationery Office had given. This was considered by the Committee on the 15th and Scott was instructed to reply, enquiring as to whether Airy was acting in his private capacity or as PRS "... because a question of grave import may arise if there should exist any misunderstanding as to the constitution of the Committee and its relation to the Royal Society ...". It was pointed out that the Royal Society, apart from its role in appointing the Committee was "... in no way connected with the Meteorological Office ...". If Airy was acting in his private capacity then no such problem would arise. A copy of the official letter setting out the exact position of the Office was enclosed (371). Scott's letter was dated 16 Jan. Airy's reply was dated the 18th. In it he disclaimed any wish to control the "... daily proceedings ..." of the Committee, but thought it a "... matter of duty in the officer representing the Royal

Society ..." to be acquainted with their general work since this was of public interest. He acknowledged that if he had not become PRS then he might perhaps not have made the inquiry, but he still thought the matter to be of sufficient general interest to have wanted to know the answer anyway. Scott's reply was approved individually by each member of the Committee. The cost of transferring and lithographing the plates for the seven observatories was quoted as £352-12-4 per annum. The rate was less than for 1869 due to various improvements invented by members of the Committee, and it was anticipated that the cost would become lower still. Airy had meanwhile written again - his letter must have crossed with Scott's - enclosing a copy of a paper he had presented to the Royal Society Council on 18 Jan. The paper started by assuming much closer control of the Meteorological Committee than had been the practice ("The Meteorological Committee is virtually a committee of the (Royal Society) Council"). Airy then pointed to the £250/annum grant to Kew that had recently been agreed by the Committee for its work as a Committee observatory, and suggested that the observational role of Kew could just as easily be filled by the existing Meteorological Department of the Royal Observatory, Greenwich, thereby furnishing at "... insignificant expense all that is now furnished with an annual expense of £250 to the Government...".

At the next Committee meeting on 29 Jan "... various drafts proposed ..." were considered and Scott was directed to reply to Airy "... in accordance with the general opinions expressed ...". Scott's subsequent letter re-iterated the position of the Council vis-a-vis the Royal Society, noted that it was essential for Kew to retain its observational function if it were to be able to exercise efficient control over the other observatories, and pointed out that it was essential that the normal observatory (ie Kew) be controlled by an independent body and not be connected with a department of Government over which it had no control.

Airy's final shot came in a short letter dated 8 Feb. He assured the Committee (again!) that he was not trying to interfere with their affairs. But he expressed disagreement with their views and sought their consent to his reading Scott's last letter at the next meeting of the Royal Society Council. This was forthcoming but the Council subsequently negatived Airy's request to proceed further and the whole matter was dropped (372).

This episode does not rate a mention in the biography of Airy entitled "Autobiography of Sir George Biddell Airy", which is a collection of some of Airy's personal writings edited and expanded by his brother and supplemented by a considerable amount of biographical material. In the listed papers contained therein, however, is included the entry "1872. Jan. Address to the Council of the Royal Society on the propriety of continuing the grant to the Kew Observatory for meteorological purposes", although there is no hint of its contents (373).

8.2 The Devonshire Commission

Awareness of the position of science in the community was growing. One result of this increased consciousness was the appointment of the Royal Commission on Scientific Instruction and the Advancement of Science, commonly known as the Devonshire Commission after its chairman William Cavendish, Duke of Devonshire. The story of its instigation by Colonel Alexander Strange is well known (374). Strange successfully used the British Association for the Advancement of Science as a platform to call for such an inquiry. The Commission was a widely ranging investigation into the state of science and its relationship to Government within Britain. It met over a period of several years, producing eight voluminous reports, and much of its work does not concern us here, but a comprehensive investigation into meteorology and the Meteorological Office formed a major portion of the Eighth, and a lesser part of the Fifth, Reports (375).

The first of the evidence concerning meteorology was taken from Strange, Sabine, Stewart, Buchan, Milne Home and Farrer between Apr and Jul 1872. This appears in the Fifth Report of the Commission. More significant for our present purposes was the later and more detailed investigation into meteorological services that formed a large part of the Eighth Report. The latter started by citing the scientific work financed by government officers and departments. The Commission thought it unnecessary to make a close study of most of these activities, but the unique position of the Meteorological Office was recognized and it was decided "... to take evidence at some length both as regards its *scientific and financial* administration ..." (376).

The Fifth Report's conclusions pointed to the unsatisfactory nature of the supervision of the Office's work by an unpaid, voluntary, body. In his own evidence Strange said that the Office "... did very well what it professed to do, but (was) ... very far from fulfilling what is required ...". He criticized the form of the Meteorological Committee and considered that "... a body of that kind is calculated to dwarf (the Director) ..." which meant a "... man of the ... highest distinction in science ... would (not) accept such a post ...". Also missing was an "experimental" approach to meteorological problems, the work of the Office being too purely observational (377). Balfour Stewart echoed the call for a stronger power of direction by the executive officer in charge and suggested there should be a Meteorologist Royal, responsible directly to a Government Minister and in a position analogous to that of Airy, the Astronomer Royal, at Greenwich. He also deplored the fragmentation of meteorological effort within the country and cited the separate provision of rainfall data by Symons's British Rainfall Organization and the work on atmospheric electricity at Greenwich and Oxford. Different systems were in operation and greater co-ordination was required. In addition Stewart put in a strong plea for publication of tabulated hourly values of the various

weather elements (378). The evidence of Buchan and Milne Home was largely concerned with Scottish affairs, and the latter dealt at some length with the attempts of the Scottish Meteorological Society to get Treasury assistance for their work (379). Not surprisingly both Farrer and Sabine saw the work of the Office in a more favourable light than the other witnesses - the latter was chairman of the supervising committee and the former an architect of its formation - but Farrer did suggest that it was "... quite impossible (to) ... expect any gentleman to go on permanently giving attention to the management ... without payment ..." (380).

The Eighth Report of the Commission followed some two years later. It looked more directly at the actual work and organization of the Office itself as well as at the progress of work on meteorology generally. Evidence was taken during Apr and May 1874 from Scott (twice), Stewart, Rev. Robert Main (President, British Meteorological Society), Strachey, Buchan and Glaisher. Scott was questioned closely on the day to day running of the Office, the controversy with Airy being considered at length as was a dispute with the Scottish Meteorological Society (see pp. 121-133). The various sources of meteorological information within the country were noted and also the relationships between British and overseas meteorologists (381). A particular cause of concern was the method of financing the Office and the conditions of service of its staff. In his second appearance before the Commission Scott compared the British organization with those elsewhere, and in particular with that of the United States. The latter had developed under an overall military control following the use of meteorological services by the Federal forces during the Civil War. The level of financing was on a totally different plane to that elsewhere and Scott was envious of the resources provided (as FitzRoy had been of Maury earlier, see p. 33). Also considered at length were the forecast and warning systems that had been inaugurated by FitzRoy, but then stopped and later re-started in a modified form by the Committee (382).

Strachey was asked about the role of the Committee itself. He accepted the suggestion that the body was in the position of a quasi visiting board which maintained its influence by exercising a broad superintendence of Scott as Director. He felt the organization of the Office was a good one for its present purposes but thought that more research should be carried out. The Office collected facts efficiently but results of scientific importance were lacking: it would be better if the Committee were disbanded and the executive officer in charge given more power (383). This point was echoed by Stewart, who renewed his call for a Meteorologist Royal (384). He considered the title of Director inappropriate for a head of Office who had to perform his duties under the direct control of a supervising body, and recommended abolition of the Committee.

The work carried out by Glaisher for the Registrar General also came under the Commission's scrutiny, and Stewart in particular was questioned as to his opinion. Glaisher had received an annual grant of £150 to help with this work, but this was withdrawn in Mar 1874 on the understanding that the Meteorological Office would be able to provide similar information free of charge. Stewart was opposed to such a change and implied that Glaisher had been treated badly (385). Glaisher was more forthright. He was called to give evidence mainly as a consequence of some correspondence relating to this work. His opinion of the Office was not high and he thought that its efforts should be confined to maritime aspects. Meteorology was "... not yet a science (but a) ... collecting (of) facts ...". Local societies were well able to carry out this duty in regard to land observations; Government action should concentrate on getting "... the physics of the globe ...". This necessarily meant having a Director who was a good physicist and mathematician and able to use the results obtained. Glaisher criticized the Office at some length pointing out, inter alia, the incompatibility of the observations made at its six observatories. For example, the thermometer bulbs were exposed at a variety of heights above the ground,

ranging from 4 feet (Armagh) to 48 feet (Aberdeen) (see p. 106 above; the Office's records quoted 41 feet for Aberdeen). He always insisted on a uniform exposure 4 feet above ground level so that the temperatures were strictly comparable (386). In supplementary correspondence Glaisher was even more uncompromising, referring to "... the great waste of public money, which I in common with most meteorologists, considers takes place by the Meteorological Office ..." and expressing the hope that the Office's grant be cut (387). Glaisher had striven over many years to build up a major source of meteorological information. Initially he had carried this out completely without payment and at personal cost to himself. He believed that scientific work was best performed by individual enterprise and was ideologically opposed (as, of course, were many others) to Government finance being used for research. His feelings towards the idea of having his life's work usurped, as he would have seen it, by a publicly funded body do not require much by way of imagination. But Glaisher was a difficult and irascible man who was not slow to make enemies. The Commission was adept at winnowing out the dross from his evidence and many of his more controversial remarks were ignored.

The overall verdict on the Office was not a bad one and, although its anomalous position was highlighted, the Commission felt that in the circumstances "... no other form of organization could advantageously have been adopted ...". Nevertheless they thought that much of meteorology would be better carried out within a governmental organization, with the head of the Office responsible to a Minister of Science. Glaisher's pleas were not overlooked and the role of individuals and societies in making observations was acknowledged. Any government involvement here would properly be subsidiary, although assistance given to voluntary work should be systematically organized under the surveillance of the Minister (388). The full recommendations of the Eighth Report were signed on 18 Jun 1875 and they emphasized these conclusions. Substantial increases were proposed

in government aid to science and in recommendation III meteorology was specifically picked out as a subject that, in many of its aspects, "... cannot be advantageously carried out otherwise than under the direction of government ...". An appendix to the Report also showed that, in addition to the Meteorological Committee's annual £10,000 grant, the Government Estimates showed a further £2,082 as being expended on meteorological activities during 1874-75 - £1,221 being for the Royal Greenwich Observatory, £596 for Woolwich, £115 for the Royal Observatory, Edinburgh, and £150 for Glaisher's work on behalf of the Registrar General, although payment of the latter grant had, as noted above, already been discontinued (389).

The Commission's Reports were important documents for the Office but they did not lead to any immediate changes. A useful review of its work had been put down in black and white, various relevant facts and figures had been compiled and were now published in a readily available form, and the Committee had been forced to look into its own role in some detail and to consider its future. The proposed Ministry of Science never materialized, however, and without it many of the other recommendations were without substance and were shelved.

8.3 Scotland the brave

But change was on the way, and was not to be long delayed although it did eventually choose another route by which to arrive. It had its origins in a request by the Scottish Meteorological Society to the Treasury for a grant to help defray expenses incurred in obtaining meteorological observations made by voluntary observers throughout Scotland (390). The Society had a very good case. Apart from the inherent importance of its work towards the advancement of meteorological science, it also supplied observations for official purposes to the Registrar General for Scotland.

For this its only recompense was the right to use two small rooms in the attic of Edinburgh Post Office, for which the Society was charged £30 per annum (391). Initial relations with the re-organized Meteorological Office in 1867 had been cordial and the Scottish Society expressed themselves in warm approval of the new arrangements, save only for the cessation of storm warnings that accompanied them (392). The Society's application for grant was referred to the Meteorological Committee for comment; the amount requested was £10-4-0 per annum, this being intended to help the Society reduce observations from a number of additional stations, presumably on behalf of the Registrar General. The Committee considered this to be "... very moderate ..." for the task (393). However no Treasury assistance was forthcoming.

Direct communication with the Scottish Meteorological Society began in 1868 with a letter to the Committee from A. Keith Johnston, the Honorary Secretary of the Society. A further application for an annual grant - this time the request was for £68 per annum - had also been turned down by the Treasury. In their reply the Treasury had implied that co-operation between Society and Committee would be advantageous. And they had pointedly remarked that the grant to the Meteorological Committee was intended, inter alia, for the collection and reduction of weather observations throughout the British Isles. Johnston consequently asked if a portion of the Committee's grant could be passed to the Society. Scott's reply was lengthy. The Committee would have "... the most sincere satisfaction ..." in co-operating with the Scottish Society and, indeed, had two observatories and four telegraphic stations within Scotland. There were also the oceanic observations upon which collaborative work would be advantageous. The wish for harmonious action was most cordially reciprocated. But - it was "... absolutely out of their power ..." to give the Society any part of the £10,000 grant, which was insufficient to meet current expenses (394).

Within a week Scott was again in correspondence with the Scots. This time the contents of his letter were more acceptable. The Office was making a comprehensive check as to the whereabouts and condition of the instruments that had been issued by the open handed but somewhat disorganized FitzRoy. Twelve sets of instruments had actually been presented to the Society and a further £100 worth were held on loan. The Committee was prepared to offer all of the instruments to the Society free of charge if they were able to use them (see p. 95) (395).

The response of the Scottish Society was (a) to press the Treasury further by informing them of the refusal by the Committee to give financial aid - prompting the Treasury to ask the Board of Trade if it was necessary for the annual grant to be as much as £10,000 - and (b) not surprisingly, to accept the offer of the instruments. Ironically a consequent request from the Board of Trade for the Committee's comments on the sufficiency of its grant and the letter from the Scots accepting the instruments arrived at the same time. With exquisite timing, and by the same post (see p. 110), came a letter from the Office of Works telling the Committee that they had to vacate their (rent-free) accommodation in Parliament Street as quickly as possible. With commendable restraint the Committee produced both a detailed defence of their level of expenditure, and an approval of the donation of instruments, without further comment (396). But the Scots were not mollified and Johnston both passed their thanks for the instruments and intimated they would be applying to the Treasury, exploring the possibilities of some of the Committee's grant being passed to them, in one and the same letter (397).

So far the disagreement had been a simple question of whether or not the Committee could (or would) set aside a portion of their grant in order to assist the Society. Scottish susceptibilities were soon to be troubled further. Responding to the Society's expressed wish to co-operate with the

Committee Scott, in Jan 1870, requested that information be supplied from a number of Scottish and far northern stations. He enclosed forms to be filled up in Edinburgh from the returns received by the Society and included an offer to pay the costs of extraction and postage. Scott also asked that the request be backed by a notice from the Society to its observers. The Society rejected this approach on the grounds that the observers were all volunteers and it would be unreasonable to ask them to fill in extra returns on another form (this had not, in fact, been requested). However Buchan would supply whatever information there was in the existing schedules. Most specifically the Society could not agree to "... any direct communication between your committee and the Society's observers ...". Scott replied on 22 Mar thanking the Society for the aid proffered via Buchan, offering to pay for any of the expenses thereby incurred and giving assurance that there would be no interference in the workings of the Society (398). By way of response the Society now forwarded a copy of their Council Minutes for 28 Mar. Before instructing Buchan to fill in the schedules from the Meteorological Office the Council were proposing four conditions to be observed by way of an agreement between the two bodies. The first three referred to the observations, but the fourth stated "That no direct communication shall take place between the Meteorological Committee and the Society's observers". On 4 Apr the Committee accepted these conditions as a basis of agreement, excepting that the four observers currently carrying out work for them in Scotland should be excluded from the fourth condition, and the Committee itself should not be precluded from establishing other stations in Scotland independent of the Scottish Society (399).

This reply from the Committee, and also that from the Board of Trade in response to a Society memorial asking for a separate grant, were both considered by the Scottish Council on 26 Apr. It was not accepted that the Meteorological Office might have the right to establish further stations in

Scotland unless they had previously cleared their interest with the Society. However the Council looked forward to co-operating with the Committee and wished to leave it to the Board of Trade to fix the sum to be paid for the Society's services, the payment to be without prejudice to its independence. This information was conveyed to the Committee by again forwarding a copy of the relevant Council minutes, signed by Johnston as Honorary Secretary. Closely following came a letter dated 9 May and also signed by Johnston. This was apparently written without the Council's authorization and no copy of it appears in the Minutes of Council now held in the Meteorological Office, Edinburgh. Johnston was getting impatient and the letter contained a scarcely veiled threat:

"On 27 ultimo I transmitted to you (an) extract from Minutes of Council ... asking your Committee to suggest terms of an arrangement between you and us. Some of our friends in Parliament have written to say that, in view of the impending discussions in the House of Commons on the subject of the annual grant of £10,000, they are very anxious to learn whether a satisfactory arrangement has been effected between your Committee and us. They say that such an agreement, if it could be referred to in the course of discussion, would strengthen their hands against sundry enemies to its continuance. We shall be glad to receive an immediate reply." (400)

That Johnston had written this letter without authorization was unknown to the Committee at the time. Scott was sufficiently incensed by its contents to accuse the Scots of later suppressing the letter in copies of its correspondence (401). This was vehemently denied by Milne Home and Stevenson who both disowned its contents and insisted that the letter had not been authorized as having emanated from Council. Nor had the Council any record of Scott's reply (402). Nonetheless, the fact that considerable support for the Society really did exist amongst Scottish Members of Parliament was undoubted. The previous year Col W.H. Sykes had

led a deputation of 20 of their number to see the Chancellor of the Exchequer in support of the Society's application for assistance, whilst Lyon Playfair was working actively on their behalf at this time (403).

Scott did reply to Johnston immediately. The Scottish minutes had not contained any request that the Committee should "... suggest terms of an arrangement ..." - could Johnston confirm whether there had been a mistake in copying the excerpt of the minutes that had been forwarded? Johnston backtracked a little, "... our meaning was simply to ask ... (if you) are prepared to recommend to the Board of Trade that we should have the grant of such a sum ... as will enable us to engage ... assistants, in order that we may co-operate with you ... (as) indicated by the Board". Predictably either Scott or the Committee (or both) were also getting impatient. They were "... not prepared to recommend ..." such a sum of money as suggested. The co-operation proposed would only have been asked for whenever a storm or sudden change in weather was noticed. The attendant expense that might be incurred from time to time would be defrayed by the Committee as it arose. This letter was forwarded on 16 May. Scott was instructed to forward copies of the whole of the correspondence that had passed between the Committee and the Scottish Society to the Board of Trade (404).

The storm died down for a time and there came a lull in the correspondence. The Devonshire Commission was now sitting and Scott noted that the Scottish Meteorological Society had referred to the dispute in their memorial to the Commission. The memorial indicated that the negotiations with the Committee had ended in failure and Lockyer, the Secretary to the Commission, asked Scott for a copy of the relevant correspondence (405). This was supplied on an unofficial basis and Scott was later called to give evidence before the Commission (see p. 118). The matter of relations between the two meteorological bodies formed a prominent part of his testimony (406). But by then these had plumbed new depths.

The improbable spark that caused the explosion was the laying of a telegraph cable to the Hebrides. Scott noted this in the report he submitted on 28 Oct 1872 following his annual tour of inspection of the telegraphic reporting stations. He had immediately been impressed by the obvious opportunity for gaining a particularly useful observing station and made enquiries as to the availability of a suitable observer. He was successful in finding Mr John Smith, a gardener at Lews Castle near Stornoway, who was both willing and competent to carry out the duty. The Committee authorized Scott to establish a reporting station at Stornoway (407). Scott was aware that Smith, who worked for Sir J. Matheson, already supplied reports to the Scottish Meteorological Society and so obtained from him a written assurance that if he undertook telegraphic reports for the Committee, then these would in no way interfere with his relations to the Society. A statement was also received from Matheson that he was "... well pleased ..." that Smith should undertake the reports. With these assurances in hand Scott "... entered into correspondence ..." with Smith, aiming at the opening of a new station by 1 Dec. He also wrote to the Scottish Society apprising them of the situation (408).

The succeeding Council meeting of the Society on 27 Nov breathed fire and brimstone. They deeply regretted the communication. The result of the practice, if extended, would deprive the Society of the services of observers whom it had "... secured and trained at much trouble and expense ...". The meeting pointed to an ignoring of the agreement by the Meteorological Committee that they would not communicate with the Society's observers. Even if no agreement had been made, the Council would "... deprecate such interference as inimical to the interests of science ...". Under different circumstances they would have "... cheerfully aided ..." the establishment of an observing station at Stornoway. A copy of the minutes was signed by Admiral Sir William J. Hope Johnstone, Chairman pro.

tem., and forwarded to the Meteorological Committee after signature by the absent Chairman, David Milne Home, and the President, the Marquis of Tweeddale (409).

It seems probable that Scott actually entered into the agreement with Smith on an informal basis whilst he was in Scotland on his inspection visit. He learned of the new telegraph line and promptly took steps to recruit an observer whilst having the good fortune to be on the spot. If a suitable man could have been found with no connections to the Scottish Society then doubtless Scott would have recruited him, but potential observers were scarce and time was short. He had thought that Scottish susceptibilities would have been quietened by the assurance from Smith that his Society work would not be in any way affected, and by his own frank approach to the Society in his 9 Nov letter. But 1872 was a time when Scottish feelings were easily roused, and the thought that anyone from London (even an Irishman) was playing fast and loose with Scottish interests could rouse the deepest, and at times unreasonable, ire. The great surge of nationalistic feeling that had culminated in the erection of the national Wallace memorial at Abbey Craig just three years earlier was still being stirred by such as William Burns, who was the first to point to "... the enormity of allowing 'Great Britain' to be referred to as 'England' and of the use of 'Scotch' instead of 'Scottish' ..." (410). It would seem that the Committee had run into a force that defied rationality even amongst those of normally rational inclination. Indeed it would be difficult to explain the rather intemperate reactions of an eminent body of men otherwise. Faced with this situation Scott chose to point to the possibility of a complete misunderstanding.

In the Committee's response Scott brought attention to the lack of a reply by the Scottish Society to his letter of 16 May 1870 (see pp. 124-126). Until such a reply was received then the Committee could not consider that

the proposed agreement had been accepted. Scott also pointed to the memorial of the Society to the Devonshire Commission in which the "... failure of their negotiations ..." with the Committee was reported. He gave his personal opinion that the best procedure would be for all parties to disregard the negotiations "... in toto ...", adding that "... The difficulty ... is that to the memorial a fragment of ... (the correspondence) has been appended, and with your present letter you forwarded a portion out of the middle, neglecting the beginning and end ...". He added a postscript pointing out that a "... complete outfit ..." had been sent to Stornoway so that Society instruments were not being used for Meteorological Office reports (411).

A further excerpt from the Scottish Council minutes was soon forthcoming. Scott was accused of treating two entirely separate matters - the agreement precluding the Committee from communicating directly with the Society's observers, and the application made to the Committee for a portion of their annual £10,000 grant - as if they were one. The Council still awaited a reply to their communication forwarding their minutes of 26 Nov (412). Sir Charles Wheatstone, who had joined the Committee in Apr 1871, was requested at this stage to give his opinion on the whole of the correspondence to date. Unfortunately his subsequent comments were never minuted.

The Meteorological Committee had had enough and decided to withdraw from the whole affair. On 13 Jan 1873 they adopted a resolution to the effect that the matter of the Stornoway observations was one that simply concerned the relations between the Scottish Society and the observer. They also considered, by virtue of the correspondence between 19 Jan and 16 May 1870 and by the wording of the Scottish memorial to the Devonshire Commission, that the arrangement between themselves and the Scots had been abandoned (413). One wonders how poor Smith, the Stornoway observer, viewed these

wranglings over his services between distant and distinguished bodies and if, indeed, he ever knew exactly what was happening and, if he did, whether he truly understood its import.

Relations now reached rock bottom. A copy of the Committee's resolution had been forwarded to Edinburgh and was considered at the next Scottish Council Meeting on 20 Jan. The minutes fairly seethed. The "London Committee" (a term used 12 times in the minutes - it had never appeared previously) had "... appropriated ..." their observer "... without any previous communication through the Scottish Society ..." who were unable to offer him payment - while the Committee "... backed with Government money ..." could pay him and so would gain his exclusive services. The Council protested severally and volubly against this use of Government funds, accusing the Committee of using their grant for the purpose of "... destroying the influence of the Scottish Society ...". They re-iterated their charge that the "London Committee" were treating two separate matters as one. Unless the Council received assurances that the Committee would be bound by the agreement in force they would "... take instant measures for protecting their interests ...". A copy of the minutes was again forwarded to London and Scott was promptly instructed to forward copies of all the correspondence to the Board of Trade. He also replied to the Scots, denying any intention to damage the work of the Society. The only co-operation that had been contemplated, and which had not been modified completely by other correspondence, was such as should from time to time be proposed by the Committee and which would be paid for. Co-operation had been requested by the Committee in their letter of 16 May 1870 and in nearly three years they had still received no reply (414).

The minutes of the Meteorological Committee were becoming totally dominated by the Scottish issue. The next communication from Edinburgh was another excerpt from the Scottish Council's minutes this time from their meeting of 25 Feb 1873. Again there were frequent references to the "London

Committee" and the disagreements were getting rather pedantic. It was not interference with the "returns" from Stornoway but with the "observer" that was objected to. The Committee's letter of 16 May 1870 was interpreted as confirming the agreement regarding co-operation and had not been thought to require a reply; the accusation was also made that their subsequent actions would lead to the "... gradual extinction ..." of the Scottish Society's stations. The Council would decline to hold further communication with the Committee on the subject and would take steps to "... vindicate their position and ... (protect) their interests ..." (415). Virtually a repeat of the implied warning that was barely a month old (see last para).

The Scots also wrote again to the Board of Trade repeating the accusations against the Committee for appropriating their observer, breaking a written agreement and undermining the Scottish Society. The Society thought they had been hardly done by "... but they certainly did expect that at least they might have been let alone and allowed to prosecute unmolested their voluntary labours ..." and they considered it a waste of Government money to be so used in a way that was "... directly hurtful to the cause of science ...". There was also a request for the Board to receive a deputation to state their case more fully. A copy of this letter was forwarded to the Committee by Gray, the Secretary of the Board of Trade (416).

Scott responded with a most emollient letter to the Board enclosing a copy of his 9 Nov 1872 letter to the Society. He stressed that there was no way in which the telegraphic observing duties of the Stornoway observer would affect his work for the Society, but conceded that if there was conflict then he would conform to their wishes and seek another observer. He remarked that there would be very few other localities where it would be difficult to find separate observers. Finally, he fastidiously refrained from comment on the more outspoken phrases in the Society's letter as being

"... not necessary to disclaim ...". Gray replied with the hope that relations between Society and Committee would improve "... notwithstanding what has passed ..." so that they could "... work in harmony in future ...". Peace appeared to be dawning because a similar letter from Gray to the Scots, enclosing a copy of Scott's last communication, also evoked a placatory response from Thomas Stevenson, the Honorary Secretary of the Society, and an offer for the two bodies to engage in friendly co-operation in their investigations (417).

But the Scottish Society had not given up in their quest for aid. Only two to three months later an exchange of letters took place between the Marquis of Tweeddale and William Baxter, Secretary to the Treasury. This correspondence seems to have been something of a reversion to square one, with Baxter indicating that the Scots might come to some sort of an arrangement with the Meteorological Committee. After an inexplicable delay of some four months copies were eventually forwarded to Scott for the latter's attention. An offer of co-operation was immediately forthcoming, but the Society were already preparing a memorial to the Treasury requesting a direct grant which could be separately administered by the Royal Society of Edinburgh (418). They were clearly, and somewhat hopefully, aiming at a grant analogous to that received by the Meteorological Committee for running the Meteorological Office. The attack was being directed along another line. The Scots had at last accepted that the Committee would not be prepared to let them have the sort of sum they were seeking - which was in the region of £300 - so they were trying a final fling in the form of a frontal assault on the Treasury coffers. In the meanwhile a harmonious deal had been speedily effected with the Meteorological Society in England whereby the Meteorological Office paid £25 per annum for data from 10 stations supervised by the Society (419). This was a very much smaller sum than the Scots had been seeking - and which had, of course, included payment for clerical assistance - but Scott

was instructed to write to the Scottish Society offering similar terms. The Scots expressed their willingness to supply observations free but again the lines became tangled and difficulties arose over the exact form in which the information would be given (420).

The biggest crunch of all was still to follow. At their meeting on 26 Apr 1875 the Committee were faced with a minute from the Board of Trade relating to (a) the memorial from the Scottish Meteorological Society for a grant, and (b) motions before Parliament by (i) Mr Malcolm to reduce the vote to the Meteorological Office by £500, (ii) Mr M'Lagan to *reduce it by* £1,000 (421). No prior notice of the motions, about which they must presumably have known, appears to have been given by the Scots. But these drastic tactics had the desired effect. The Meteorological Office vote passed the House of Commons on 30 Jul but the implied protest of the Scottish motions had been noted. On 11 Oct 1875 Mr W.H. Smith, on behalf of the Treasury, announced that

"It was the intention of the Treasury in the course of the Autumn to conduct an inquiry and ascertain for themselves what appeared to be the best method of conducting observations for meteorological purposes" (422).

The investigating Committee was duly constituted under the chairmanship of Sir William Maxwell Stirling on 2 Nov 1876 (423).

8.4 The Treasury Committee

The new inquiry was in many ways a follow-up to the earlier investigation carried out under Galton in 1866 and which had recommended that a further inquiry be made within three years (424). Of the three members of this earlier committee two were re-appointed. Galton himself was an obvious candidate and Farrer was also invited, apparently against his wishes, but both agreed to serve (425). Evans was not on the new Committee but was

called as a witness. As has been noted above the chairman was Sir W. Stirling Maxwell, M.P. for Perthshire, who was an indefatigable member of committees and commissions and a man of many and diverse interests, although without obvious scientific connections. Thomas Brassey was another parliamentarian with a keen interest in naval affairs. Also appointed were R.R.W. Lingen, Permanent Secretary to the Treasury, J.D. Hooker and Lieut-General Richard Strachey who, like Galton, was a member of the Meteorological Committee (426). None of the initial appointees was readily seen as being closely conversant with the views of the Scottish Meteorological Society. These were clearly fundamental to the whole reason for setting up the inquiry, and so a re-appraisal saw the name of David Milne Home added to the Committee (427). The Secretary appointed was Horace Seymour but, in the event, the secretarial duties were carried out by J.G. Fanshawe.

The Committee was asked to report on four points:

1. Had the collection of statistics led to any greater scientific understanding?
2. Had the principles used in the issue of storm warnings been justified by results?
3. How far was the appropriation of a large sum of money in aid of meteorology justified?

and

4. What was the best means of administering the grant and how should it be applied? (428)

Evidence was taken on 13 days between 9 Feb and 7 Jun 1876 and the investigation was thorough and wide ranging. De La Rue and the Earl of Rosse were called as members of the Meteorological Committee, whilst Scott and Toynbee were closely questioned about the working of the Office. Naval evidence was taken from Capt Evans who was now the Hydrographer, from his

predecessor Rear Admiral Richards, from a former sea lord Admiral Sir F.W. Grey, and from the Professional Officer to the Board of Trade Capt Murray. Less elevated maritime opinions were also sought from Mr C. Dawson, an employee of a saw mill in North Shields who had close contacts with the local seafaring community and had been engaged in a review of storm warnings in that area, and from George Thomas Watson, the manager of the sailor's home in Yarmouth. Other practical users of meteorological science were represented by Dr William Farr, who was investigating links between weather and public health, and by James Caird, who had interests in scientific agriculture. More academic meteorologists called by the Committee were John Knox Laughton of Greenwich Naval College and Dr Robert James Mann, past President of the Meteorological Society, whilst the Scottish Meteorological Society's witnesses were Thomas Stevenson and Alexander Buchan. Broader scientific concerns were represented by Sir George Biddell Airy, the Astronomer Royal, and by William Thomson, the future Lord Kelvin. The advice of the Royal Society was also sought (429).

The Committee's report was presented to Parliament on 13 Feb 1877. Like the earlier Galton Report it was a substantial document and with its supporting evidence it forms an invaluable source for the meteorological historian. The work of the Office was described as coming under two heads - ocean meteorology and the meteorology of the British Isles. The latter was subdivided into the telegraphic branch, concerned with the issue of daily weather reports and storm warnings, and the statistical or climatological branch, which processed information from both the continuous recording observatories and the eye observations made by a network of voluntary observers. These were all thought to have "... produced results of value and should be continued ..." (430).

Here the Committee made its first innovatory suggestion. It recommended that work on marine meteorology be transferred to the Hydrographical Department of the Admiralty - a recommendation that was actually at variance with the views of the Hydrographer himself although supported by his predecessor. Inherent in the scheme was an expansion and re-organization of the Hydrographical Department itself (431). A second major proposal concerned the overall control. Having considered the alternatives of a voluntary committee or a single permanent head which, if we accept the continuum with the Board of Trade period, had been the two systems tried up to this time, the Committee rejected both. Recommended was the formation of a paid Council, smaller in size than the Meteorological Committee, with appointments being made for limited periods on the advice of the Royal Society, and renewed where necessary. The chief officer would be under the control of the Council and would be designated more appropriately as Secretary rather than Director (432).

Several detailed recommendations followed. Perhaps the most important was the idea that an element should be added to the grant in order to finance research on selected projects. It was intended that most of this work should be done outside the normal routine of the Office and the employment of internal research workers was not considered. Indeed the word "research" does not rate a mention in the comprehensive index to the Report. This proposal followed directly from comments on the desirability of providing "... funds to be employed in original investigations ..." that were contained in the Royal Society's reply to Maxwell's request for advice (433). Other suggestions for future implementation included the inauguration of Sunday telegraphy to eliminate the undesirable gap in the storm warning system between Saturday and Monday; the continuation, but possible reduction in numbers, of the recording observatories (the cost of servicing all seven was thought to be diverting resources from other investigations); an increase in the number of voluntary observers,

especially in Ireland; and the maintenance and possible enhancement of co-operation with the voluntary societies. Co-operation in the taking of observations synchronous with those in other countries was also to be encouraged. The evidence taken on the medical and agricultural implications of the weather was acknowledged but it was felt that no specific action was required at this stage over and above that covered by the general observational programme (434). Not surprisingly the position of the Scottish Meteorological Society rated a special mention but the Committee's proposals were not over-generous. Payments to the Society were suggested for

"... obtaining observations ... required for the purposes of the Council (and) ... for special researches conducted by the Society with the approval of the Council; but ... no grants should be made for ... purposes ... beyond the scope of the operations to be placed under the Council ..." (435),

a recommendation that must have disappointed the Scots. They could now receive payments, but only for carrying out work directed from outside. A final suggestion emanated from the evidence given by Thomson. He had proposed an investigation into the periodic changes in the continuously recorded weather elements. This would involve a harmonic analysis of the curves from the recording instruments, and it was hoped that it would result in a greater understanding of the cyclical forces controlling the atmosphere (436).

The estimated cost of these proposals implied an increase in the annual grant to £13,000, a figure reached by taking the current grant of £10,000, adding £4,500, made up of remuneration of Council (£1,000), research (£1,000), Sunday telegraphy (£500), new land stations (£1,500) and inspections (£500), and then deducting £1,500 for the saving on oceanic meteorological work transferred to the Admiralty. The total additional cost to the Treasury would be £4,500 (437). Appended to the Report was an

"Outline of duties of future council" prepared by "... a member of the present (Meteorological) Committee who is also a member of our Committee ...", which meant either Galton or Strachey and almost certainly the former. This gave a fairly detailed programme for action by the new Council (438).

CHAPTER 9

THE SCOTT ERA - PART 2 - THE PROFESSIONAL COUNCIL

9.1 The Meteorological Council

Initial action on the Treasury Committee's recommendations was swift and must have been decided before the official date of presentation of the Report. The Meteorological Committee had offered their resignations to the Royal Society en bloc on 31 Mar 1877. Accompanying the offer was a request that prompt action be taken to introduce the new management system, since the current state of uncertainty meant that decision making, other than the most short term and routine, had become quite impossible (439). Correspondence between the Royal Society and the Treasury took place with some urgency, and approval for the composition of the new Meteorological Council came on 28 Jun (440). Three of the former Committee members were retained - De La Rue, Strachey and the ubiquitous Galton. The Hydrographer held a seat ex-officio; the Secretary of the Royal Society, George Gabriel Stokes, was also appointed (441). The new Chairman was to be Prof H.J.S. Smith, Savilian Professor of geometry at Oxford University (442). It was a formidable body and suggests a high place for the perceived importance of meteorology, despite dismissive references by several authorities such as Glaisher and Airy (443). But the appointment of Smith as Chairman was, prima facie, surprising. Like Scott he was an Irishman, a graduate of Trinity College, Dublin, and the son of a barrister. Politically a progressive liberal, his main academic work was in the sphere of pure mathematics and he made distinguished contributions to the theory of numbers. Earlier connections with meteorology appear tenuous but he had been a member of

the Devonshire Commission and his questions had revealed more than a superficial knowledge of the subject. The Council took over control of the Meteorological Office on 9 Jul 1877.

There must be very few instances of a small department being subjected to two independent major inquiries within the space of two years. The information that was gleaned thereby must have been extremely useful to the incoming Council and their future course of action was strongly influenced by the findings. In the event the proposed "hiving off" of the oceanic statistical work to the Admiralty never took place - probably due to the Hydrographer's opposition - although no record of the actual decision not to proceed has been found. An interim rise in the annual grant was provided by means of a supplementary vote of £2,000 during the first year, and the grant was then raised to £14,500 for 1878-79, this being the full amount recommended for meteorological purposes by the Treasury Committee (including the oceanic statistics) (444).

The first task of the Council, once the formalities of takeover were completed, was to decide upon its own constitution. Scott was appointed Secretary at £800/annum, the same salary as previously, and was authorized to sign official correspondence "by order of the Meteorological Council". The Council was to meet on the first and third Wednesday afternoon in each month, excepting August and September, and three members would constitute a quorum. No permanent Deputy Chairman was appointed. The £1,000 allowance for the payment of Council was to be allocated by paying £300/annum salary to the Chairman and £50/annum retaining fee to each non-official member, the balance then being divided amongst the Council members (excluding the Chairman) on a pro rata basis according to number of attendances (445). A sub-committee was appointed to consider future work on land meteorology and amongst its first recommendations was the appointment of Alexander Buchan as inspector for

Scotland at a salary of £150/annum plus travelling expenses. Buchan accepted the offer and the long standing feud with the Scottish Meteorological Society seemed about to end in amicable agreement (446). Unfortunately events were to prove otherwise and Scottish/English relations were to remain in a sensitive state within the world of meteorology for some decades to come (see pp. 196-204).

9.2 Programme for research

One of the most promising recommendations of the Treasury Committee had been the allocation of a substantial sum of money for "special researches". The amount set aside for this purpose was £1,000/annum but it was never intended that the work would be carried out primarily within the Office. A contractual arrangement was favoured in which specific items of research were to be identified, appropriate researchers engaged to carry out the tasks, and suitable fees determined by mutual agreement (447). The parallel with the 1971 Rothschild customer-contractor principle is obvious although, of course, in the case we are considering the contractor was external and the customer internal to the organization concerned, whereas the Rothschild proposals reversed this relationship (448).

The Council was anxious to take the fullest advantage of this research provision and one of its earliest actions was to compile a list of suggestions for researches (449). It has been stated elsewhere that Galton had already lost most of his interest in meteorology after the 1860s so it is worth noting that, of the ten proposals made, no fewer than six were originated by him, whilst one each was due to Stokes, De La Rue, Prof Everett and Sir William Thomson (450). Four of the proposals were concerned with the development of instruments and observational methods, three (all due to Galton) with what may broadly be

termed synoptic meteorology, one with charts for ocean meteorology, one with atmospheric electricity and one with the harmonic analysis of meteorological variables.

The development of instrumentation was to continue as the most prolific source of research projects throughout this period, whilst the last mentioned of the projects had originated with the suggestions made by Thomson in his evidence to the Treasury Committee. It was proposed that the analysis be undertaken using a specially constructed machine. The work was to be based on Fourier's method, as introduced to meteorology by Bessel. Thomson considered that a minimum of 11 years records (the sun spot period) should be studied for each of the seven observatories, and that a "... thoroughly able young man, well acquainted with mathematics ..." might be employed for a year to try and get scientific results (451). A machine was acquired that could obtain the desired coefficients with sufficient accuracy, and over the course of the next 13 or so years this "harmonic analyser" was to occupy many man hours of labour, be the subject of numerous reports and memoranda, and take up a major portion of the lengthy correspondence between Scott and Stokes (452). But by 1890 it had "... eaten a great many curves without being visibly the better for it ..." (453), and the work was subsequently abandoned following a report by Prof G.H. Darwin that concluded the results were unsatisfactory (454). Manual harmonic analysis was continued for a time but was eventually discontinued and the work of extracting the periodic changes from continuous records was terminated.

Another abortive project was a programme of cloud photography which was aimed at measuring the height and movement of clouds by using pictures taken simultaneously by two or more cameras. It was inaugurated by Galton and Stokes in 1877 and proceeded desultorily for several years, with most of the work being undertaken by Capt (later Sir William) Abney

F.R.S. in the Old Deer Park, Richmond (455). The results were inconclusive and this study in turn was "... left derelict and ... never ... completed" (456).

More exciting were the collection of upper air data by means of manned balloon flights and the measurement of high level winds using the smoke puffs from artillery shells exploded at varying heights. The use of balloons was not new. The first manned flights took place in France during the latter part of the 18th century (457). The opportunities presented by balloons *for scientific study of the atmosphere were quickly recognized and, amongst Englishman alone, John Welsh and later Glaisher* had made a number of balloon ascents with the prime purpose of meteorological investigation. Indeed, the British Association for the Advancement of Science appointed a Balloon Committee in 1858 to "... confer with the Kew Committee as to the expediency of arranging further balloon ascents and ... to carry them into effect ..." but the initiative lapsed some *three years later* (458). *The Council's interest in a programme of flights apparently originated in conjunction with an investigation into the nature of London fogs, and of the structure of the atmosphere at the time of their formation and persistence. The fog investigation started in Dec 1880 with the setting up of an investigative sub-committee under Dr W.J. Russell of St. Bartholomew's Hospital* (459).

The actual balloon flights were carried out under army auspices with expenses incurred on specifically meteorological ascents being defrayed by the Council. Capt Templer of the King's Royal Rifle Corps was the officer-in-charge of the project. Unfortunately disaster struck early in the programme. On Fri 9 Dec 1881 London was enveloped in a "... very peculiar fog ..." and Templer determined to make a flight to investigate the conditions. The balloon "Saladin" was at Bath and Templer travelled there by train, but was delayed by the fog. Being too late to make the

flight on the Friday he delayed until the next afternoon. The fog had cleared by then and cold northerly winds with scattered snow showers were reported during the flight, temperatures as low as 26 F being recorded at 2,000 feet. These were strange conditions in which to investigate, from Bath, the atmospheric peculiarities relative to a fog in London on the previous day but presumably Templer, having made the effort to get there, thought that he might as well go ahead with the flight anyway. The balloon crew consisted of Templer himself, who was to make the observations, Mr Walter Powell who was to work the balloon and place it at the desired altitudes, and Mr A. Agg-Gardner who was to assist with the observations. The ascent commenced at 1350, passed Wells an hour later at 4,200 feet and headed south past Crewkerne and later Beaminster, finally descending as it approached the coast at Symondsburry, just north of Bridport. At this point Powell, for some reason, threw out ballast from the car and Templer, aware of the proximity of the coast, desperately tried to counteract the increased lift by opening the gas valve. The time was now 1640 so dusk must have been approaching. The balloon came heavily down to earth some 500 yards inland from the cliff edge. As it struck the car capsized throwing Templer and Agg-Gardner out, the latter suffering a leg fracture. Although the balloon now remained low enough to jump for some seconds Powell remained in the car, presumably with the intention of bringing the balloon under control and making a normal landing. Unfortunately the balloon started to rise rapidly and Powell was carried out to sea. Despite the mounting of an immediate search no trace of either he or the balloon was ever found. Powell was a prominent figure and a Member of Parliament who had volunteered his services in order to help with the investigation. His loss was a major blow and the use of manned balloons for meteorological purposes was brought to a premature end (460). A map showing the course of the fatal flight is shown at fig. 4.

Despite this mishap the work of the sub-committee on London fogs continued under the direction of Dr Russell. Samples of fog laden air were collected by him at St. Bartholomew's and determinations of various pollutants were made, although problems of collection were never fully overcome. In Oct 1884 Russell presented a report of work carried out and proposals for a programme of further study. He also intimated that he had exceeded his authorized expenditure by over £30. The Council awarded him an honorarium of £50 for the work performed but there is no record of the overspend being re-imbursed and, despite Russell's proposals, support for the investigations was terminated (461). A subsequent investigation was later set up in 1901 with financial assistance from the London County Council, the work being carried out by Capt Alfred Carpenter R.N., a member of the Royal Meteorological Society Council. Accommodation and clerical assistance were provided within the Meteorological Office (462). The other area of research where the Council sought military assistance was the determination of wind velocity at altitude by measurements of puffs of smoke caused by shell bursts at known altitudes. The idea originated with Galton and was carried out by Capt W.A. Noble of the Royal Artillery at the Elswick Works, Newcastle-upon-Tyne, but was soon discontinued due to cost (463).

The revised FitzRoy Barometer Manual had become due for further revision and re-printing, and this was taken up by the Council under the Special Investigations umbrella. The work was entrusted to Rev. Clement Ley, a prominent member of the British Meteorological Society who was also subsequently appointed as the Office's Inspector of English stations (464). Ley was by profession a clergyman but he made many contributions to the science of meteorology publishing several papers in the Society's Quarterly Journal. He was at this time rector of Ashby Parva in Leicestershire (465). Ley produced a first draft of part 1 of the Manual in 1878. This was approved by the Council, subject to some revision, but

preparation was deferred of additional parts which were to deal with weather telegraphy, storm warnings, types of gales and use of the barometer by seamen (466).

Eventually it was agreed that a second part should be written by Hon. Ralph Abercromby, another well known amateur meteorologist, but when Abercromby's first draft appeared the Council considered it to be incompatible with Ley's part 1 (by now termed a "weather guide") and it was resolved to publish the two as separate books (467). These came to be regarded as the classic English meteorological texts of the 19th century. Ley's book was published in Aug 1880 as Aids to the study and forecast of weather, for which he received an honorarium of £60 (468). Abercromby's work was not finished for several more years. His final draft manuscript was submitted to the Council in Jun 1883. Publication was further delayed because of the author's illness but it appeared at last in 1885. Before the end of the year the Stationery Office were calling for a second edition. Abercromby was awarded an honorarium of £60, the same as Ley, and had also received an earlier interim payment of £15-15-0, but he was unhappy with this "... very small ..." remuneration and asked for something from the second edition (469). There is no record that this was forthcoming. Abercromby's book, published as Principles of forecasting by means of weather charts, was to exert a massive influence on the development of weather forecasting within Britain. Extensive verbatim extracts from it were still being quoted as late as 1940 and a "revised and updated" version is still on many contemporary meteorological bookshelves to the present day (470).

This served only to underline the relative stagnation that overcame meteorological science within Britain during the late 19th and early 20th centuries. The remarkable influence of Abercromby is surprising. He had no pretensions as a scientist and his interest in meteorology was that of

the enthusiastic amateur. He had a military background but his constitution was not strong enough for the rigours of army life, and he doubtless threw his energies into the pursuit of a boyhood interest in meteorology in order to compensate for being unable to follow his chosen career. He was certainly very active within the British (and later Royal) Meteorological Society and made many contributions to its publications (471). Unfortunately his principles were based on "... sterile isobaric geometry ...", linking a variety of isobaric shapes and figures with specific weather patterns that were reputed to occur in conjunction with them (472). The basic problem of forecasting was presented as the ability to foretell the occurrence and movement of these configurations. Meteorology was moving into an impasse and there was no generally accepted model to help explain the development of weather systems or the dynamic interaction between masses of air with different physical properties. The cry at this time was for

"... a Kepler ... (to be) forthcoming to discover the laws by which our science works; for us to endeavour to force the plant in its growth is hopeless ..." (473).

In retrospect Abercromby has been described as the "... British Aristotle ..." of meteorology - by exaggerated reference to his work acting as a blanket on further initiatives at this time (474). This is, perhaps, a rather harsh judgment since observing networks were still too sparse and too limited to allow readily for broad conceptualizations. FitzRoy's earlier trajectorial models were closer to modern ideas, but they owed a lot to the imagination and it would have been difficult to infer their superiority at the time; and, doubtless, with Galton's influence still strong, FitzRoy's was a discredited name in "scientific" meteorological circles. But Abercromby (and others) can still be criticized for overlooking or failing to recognize many features that had been observed, and so were known, but which were simply ignored because they did not fit into the current theory. In Kuhnian terms he was forcing the facts to

fit (the concept of) a "paradigm" in which weather causation was due to isobaric shapes (475). The subsequent "scientific revolution" was still some years away.

Weather disasters were sometimes referred to the Council for investigation and when the old Tay Bridge was destroyed by exceptionally strong winds on 28 Dec 1879, together with a passenger train and all its passengers, a joint committee of the Royal Meteorological Society and the Meteorological Office was formed. The committee selected W.H. Dines, a young mathematician from Corpus Christi, Cambridge, to carry out a study of wind gustiness. Dines was then 24 years old and this was to be the start of a long and distinguished career in meteorology, largely associated with the development of anemometers and instruments for investigating the upper air using kites and balloons. The Dines pressure tube anemograph has withstood the test of time, and is barely obsolescent even at the present day. Much of his work was carried out in conjunction with, if not actually within, the Meteorological Office. He also founded something of a meteorological "dynasty" in that his sons later filled several important roles within the Office structure (476).

Perhaps the most important study that was looked at under the research programme, however, proved to be an investigation into hygrometric measurements, although for reasons other than its intrinsic worth. The hygrometric tables in use in Britain during the third quarter of the 19th century had been derived empirically by Glaisher, who had made "... many thousands ..." of observations with a Daniell's hygrometer. Other published tables were due to Dr C. Jelinek, Director of the Meteorologische Centrale in Vienna. Jelinek calculated his results from formulae established by Regnault. At high humidities the differences were small, but they increased with decreasing temperature and humidity so that at 41 F, a wet bulb temperature of 35 F, for example, gave a

relative humidity of 58% according to Glaisher and 49% according to Jelinek (477). Measurement of humidity is difficult, especially at low temperatures, and Stokes sought out a scientist of some distinction to carry out the work. And the selection of the scientist was to prove more important than the investigation. By this means was William Napier Shaw introduced to meteorology. Over the next 50 years his influence upon its development was to be enormous (478).

9.3 A more settled outlook for weather forecasts

The routine issue of weather forecasts, as opposed to special storm warnings for shipping, had been inaugurated by FitzRoy in 1861. The story of their criticism by the Galton Committee and their subsequent discontinuance through the period of the Meteorological Committee's suzerainty, has been fully described above (see pp. 56-59 and 66-68). It was not long before the Council decided that the new synoptic techniques provided a sufficient scientific basis to consider restoration - it was their "empiricism" that had aroused Galton's earlier disapproval - and moves towards their re-commencement were soon forthcoming. Already the observational network had been improved. The grant provided to the old Committee by the Treasury was not increased, but The Times newspaper both requested that a 6 pm chart and accompanying reports be supplied daily, including Sunday, and undertook to cover the additional costs involved. The total cost was estimated at £250 per annum, but the Office defrayed £90 of this by virtue of the extra additional work the clerks were able to perform during their extended periods of duty. The Times retained exclusive use of the information although expressing willingness to share it, provided costs were borne equally by anyone doing so (479). The allied task of supplying storm warnings on Sundays ran into the problem

of the manning of telegraph offices. Apparently some telegraphic stations worked Sunday mornings only and no more than a limited scheme could be implemented (480).

The concept of providing forecasts of the expected weather was gaining in acceptance elsewhere. In America the issue of such forecasts, or probabilities as they were called, had already been started by the new meteorological service that had been formed under military auspices after the Civil War. This developed under the control of the Chief Signal Officer of the army, Col Albert J. Myer, and of Prof Cleveland Abbe, the former Director of the Cincinnati Astronomical Observatory (see p. 118). By European standards it had a very large budget to finance its work. Rules for the preparation of the probabilities were very detailed and extended, with military exactness, even to the precise wording of the messages (481). European thought was also moving favourably towards the idea of prognostication, with an overwhelming positive response being given to a questionnaire on the subject that was presented to the 1873 Vienna Meteorological Congress (482). The time for a resumption of the forecasts was becoming overdue.

The date upon which this event took place is quoted as being 1879 by a number of sources, and more specifically as 1 Apr 1879 in the Council minutes, but The Times was already carrying a prognostic statement, albeit brief and generalized, as early as 26 Jul 1877. Remarkably no record concerning this appears in the Council minutes or in its annual reports, nor was there any special announcement in the paper itself about the resumption of forecasts (483). The "forecast" published in The Times on 26 Jul 1877 was accompanied by a chart of the British Isles, and preceded by an explanation of the chart and summary of the weather. It simply stated (for the whole country):

"Under these circumstances it seems probable that, while fresh to strong south-south-west to southerly winds and rain will prevail in the west and north, light southwesterly breezes with dull and possibly wet weather will be experienced in the southeast during the early part of the day." (484).

Even earlier, during the time of the Meteorological Committee, a prognostic remark was sometimes included as part of the weather summary, for example, on 2 Mar 1876,

"... As long as the barometer remains so high in the south in comparison with that in the north, any settled weather can hardly be anticipated." (485).

The initiative for starting the more comprehensive forecasting service that did begin on 1 Apr 1879, the date quoted above, came from the prime architect of the earlier cessation, Francis Galton. Arrangements were made not only to supply The Times with an 8 pm forecast for printing in the following day's paper, but also for receipt of telegraphic enquiries about forecasts or about actual weather, provided the reply telegram was prepaid by the enquirer (486). The charge for this service was 2s for the prepaid telegram plus a fee of 1s, 3d of which was retained by the Post Office as payment for "extra trouble" with the remaining 9d going to the Office as a fee for the work involved. Three regular forecasts were also issued daily and posted outside the Office door. The times of issue were 11 am, 3.30 pm, and 8 pm. The morning forecasts were passed to The Times and Globe newspapers for their early editions, whilst the 3.30 pm issue was even more popular. At its inception free copies of the London district forecasts were despatched by hand to 25 clubs around Pall Mall for a trial period of a month, and subsequently 16 of the clubs took out a subscription. Four copies of regional forecasts were also sent to provincial newspapers, with national forecasts to The Scotsman and Sheffield Daily Telegraph through the Press Association. A small

printing press was used for the London district forecasts and it was possible to set the forecast up, make any corrections, and print 60 copies in half an hour. Once it was set up 900 to 1,000 copies per hour could be printed. The new arrangement with The Times, involving 8 pm forecasts for early morning editions, was soon to be shared by the Standard, with costs split at £300 each (instead of £500 by The Times alone), the additional money being used to improve the service (487).

The format of the new forecasts was somewhat more formal than those issued by FitzRoy. The British Isles was divided into 11 districts and, following a synopsis of the weather situation that was shown on an accompanying chart, the forecasts were given for each region. The 11 am forecast referred to the period until noon on the following day, the afternoon and evening forecasts were for "tomorrow" (see fig. 5). They proved popular and demands for further outlets were soon forthcoming. By mid-June they were exhibited daily at 11 additional places throughout the West End and the City, including the Mansion House and the libraries of the Houses of Lords and Commons. The Daily News also came on to the distribution list for the evening forecasts, contributing £300 for the privilege, and the whole question of distribution of forecasts to the newspapers and the costs of so doing was brought under review. Smaller newspapers were unable to pay a substantial contribution and, although the newspapers already supplied were quite willing to accept that the forecasts should not be confined to themselves, they were not prepared to subsidize rival publications (488).

The Office did not have the resources to supply extra forecasts without an additional source of income; its only possible means of financing the requirement would have been to curtail its research programme, which was undesirable. The Treasury was not blind to the problem and, for once, the purse strings opened readily, the annual grant being increased by

£500 to £15,000 (489). This contrasted with an earlier Treasury decision in Nov 1878, when an inability to deal with accumulating oceanic data due to insufficiency of staff was noted. On this occasion Lingen's attitude was that if such a deficiency in "... one of the branches of the subject which show ... practical benefit ..." could not be met, then the Council should "... economize in other directions ...", and this clearly implied a cut in the less "practically" beneficent research expenditure (490). The difference in Treasury attitude to these two incidents is illuminating. Presumably public opinion, certainly publicity, and possibly votes, were thought to lie on the side of the newspapers, whilst oceanic statistics only affected *the remote seafarer*. *The positive* response to the later approach might also be ascribed to the fact that it had been made personally by Smith to Lord Frederick Cavendish, the recently appointed Financial Secretary to the Treasury, rather than through the normal channels (491). This could be too cynical a view, however, because a further appeal to the Treasury, routed via *the Royal Society* and pointing out that the £500 increase in grant was to be set against a loss of £900 from the combined contributions of the newspapers, elicited a prompt and favourable response. This time a further increase of £300 was found bringing the total grant up to £15,300, a figure at which it was to stay for the next 24 years (492).

A major extension of the new forecast system came with the start of a special service for agriculturalists. The provision of meteorological information for agriculture had been amongst the first considerations of the Council, but the idea of providing actual forecasts came later. The concept was not original, such forecasts being already available in Germany (493). The Council's proposals became linked to a scheme that sought Government aid in forwarding the afternoon forecasts to telegraphic offices for public display. This did not get very far, but an alternative idea was eventually put into operation with information

about expected weather being targeted to interested individuals during the period of the hay harvest. A trial run was made during the 1879 haymaking season. The Royal Agricultural Society nominated 24 participating landowners across England and Wales, covering from Morpeth in the north to Maidstone and Cornwall in the south. Forecasts were also displayed at a show held by the Society at Willesden (494). The experiment was considered a success and the scheme was extended to Ireland and Scotland although the number of direct participants remained small. The harvest forecasts were continued free of charge until 1899 but thereafter a small fee was levied to cover the cost of postage and telegrams (495).

Results of the new public forecast system were encouraging. For the period 1879 to 1885 comparisons made by the Office showed that the success rate for routine forecasts (which covered the following day) rose from 75% to 83%, "success" in this context meaning that the forecast was considered to have been "... more than half ..." correct. "Completely successful" forecasts showed an even bigger improvement, rising from a rather disappointing 28% to 51%. The hay harvest forecasts were strictly comparable showing a rise from 76% to 84% success between 1879 and 1886. These were of course made during the more settled summer months when forecasting was easier, but they were assessed by the users themselves so the close comparability of the results diminishes any possible charge of significant bias in the Office's assessment of its own performance. By way of comparison the storm warnings issued during the same period showed an average success rate of 80%. A warning was considered correct if a wind as strong as Beaufort force 6 was recorded anywhere along the coastal stretch warned; if occurrence of a force 8 gale had been made the criterion then the success rate would have dropped to 57% (see tables 8 and 9) (496). This was worse than the rate claimed by FitzRoy whose warnings covered 72 hours instead of 48 hours under the new system (497).

The figures quoted by Galton for FitzRoy's warnings were significantly worse but, as has been pointed out above, the method used to produce them was seriously flawed (see pp. 60-62). Even the most dispassionate view must have acknowledged the gross disparity between the method used by Galton to assess FitzRoy, and that now used by the Council (of which Galton was a member) to assess Scott, but no contemporary acknowledgement of this has been found.

9.4 The marine branch

A recommendation of the Treasury Committee was that the work of the marine branch should be transferred to the Hydrographic Department of the Admiralty, but as already noted this move never took place (see p. 140). The Hydrographer, who was an ex-officio member of the Council, undertook a survey of the branch and produced a report in which he indicated that, (a) the quantity of material already possessed by the Office and still in need of processing was so large that either the staff should be increased, or the rate of collection of further observations should be decreased, and (b) the observations should be recorded on charts rather than in data books. Toynbee thought that (a) was unnecessary since the present staff were coping adequately, and that (b) was unwise and would not help in obtaining mean data for each square; besides, many plotted observations yielded an "... extremely confusing ..." picture. It was resolved that current work (the six Cape of Good Hope squares) be continued, but that charting of data also be commenced and carried on pari passu with extraction into data books (498). Toynbee was very sensitive to accusations that work in the marine branch was lagging in the way implied by Evans. He defended his record vigorously and at some length in a letter to Smith, written in Jul 1879, putting the blame for any delays on a lack of proper direction by the Council; he also changed his earlier attitude and pleaded shortage of staff (499). This letter is

not mentioned in the Council minutes, nor has any reply been found, but increases in the staffing of the branch were soon to follow. Within three months Lieut C.W. Baillie, R.N., was appointed as an assistant to Toynbee. He had formerly been the Director of Naval Statistics at the Imperial Naval College in Japan. A writer was also employed to serve under him. Baillie's first task was to complete work on Pacific sea surface temperatures (500).

The first International Polar Year was organized to take place during 1882-83. Britain was an active participant and a British station was established at Fort Rae in northern Canada to make meteorological and geophysical observations (501). There was direct Office involvement, both in supplying meteorological instruments and in giving advice as to the work to be carried out. Scott was also elected a member of the I.P.Y. Commission (502). The Council proposed that an investigation of the North Atlantic be made simultaneously with the work of the I.P.Y., and aimed to increase the number of observations obtained during this period, a move endorsed by other countries several of whom offered their co-operation (503). Earlier proposals had been made regarding the production of synoptic charts of the Atlantic by Denmark, France and Germany. Capt Hoffmeyer of the Danske Meteorologiske Institut had undertaken the regular issue of such charts some years previously and, although the Meteorological Office had been unable to assist when he ran into problems, the Deutsche Seewarte under Neumayer had come to the rescue and a valuable series of charts was still being compiled (504). British work was also directed towards the charting of global sea surface temperatures (505). Opportunities for enhancing meteorological knowledge were increasing rapidly, and the organizations that had to process the resulting information were developing. Co-operation between countries was growing world wide and especially in Europe, although the official

attitude within Britain was not always favourable (506). The charts that resulted from the special Atlantic co-operation of the Polar Year period were eventually presented to the Council by Toynbee in Apr 1886 (507).

Meanwhile the painstaking collection and recording of routine data went on. Work on the Cape squares and on global sea surface temperatures were nearing completion by late 1881 and the next subjects for investigation were being contemplated, although a Colonial Office suggestion for the publication of a set of Meldrum's synoptic charts of the Indian Ocean was turned down on financial grounds (508). A major review of the Office programme pointed to the belt surrounding the Antarctic regions, including the Cape of Good Hope to Australia and New Zealand thence on to Cape Horn, as the next area for attention. It was also suggested that global studies of *other individual meteorological elements* (e.g. air temperature, winds, pressure) be undertaken and published (509).

High standards of observing by ship's officers continued to be encouraged by the marking of weather logs received. Where these were deficient the Marine Superintendent would get in touch with the captain or observer concerned and give advice on how to improve their work. The practice of rewarding "excellent" observers that had been started by FitzRoy also continued, the observers being presented with sets of published charts of the regions that had been completed; a second "excellent" award elicited the "marked thanks" of the Council (510). In this way H.R.H. Prince George of Wales, who took observations on H.M.S. "Thrush", was recorded in the minutes for 18 Mar 1891 as an "excellent" observer (511).

In 1884 a joint Anglo-French initiative tried to extend the range of observations available for use in operational forecasting and for giving advice to ships on the trans-Atlantic run from Europe. The scheme was for telegraphic reports to be despatched from America giving details of observations made by westbound vessels arriving at U.S.A. and Canadian

ports, and from west Atlantic coastal stations, and it received a ready co-operation from the U.S. Signal Office. An earlier attempt to utilize the observations from a single station in Newfoundland had proved unsuccessful (see p. 98) but Toynbee obviously thought that this broader network was likely to prove more beneficial, and he proposed using the information to extend the range and accuracy of the forecast and warning service (512). Costs were shared equally by the two services but an extended trial showed little practical result obtaining - the observations were too sparse and frequently too late for reliable conclusions to be drawn - and the programme was subsequently abandoned (513).

The branch had also started to process observations from the Red Sea, newly important - but comparatively unknown - following the opening of the Suez Canal in 1869. This work was nearing completion by early 1888 and the examination of observations from southern waters was about to commence (514). But this was overshadowed by the retirement of Henry Toynbee, the Marine Superintendent originally appointed by the Meteorological Committee in 1867. He stood down on 31 Jul 1888 and was granted a pension of £144 per annum. Lieut Baillie was appointed to succeed him at a salary of £350 per annum (515). Toynbee had been a hard working and conscientious servant possessed of strong principles and idiosyncratic religious fervour (516). He was not a man of science but was methodical and painstaking, if somewhat pedantic and lacking in imagination. He had made a significant contribution to marine meteorology and to the work of the Office; but perhaps he had also acted as something of a damper upon its pioneering excitement, as inherited from the mercurial FitzRoy.

9.5 The observatory programme

The programme of observations from its network of continuous recording observations had been the principal innovation introduced into the work of the Office following upon the Galton Report (see pp. 99-107). The checking and tabulation of the records and the reproduction of the actual instrument traces by pantagraph had been one of the main achievements of the Meteorological Committee (517). Of the seven observatories in the network, Kew and Valentia were directly funded and supervised by the Meteorological Office, but the others were maintained by external bodies, each receiving grants of around £250 per annum from Office funds (518). The Treasury inquiry had thrown doubts on the value of maintaining all these recording stations in relation to the proportion of resources they consumed. One of the recommendations made had been for the Council to consider "... whether some at any rate of the existing stations may be discontinued ..." (519).

It was several years before any move was made by the Council to carry out this recommendation but, at last, in Apr 1882 the issue was considered and it was resolved to consult outside opinion. Smith wrote to Henry Storkes Eaton, who was a former President of the British Meteorological Society, and to Professors Hann of Vienna and Wild of St. Petersburg, asking their opinions on the advisability of reducing the number of observatories from seven to three (Kew, Valentia and Aberdeen) (520). The wording of Smith's letter was such as to "lead" the replies, and it was not surprising that all the addressees responded by agreeing to the suggested reduction in numbers and to the suggested list of retained observatories (521). The replies were considered at the 22 Nov meeting of Council but no decision was taken. Two months later the nettle was grasped and a letter was approved for forwarding to the observatories at Armagh, Falmouth, Glasgow and Stonyhurst. This gave notice of cessation

of the annual grant as from 31 Dec 1883, but offered to leave the instruments in situ wherever the supervising institution wished to continue an observational programme with its own resources (522). Smith was in the chair at the meeting that approved the draft of this letter but it was his last action as head of the Meteorological Council. Nine days later a severe cold was followed by congestion of the liver and his death followed immediately. He was succeeded as chairman by Strachey (523).

The letters came as something of a bombshell to the bodies concerned. The Royal Cornwall Polytechnic Society, who controlled Falmouth, were especially strong in their reaction and asked the Council to receive a deputation to plead their case. The Council agreed and a party of 23 Polytechnic Society members - including 3 peers, 3 F.R.S.s, 8 M.P.s, 2 baronets, 2 professors and an army colonel - duly arrived on 27 Jun to present a memorial that stressed the desirability of maintaining Falmouth as an observatory site. It also noted that Falmouth possessed the only bright sunshine recorder in Cornwall and the only self-recording rain gauge in the west of England. A letter followed some days later from Prof John Couch Adams F.R.S., who had been a member of the deputation but wished to put his own views more fully. Adams pointed to the "unique" situation of Falmouth in the far southwest, and expressed the view that the observatory work was "... almost the last branch ..." of the Office where financial savings should be made (524). The campaign in favour of Falmouth continued. Mr A. Pendarves Vivian, a parliamentary member of the Society's deputation, raised the matter in the House of Commons on 2 Aug (525). Perhaps more significantly the Committee of Section A of the British Association for the Advancement of Science passed a resolution critical of the proposed withdrawal of support to the observatories. This referred at length to the great value of long sequences of records and gave specific reasons why each of the four

threatened observatories should be maintained. The list of signatories was impressive and included Thomson, Adams, Stewart, Glaisher, Laughton and Symons (526).

The response from the supporters of Armagh was in a lower key. It came in the form of a memorial which again laid stress on the need for continuous records over a considerable period of time. It also (inevitably) pointed to the special position of Armagh - in this case the feature selected was its position midway along a straight line from Valentia to Aberdeen. The record of meteorological observations there dated back to 1833 and Robinson's original cup anemometer had been in operation since 1846. The signatories included the Earl of Rosse and John H. Jellett, Provost of Trinity College, Dublin (527).

The weight of support for these protests was considerable but the Council upheld its original position and pointed to the Treasury Committee Report and the letters from Hann and Wild for support. The disproportionate amount of strictly limited resources that was taken by the observatories was stressed. It was quoted as having totalled £52,782 since the observatory programme had started. Costs of printing and publication were extra and many of the instruments were due for replacement, which would involve further considerable outlay. The Council acknowledged the value of maintaining a long sequence of records - but the observatories were simply taking too large a share of the cake. Other factors were also mentioned. For example, Falmouth had a good geographical position but a poor observational site. The Council expressed the hope that local efforts might be able to maintain the observations, and promised that "... moderate grants ..." would be available for a limited period if this were done. These points were all made at considerable length in the Council's reply to the British Association, and copies were sent to Falmouth and to Armagh. The Cornish protest also elicited the response

that any proposal for a new observatory on a better site at Falmouth would be given sympathetic consideration (528). The Polytechnic Society saw their opportunity and offered to erect an observatory near Falmouth on a site of the Meteorological Council's choosing - provided the grant be guaranteed to continue at not less than £300 per annum. This took the Council somewhat by surprise but they responded by offering £250 with a guarantee period of not more than five years, an offer accepted with alacrity by the Cornishmen. Armagh had made its protests less loudly and received less. The closure of the continuous recording observatory was confirmed and the instruments were later removed. A sum of £50 per annum was granted to assist with a programme of eye observations. In addition the observatory assistant, Mr Call, was awarded a gratuity of £75 as compensation for losing his employment (529). The withdrawal of allowances passed off more peaceably at Glasgow and Stonyhurst. Both governing establishments (Glasgow University and Stonyhurst College) opted to keep their observational programmes going with their own resources, and the instruments in situ were presented to them free. Having conceded the principle of giving a reduced grant of £50 per annum to Armagh, the Council did the same for the other two observatories as well (530).

So the overall result of the cost cutting exercise was that, of the original seven observatories, three (Kew, Valentia and Aberdeen) continued with their full programme of self recording observations as before; one (Falmouth) re-sited its observatory at local expense, but kept its full observational programme and allowance intact - for the time being at least; two (Glasgow and Stonyhurst) maintained their observational programme, but largely at local expense; and one (Armagh) ceased to operate as a self recording observatory although a programme of eye observations was continued. The saving resulting from these economies was in the region of £500, but this was soon to be whittled

away in supporting a Scottish Meteorological Society initiative for making observations at the top and bottom of Ben Nevis. The Armagh instruments were transferred to a new site at Fort William near the foot of the mountain, whilst another observatory was built on top of the Ben itself. The saga of the Ben Nevis Observatories is a remarkable story. Its ramifications were complex and they will be considered in more detail below (see pp. 196-211).

9.6 "Sanitary" meteorology

The mid-nineteenth century was a time of great awakening in the field of public health care in Britain. The Chadwick Report of 1842 pointed to the desperate situation in working class areas of the dense conurbations, and a broad movement of reform led to the formation of a number of societies devoted to sanitary improvement, and to the Public Health Act of 1848 (531). The Act obliged local authorities to appoint medical officers of health, and in 1857 an investigation into the efforts of weather upon public health was set up by the Medical Officers of Health for the Metropolis under Dr Tripe (see p. 29) (532). Meteorological information was obtained through Glaisher, who had supplied observations to the Registrar General from a network of voluntary observers since 1844 (see pp. 119-120). Glaisher's work was covered at some length by the Devonshire Commission, whilst the Treasury Committee Report contained both a lengthy appendix inserted by Dr W. Farr of the Registrar General's office showing the sort of returns supplied by Glaisher, and a memorandum by Dr A. Mitchell, Chairman of the Medico-Climatological Committee, which inter alia, asserted that "... each disease is influenced as regards the number of deaths which it causes by states of weather ..." (533). The Committee's recommendations implied that the meteorological aspects of this work should be taken up by the Meteorological Office, and that the Council should "... place themselves

in communication ..." with the Registrar-General's office for this purpose. The Council very promptly did so - just 23 days after coming into existence - offering to supply information gratis from a network of 38 stations; but the Registrar-General and the Medical Department of the Local Government Board just as promptly turned the offer down. Glaisher, whose life work this was, had earlier withdrawn his claim to an allowance and the recipients declared themselves as well satisfied with his returns, which fully covered their routine requirements (534). So Glaisher continued to supply the information until 1902, when he was 93 years of age (535). He died the following year. Yet the work of the medico-meteorologists proved abortive and no substantive conclusions appear to have resulted from their efforts other than the continuing work on atmospheric pollution.

9.7 Staff matters

The staff in post at the time of the 1877 re-organization consisted of Scott, Director (re-designated as Secretary under the new regime), on a salary of £800 per annum; Toynbee, Marine Superintendent, £400; J.S. Harding, junior, Chief Clerk, £250; four senior clerks, £170-200; six junior clerks, £100-130; an office keeper, £1-18-6 per week; fourteen temporary clerks, 12/6d - £1-18-6; and an engraver, £2-2-0; whilst Cullum, the Superintendent of Valentia Observatory, was paid directly by the Office at £170 per annum (536). A headquarters staff of 29, all non-superannuated, and very definitely not civil servants as the Treasury lost no opportunity to point out. Six of the staff, J.S. Harding, junior, (who had joined the former Meteorological Department in 1855 and had been private secretary to FitzRoy 1863-65), R. Strachan, F. Gaster, C. Harding, R.H. Curtis (the four senior clerks) and J.S. Harding, senior, (the office keeper), had all transferred from the Board of Trade.

The numbers had grown from a complement of eight at the time of that transfer, and the expense of staff remuneration had risen from a total of some £1,500 per annum in 1866 to £4,300 in 1875 (537).

Comparable contemporary salary scales were generally higher than those afforded by the Office. Scott quoted figures from the 1874-75 Civil Service Estimates to the Devonshire Commission which showed a shortfall relative to clerks of similar status within the public service who, of course, also had the advantage of superannuation (see p. 109 and table 7) (538). The private sector also paid better and there seems little doubt that the Meteorological Office staff was relatively poorly remunerated (539). Dissatisfaction with their salary levels was voiced openly by members of the Office staff on a number of occasions. The salaries were reviewed annually and individual increases awarded where thought appropriate. In 1879, for example, three members of staff were discontented with their increases. They applied for - and got - slightly higher awards, but in making them the Council also ruled that this method of modifying the salaries awarded would not be used again, and applications for rises the next year were turned down. The junior and temporary clerks then joined in writing to Council asking that an application be made to the Treasury for an increase in grant that would enable further rises to be paid. The request was turned down and a number of temporary clerks resigned from the Office during the following year, presumably in disenchantment with the position (540). The clerk's feelings were not helped by a flat refusal from the Treasury to consider a proposal by Smith for provision of superannuation allowances to the staff, despite strong Royal Society support (541). Sympathy for the clerks was evident amongst the members of Council and another application for increases by several of the staff was given special consideration by the Chairman and Secretary despite the earlier ruling, but without positive result (542).

The problem of superannuation was to cause considerable trouble in future years (see pp. 185-187) but the only immediate worry was with the office keeper, J.S. Harding senior, who retired in 1882. He had joined the former Meteorological Department in 1860, transferring to the Meteorological Office in 1867, so by any definition he had been a civil servant for at least seven years, but the Treasury refused to consider any payment. The Council decided to pay a pension out of their own funds and Harding was awarded £42-16-5 per annum - equal to what he would have received for 22 years service from a civil service pension (543). The question of Toynbee's pension arose some six years later (see p. 158) and was resolved in a similar manner although this somewhat arbitrary method of dealing with the pensions problem was obviously impractical in the long term. However nothing substantive was done about the matter until several of the more senior staff were all approaching retirement some 15 years later.

Similar ad hoc methods of dealing with staff matters were adopted several times by the Council, to the general disapproval of the Treasury. An incident that illustrated the Treasury attitude occurred in 1880. The engraver, Stodart, died after a long illness, but also after 10 years good service, and the Council made a special award of £20 to his widow. Some months previously a similar gratuity had also been awarded to the widow of a temporary clerk. The Exchequer and Audit Department brought these payments to the notice of the Treasury and a firm letter from Lingen forbade any such further payment (544). The incident also shows the extent of quite detailed Treasury control over expenditure despite the Office's non Civil Service status. The role of the Council in its staff relations does seem to have been a largely beneficent one and, despite the low salaries, a degree of loyalty to the Office appears to have been generated. Several members of the same families were sufficiently attracted to its life to follow one another on to its staff,

and men with alternative careers and seemingly better prospects available to them outside would sometimes opt instead to work within the Office (545). Doubtless work in an inherently interesting subject like meteorology, even when concerned with the more mundane and routine aspects, had an appeal to some that was lacking in a bank or business house, although there was little enough of science in the clerk's tasks.

Staff numbers had been increasing and the Council were trying to economize. Any significant increase in expenditure on salaries would cause problems. A solution was required and with no sign of any diminution in the tasks to be performed it could not come in the form of a reduction in the work force. The need to plot Atlantic charts for the special observational programme associated with the International Polar Year (see p.156) was the trigger. On 22 Nov 1882 the Council resolved to engage two female assistants, and on 1 Jan 1883 Miss Everetta Anderson started work at 15/- per week, followed seven days later by Miss Maria Harris on 12/6d per week. A further fortnight and Miss Alice Whatley also joined the staff. It was decided that the women's salaries would rise to maxima of 30/- per week for the principal assistant (Miss Anderson) and 20/- per week for the others, remuneration levels appreciably less than would have pertained to male staff of comparable quality (5-6). The female staff were kept in virtual purdah, being allowed to arrive several minutes late and finish similarly early in order to avoid the embarrassment of meeting any of the male staff on the doorstep, but their introduction was apparently successful and the needed source of reliable cheap labour had been found (547). Somewhat surprisingly the number of female staff was not allowed to rise significantly higher for a considerable period.

A re-organization of the clerical staff took place in March 1885. This incorporated a full review of salary scales and incremental payments and was introduced, inter alia, to eliminate the need for consideration of ad hoc individual increases, as noted earlier (see p. 165). The opportunity was taken to lay down a formal outline of the conditions of service and rates of payment for overtime and abnormal hours. The new structure specified one chief clerk, on a salary of £333-6-8 per annum, and four other classified grades; class 1 (initially 5 clerks) max £275, class 2 (initially 7) max £200, class 3 (initially 5) max £150, and class 4 (initially 7) max £110. The salaries of unclassified clerks were not to rise above £1 per week. An eight hour working day was assumed. Increments were fixed at £5 annually up to the maximum of the class scale, but were only to be granted on a report of satisfactory conduct by the immediate superior and the Secretary. Inter-class promotion was to be based on merit, not seniority, and termination of employment could be applied to any clerk on three months notice. No right of pension was available but in the case of "... prolonged and meritorious service ..." some retiring allowance might be made from the grant. The allowance for each hour of "... extra attendance ..." was to be at the rate of one eighth daily salary, whilst after 5 pm an additional half time allowance would be given for each hour. On Sundays two hours were to be paid for, in addition, at the ordinary hourly rate, the remaining time at double the ordinary rate (548).

A "feel" for the status conferred by these salary levels in the class conscious society of late Victorian Britain can be obtained from a number of sources. Geoffrey Best's authoritative work on the period quotes an earlier book by R.D. Baxter which observed that

"... the upper middle class professional man or tradesman might live in a house at £50 rent and keep 3 women servants (on a salary of) £500 ... the clerk at £99 ... without any resident servant in a house at £15 rent ... in London ... would look very lower lower middle class indeed, and would scarcely guarantee respectability. £300 was ... a small mercantile income ... (and) did not carry a man far up the slopes of gentility. In industrial terms ... it would afford only 2 servants and a house of about 7 rooms; in London ... it would not stretch even to that ..." (549).

Donald Read also quotes Baxter, although from a different work, as estimating the numbers of the upper and middle classes in England and Wales at 4,870,000 and the "... manual labour class ..." at 16,130,000. The upper and middle classes included 2,053,000 income earners, and of these

"... 7,500 ... enjoyed 'large incomes' over £5,000/annum; another 42,000 had £1,000 to £4,999; 150,000 possessed 'middle incomes' of £999 down to £300; whilst 850,000 had 'small incomes' of £100 to £299. About another 1,000,000, though middle class, fell below the income tax threshold of £100 ..." (550).

Baxter was here equating the "middle class" with "white collar" workers.

Read goes on to mention that that indisputable authority Mrs. Beeton

"... suggested that an income of £1,000 a year could support a cook, upper housemaid, nursemaid and under housemaid, plus a male servant; £750 a year justified employment of a cook, housemaid, nursemaid and footboy; £500 a cook, housemaid and nursemaid; £300 a maid-of-all-work and nursemaid; and £200 a maid-of-all-work plus 'a girl occasionally' ..." (551)

A major innovation during this period was the full entry of the Office into the "... general mania for examining everything by means of written answers to printed questions ..." (552). The examination system, spawned

by Northcote and Trevelyan, nurtured by the Society of Arts, the Science and Art Department, the City and Guilds and many others, had greatly reduced the role of patronage in public appointments - although it was seemingly evident in Scott's attaining the Directorship in 1867 (see p. 70 above) (553). The immediate cause of the introduction of this type of competitive entry into the Office was the resignation through ill-health of a 4th class clerk, E.G. Aldridge, in Jul 1886. The Council resolved "... that an examination be held of the candidates approved by the Chairman and Secretary ..." and this was duly conducted on 21 Dec the same year. Papers were set in five subjects - writing, dictation, drawing (freehand and isobars), *geography and arithmetic*. Six candidates were admitted. There is no mention of any advertising of the vacancy and the examination was exclusively internal, all the examinees being temporary assistant clerks within the Office (554). The successful candidate was C.W. Heinemann, whose salary was raised to £60 per annum (from 18/6d per week) as from 1 Jan 1887 with a first increment of £5 due in Apr 1888. Second was H.J. Griffith, who was "... decidedly better ..." than the other four and who apparently left the Office soon afterwards (555). The following year these four others contested a similar examination. All four finished above the first timers and one, L.H. Powers, was declared successful although his starting salary on promotion was only £55 per annum, £5 less than Heinemann, probably due to his being more junior at the time of promotion although this was not specified. Competitive entry into the classified grades had become the norm (556).

9.8 The Council and the Meteorological Office

Soon after the Council assumed control a number of administrative changes were made in the position of the Office vis a vis the Government service. The accounts were to be rendered quarterly (instead of annually) and the

grant was to be made similarly in four quarterly payments, on application by the Council. The Board of Trade remained as the channel of contact and it was decided that the Office's annual reports should be rendered to co-incide with the Governmental financial year ending on the last day of March (557). The Treasury was insistent that the reports should continue to be made to the Royal Society, thus retaining the "marked distinction" between the Meteorological Council and a Government Office, although Treasury control in quite minor matters was still evident. An application by Scott to the Stationery Office for the loan of a typewriter was refused by the Treasury unless "... absolutely requisite ..." (558). Strachey was out of the country for a prolonged period from 1877. The Council wished to retain his services and an ad interim appointment was made to fill the temporary vacancy. This brought Lieut-Gen Sir John Henry Lefroy, an artillery officer, magnetician and former Governor of Bermuda (and afterwards of Tasmania) on to the Council for a while (559). Strachey had returned in place of Lefroy by 1879 and when Smith died suddenly four years later (see p. 160) was ready to succeed him as Chairman, a position he was to hold for the remaining 22 years of the Council's existence.

The final recommendation of the Treasury Committee was to call for another inquiry to be held after a further five years. Sharp on schedule, a few months before the end of the fifth financial year following the Committee's Report, the Treasury contacted the President of the Royal Society who at that time was Spottiswoode. The Society was referred to the above recommendation and asked to advise on the desirability of any changes in the working of the Meteorological Council. Spottiswoode asked the Council to comment and Smith responded quickly (560). He made seven points. The first two referred to the growth in international co-operation within meteorology; the Office had been prominent in these exchanges and it seemed desirable to maintain this

position. Problems encountered with the Post Office in the transmission and cost of sending messages took up the next two points; privileges regarding priority for telegraphic and, especially, storm warning messages had been withdrawn and should be restored, charges for transmitted messages were high and a plea for special rates was made. The fifth point related to the cost of supplying forecasts to newspapers, which had outstripped the allowance made in the grant. Point six turned to the lack of superannuation for the staff; the Office required

"... a permanent staff, the adequate performance of whose duties requires special qualifications as computers, draughtsmen, and the like, with, in some areas, considerable scientific knowledge, and long continued experience ...".

Considerations of fairness seemed to require the introduction of a scheme. Smith's final point was to commend the work of Scott, Toynbee and the rest of the Office staff.

Spottiswoode replied to the Treasury on 29 Dec, enclosing a copy of Smith's submission, since this gave "... so clear a statement of the points arising ...", and fully endorsing the whole document (561). He gave especial support to the matter of superannuation since otherwise there could be difficulties in recruiting suitable staff. It was also recommended that the work and constitution of the Office remain unchanged. Lingen replied just two days later, expressing satisfaction with the state of affairs. Whilst having reservations about differential rates for telegrams, he undertook to approach the Post Office about message priorities; the grant of £15,000 was also upped to £15,300 (see p. 153). But the strongly upheld appeal for superannuation was turned down flat (see p. 165) because of a continued unwillingness by the Treasury to take any step that might seemingly "... tend to convert the Council into a department of the civil service, for reasons which have been frequently stated ...". In this matter it was up to the Council to

"... reckon what they can afford to do ..." (562). Lingen's letter was the first indication that the official mind was beginning to regard the position of the Office as reasonably permanent. Indeed its very prompt despatch showed that Treasury thinking now seemed to be taking that position for granted, so eliminating the necessity to show the hesitation appropriate to dealings with something temporary or transient. Previously there had always been caveats about the vote being "experimental". Now the tenor was one of continuing commitment. Even so the possibility of termination was still allowed for, although it was specified that no date for dissolution of the Office should be fixed unless either Government or Royal Society gave twelve months notice of their intention.

A weakness in the position of the Meteorological Council was its lack of legal status, and in business matters it was unable to act independently. This was of little concern in the normal run of activities, but complications arose when the location of the observatory at Valentia was changed in 1891. Suitable premises came available at Westwood House, close to the existing establishment but on the mainland. The exposure was more suitable, and its location would eliminate the inconvenience of having to use a ferry. The lease of Westwood House was held by Trinity College, Dublin, and had 80 years to run. Funds were available to purchase the lease and Scott, who had become aware of the opportunity to acquire the building whilst on an inspection visit, recommended that the move be made (563). The only problem was the Council's inability to enter into a legal contract. After consultations with the Treasury, the Royal Society were approached to act as trustees for the Council and the premises were actually purchased in the name of the Society; but the purchase price (£1,400) and all related expenses were paid by the Council (564). The situation was clearly unsatisfactory and to remove this

anomaly the Council resolved to seek corporate status. The Royal Society were agreeable, and application was duly made to the Board of Trade. A Certificate of Incorporation was granted in Sep 1891 (565).

CHAPTER 10

THE METEOROLOGICAL COUNCIL UNLIMITED

10.1 Corporate status for the Meteorological Council

The first Annual General Meeting of the Council under its new constitution was held on 18 Nov 1891. The Memorandum of Association showed the name to be "The Meteorological Council", with a registered office in England. The objects of the Association were listed as:

- "(1) the administration of the Parliamentary grant;
- (2) the management of the Meteorological Office;
- (3) the doing of all such things as are incidental or conducive to the attainment of the above objects, provided that the Association shall observe any lawful conditions or directions imposed or given by the Lords Commissioners of the Treasury as to the administration of the said grant or the form of receipt to be given for payment of it".

In the event of the Association being wound up the liability of the individual members was limited to £1, but by licence of the Board of Trade the word "Limited" was omitted from the name.

The articles restricted the number of members of the Association to not more than ten, these being the members and Secretary of the Meteorological Council. The members of the Council were admitted by reason of nomination by the Royal Society except for the Hydrographer to the Admiralty, who was a member ex officio, and the Secretary, who was appointed by the Council. The Chairman was nominated by the Royal Society. The Association was constrained to submit an annual report to the Royal Society for presentation to Parliament. The annual estimates still required Treasury approval, and the accounts were to be submitted

to the Treasury for audit after examination by two members of the Association. These administrative details were, of course, in line with the Council's current practice (566).

The members of the Council, who now also formed the new Association, were showing several changes from its earliest days. They were Lieut-Gen Strachey, as Chairman, and also Francis Galton from the original Council, whilst Scott was also there as Secretary. Capt W.J.L. Wharton, R.N., had replaced Evans as the Hydrographer in 1884 (567). Of the remaining members E.J. Stone, the Radcliffe observer, had been appointed following the death of Smith; Prof G.H. Darwin had replaced De La Rue, who retired due to pressure of business in Jan 1885; and the indefatigable Alexander Buchan, Secretary of the Scottish Meteorological Society and the Council's inspector for Scotland, was appointed to the Council when Stokes resigned in 1887 (568). The latter was an imaginative appointment but it somehow failed to alleviate the cross-border arguments that continued to bedevil the world of meteorology (amongst others) as will be seen later. On joining the Council Buchan was given the reasonable indulgence of only having to attend half its meetings to qualify for full payment; he also retained his salary as an inspector (569).

The changes to the Meteorological Council's constitution had no effect on the day to day operations of the Office. Purchase of the lease of Westwood House - the original cause of the changes - went ahead smoothly enough, although there was disagreement with the Knight of Kerry over the "dilapidations" caused at the former site (570). Negotiations with the Knight and his representatives regarding the cost of repairs dragged on for some months (571). Eventually a settlement of £93 was agreed plus a £10 fee to the umpire who had been appointed to arbitrate (572). A second disagreement, this time with Messrs. Few, the solicitors acting

for the Council over the purchase of Westwood House, was settled more arbitrarily. Few forwarded a bill of costs totalling £78-10-1. The Council instructed Scott to remit £60 in full settlement. Few accepted without demur (573).

10.2 The National Physical Laboratory

The Devonshire Commission and its direct effects upon the Meteorological Office have already been noted in some detail (see pp. 116-121). The influence of the Commission was wide ranging, and the climate of opinion it helped to create had far reaching effects on many parts of the British scientific world. Calls for greater Government involvement in science increased and, in particular, the new magazine Nature, and its campaigning editor Norman Lockyer, were active in seeking more public funding for scientific projects (574). One identified need was for a national standards laboratory on the lines of the Physikalische Technische Reichsanstalt established by the Germans at Charlottenburg in the mid-1880s. Considerable pressure was put on Government by the British Association and a committee was set up under Lord Rayleigh to advise on the problem. This eventually led to the establishment of the National Physical Laboratory in 1900 (575).

That a new institution devoted to physical science would have some sort of impact upon the Meteorological Office was obvious. The extent of that impact very quickly became clear. It was planned to base the Laboratory on Kew Observatory, which was to be extended with the aid of a Government grant of up to £12,000. Official notification of this new role for Kew came to the Meteorological Council via a Royal Society letter. Enclosed was a copy of the Treasury decision to fund the new institution, with a draft reply from the Society for Council comment (576). There were two problems. Firstly Kew was the principal observatory of the

Meteorological Office and its future operation was vital to the observatory programme. Second, the current arrangement between Kew and the Office involved an annual payment to the former. In 1869 this payment was fixed at £650 per annum, made up of an allowance of £250 as an ordinary self-recording observatory plus £400 as the central observatory with a supervisory role over the records of the others (see pp. 101-102). Seven years later this arrangement was modified. Kew relinquished the examination of records from the observatories whilst accepting a corresponding reduction in the annual payment down to £400, this being the retained £250 observatory allowance plus a further £150 for additional services including, specifically, an obligation to ensure that "... a qualified assistant be kept at the observatory ready to be sent wherever his services may from time to time be required ..." (577). The Treasury notification had implied that the annual £400 payment would cease under the proposed arrangement; it also noted that the Gassiot benefaction would yield some £470 per annum to the new laboratory. The Council's reply to the Royal Society pointed out, very fairly, that cessation of their annual £400 payment to Kew would mean an effective increase in their own grant by that amount, whilst the £4,000 granted annually to the National Physical Laboratory would be reduced to only £3,600 for work not hitherto done at Kew. Irrespective of this, and however the sum was apportioned, the Council (with Galton dissenting) favoured the idea of the £400 being given directly to the N.P.L. for the observatory work rather than it being received via the Council. Galton thought that this could be a recipe for future discord (578).

This suggestion was not followed up, possibly in deference to Galton's objections; but further negotiations yielded an amicable agreement whereby the N.P.L. carried out the observatory work as before, and the Council made four quarterly payments of £100 for the services rendered. The Laboratory accepted the obligation to have a qualified assistant in

readiness to proceed wherever required, but only with the strict proviso that the requirement be interpreted to provide for only occasional visits in the case of breakdowns or emergencies (579).

In the event the N.P.L. rule at Kew was to be relatively short lived. Objections by local residents prevented erection of the required additional buildings in the Old Deer Park adjacent to the Observatory. The eventual site of the Laboratory was to be at Bushy Park, Teddington, and the separation of the two meant that supervision of Kew by the N.P.L. made less sense than had been intended. With the construction of an electric railway close to the Kew Observatory itself the site was also unsuitable for atmospheric electricity experiments and intended magnetic work. A new observatory was eventually installed at Eskdalemuir in a remote part of southern Scotland for this purpose, and when this observatory was taken over by the Meteorological Office in 1910 Kew was also transferred to the direct control of the Office for the first time (580).

10.3 Changes to the Council

E.J. Stone, the Radcliffe observer and a member of the Meteorological Council, died suddenly on 9 May 1897. At the next Council Meeting three days later Scott was instructed to inform the Royal Society of the consequent vacancy. By the time of the following meeting on 27 May a letter had been received from the Society nominating William Napier Shaw of Emmanuel College, Cambridge, to fill the vacant post. There were only four members of Council present at this meeting - Galton (in the chair), Darwin, Wharton and Shaw himself. As the latter recalled a quarter of a century later, "... the first resolution I took part in was one of remonstrance to the Royal Society for appointing me without consulting the Council ..." (581).

Shaw had, of course, been associated with the Meteorological Council since the days of his involvement in hygrometric investigations on their behalf some seventeen years earlier (see pp. 148-149). After this somewhat unwelcoming start as an actual member of the Council he became a vigorous and, at 43 years of age, comparatively youthful participant in its work. Strachey, at 80, was the oldest member of the Council but several of his colleagues were also beyond normal retiring age. Galton was 75 and Buchan 68. Darwin and Wharton were comparative youngsters at 52 and 54 respectively whilst Scott, the Secretary, was approaching the end of his long reign over the workaday world of the Meteorological Office at 64. It is little wonder that some of the Council's earlier enthusiasm had faded. The access of a new mind was a considerable fillip to the body although, perhaps, resented a little by some of the older members. Shaw's first major contribution was to involve C.T.R. Wilson of Cambridge University, a future Nobel Laureate, in an investigation into the causes of changes in the electrical potential in the atmosphere. Wilson's appointment to this work was made after Shaw had consulted Prof J.J. Thomson, and Wilson had himself attended a Council meeting to discuss the proposed investigations. The work was funded by a special grant of £200 from the annual Government contribution to the Royal Society for scientific investigations (582). The debt that meteorology, and especially atmospheric physics, owes to Wilson is immense and Shaw's encouragement at this stage in his career was probably a not insignificant factor in his contributing so much to the science later.

10.4 End of an era

The question of the Secretary's eventual successor was beginning to loom large on the horizon. Scott's place in the history of meteorology is an ambivalent one and he was to leave a difficult path for the man who was to follow. That he had been a good administrator seems undoubted, and his

regular election as Secretary of various international committees yields evidence that his powers of organization were prized within a much wider context. He was apparently a sociable and, indeed, "clubbable" man, and his letters give evidence of a nice sense of humour. He also showed a very real appreciation for the work of his predecessor, Admiral FitzRoy. But there was a debit side. The earlier hopes that had been entertained for the future of meteorology, and that had been evidenced in the publications of Galton, Buchan and indeed Scott himself, amongst others, had largely evaporated. The advent of the synoptic chart had promised much, but the reality was clearly more complex than the simple movement and extrapolation of surface pressure patterns could encompass. By the end of the nineteenth century, meteorology in Britain had entered a "... Slough of Despond ..." and Scott had lost his active interest in the subject, being content to confine his activities to the administration of the Office. And the structure of the Office itself was not conducive to furthering scientific advance, with the requisite knowledge confined to "... the Olympian heights of the Council ...", whilst the staff who spent their lives in daily contact with the observations were unqualified to promote any serious studies towards a deeper understanding of the weather processes. There were also a number of "... rather serious feuds ..." within the small community of British meteorology, and it is difficult to absolve Scott from at least some of the blame for this unfortunate state of affairs. Shaw thought his "... methodical habits ..." were a contributory cause. Shaw was an indulgent man and he wrote this in an obituary notice where criticism is normally muted, so it would seem probable that the term "finicky" would not be inappropriate to describe Scott's manner in his later years (583).

That Shaw, himself, eventually took on the mantle of Secretary to the Meteorological Council might seem surprising. He already had a distinguished career at Cambridge University behind him, and in 1898 he

was appointed an Assistant Director to the Cavendish Laboratory. His position at Cambridge was assured and the prestige of meteorology at the time was low. From a nonconformist background in Birmingham, where his father was a manufacturing jeweller, Shaw had won a scholarship to Emmanuel College in 1872, graduating with first class honours in both mathematics and natural sciences in 1876 and being elected a fellow of the College the following year. He studied briefly in Freiburg and under von Helmholtz in Berlin, returning to Cambridge as joint demonstrator of the Cavendish Laboratory under Lord Rayleigh (his co-demonstrator was R.T. Glazebrook who was to become the first Director of the National Physical Laboratory). He was elected a Fellow of the Royal Society in 1891. After twenty years at Cambridge the decision to move to a position of doubtful standing must have been a difficult one. He perceived meteorology as a field requiring serious scientific attention if it were to advance, he had become fundamentally interested in the subject through his work for the Meteorological Council, and he probably realized that if anyone was going to do anything about it then perhaps he was the best qualified to do so. He decided to accept the post with some misgiving, but with the determination to give the necessary scientific direction from within that was needed if the Meteorological Office, and meteorology within Britain, was to advance (584).

The approach to Shaw had originally come from Strachey in Jul 1898 (585). During the succeeding year this invitation was apparently endorsed by all the members of the Council individually, with the exception of Wharton. The sudden death of Baillie, the Marine Superintendent, on 24 Jun 1899 introduced a new factor, and at the Council meeting on 19 Jul it would appear that Wharton proposed combining the positions of Secretary and Marine Superintendent into a single post. His intention was that the new Marine Superintendent, when appointed, would also take on the role of Secretary, and apparently this proposal was acceptable to at

least some members of the Council who had earlier given Shaw their private endorsements. On learning the full position Wharton dropped the proposal and went on to consult Shaw regarding the appointment of Capt Campbell Hepworth to the vacant Marine Superintendent's office (586).

Before the change in command took place an Extraordinary General Meeting of the Council was held on 14 Feb 1900 to approve an amendment to its constitution. In future the Secretary would be nominated by the Council and could come from amongst their number. An ordinary meeting followed at which Scott's resignation, as from 28 Feb, was accepted and Shaw's appointment officially confirmed (587). The original intention had been that Shaw would take over on 1 Jan but the necessary approvals were delayed. In consequence Shaw, who had resigned his Cambridge position from 31 Dec, technically spent the first two months of 1900 unemployed (588).

Unfortunately the Registrar of Joint Stock Companies disallowed the newly adopted change to the constitution on a technicality, but further attention to the framework of the Council's management had become necessary anyway (589). The retirement of Scott had reduced the number of members of the Meteorological Council to six since Shaw was already a member. There was a legal requirement for a corporate body to have at least seven members, and Strachey approached the Royal Society to nominate a replacement. The Society responded by suggesting that a committee be appointed to review the Council's constitution - the need for a seventh member was merely to satisfy a legal requirement, and there was a six months grace before such an appointment was mandatory (590).

The committee appointed for this purpose was J.J. Thomson, Schuster, Symons, Strachey, Wharton, Shaw and Sir William Christie, the Astronomer Royal. Their recommendations allowed for up to ten members of the Meteorological Council, one of whom would be the Hydrographer, with the others appointed by the Royal Society (this was no more than a confirmation of the present arrangement). The main change was that five of these members, including the Hydrographer, would be nominated as Directors with the business of the Association managed by the body of Directors. The Chairman would be one of the Directors and be appointed by the Royal Society; the Secretary could be one of the Directors and would be appointed by the body of Directors. The total remuneration of the Directors was not to exceed £1,000, the Chairman to receive not more than £300 per annum, any other Director not more than £125 plus travelling expenses, and the Hydrographer to receive a yearly payment proportional to his attendances. These recommendations were confirmed at another Extraordinary General Meeting, held on 21 Nov 1900, and this time the Registrar's regulations were most carefully observed and the amendments duly came into force (591).

As was later noted:

"Thus was constituted what must be pronounced a singular anomaly - viz., a limited liability company, managed by a Board of five Directors receiving pay out of a grant made by Parliament, appointed by and presenting its annual report to the Royal Society, submitting its accounts for audit to the Controller and Auditor-General, but held bound under its Memorandum and Articles of Association to 'observe any lawful conditions or directions imposed or given by the Lords Commissioners of the Treasury to the administration of the said grant or the form of receipt to be given for payment of it'" (592).

The new constitution allowed for five Directors who would have the same function as that held previously by the whole Council. There were six current members and Francis Galton took the opportunity to tender his resignation. His role in the history of meteorology was prominent, if controversial, but by the turn of the century he had quite lost his earlier enthusiasm for the subject (see p. 187) and, at the age of 79, he was ready to go. The remaining members of Council were reappointed as Directors, whilst the Earl of Rosse, J.Y. Buchanan, of the Scottish Meteorological Society, W.H. Dines, Prof Schuster and R.H. Scott were nominated as members for fixed terms, with the option of re-appointment. It was specified that the members would only be asked to attend one or two meetings a year and would receive no payment (593).

10.5 The Office gets a pension

The Meteorological Office now had a man of scientific attainment at the head of its day to day operations, but much of his early work was necessarily concerned with mundane administrative matters. In particular the question of superannuation for the staff had to be faced at last. Since the Office had separated from the Board of Trade in 1867 the Treasury had consistently refused to entertain the idea that any of the staff might be eligible for Civil Service pensions. In 1882 the Royal Society had given strong support to proposals by Smith for making the Office appointments pensionable, but had met with a very firm refusal from Lingen (see pp. 172-173) and the matter had been allowed to drift over the years. J.S. Harding (senior) and Toynbee were both dealt with in a one-off manner when they reached retiring age, but by the end of the century several of the staff were approaching the end of their careers and something had to be done.

First of all came Scott himself. After thirty three years at the helm he was dealt with as a special case and was awarded a pension of £400 per annum (half his salary), to be paid for out of the annual grant. In order to lower the overall cost of the grant Shaw accepted a salary of only £750 per annum, which was inclusive of his £125 remuneration as a member of the Council. As no additional Councillor was appointed this reduced the net annual cost of the arrangement to £225 (594).

Clearly something more permanent was required for the remainder of the staff. A scheme was outlined to the Royal Society in 1898, with a request that an approach be made to Government for an increase in grant to help finance it. This the Society declined to do since it had effectively been ruled out of consideration in earlier approaches. However they did urge the Council to proceed with the proposed scheme with some urgency, to try to make economies to pay for it, and if the cost was then found to be seriously affecting the Office's work to approach the Government for further aid after a pension scheme was actually in operation. The proposal rejected payment of further pensions directly from the grant or the creation of a provident fund - the first because the small numbers involved meant that annual payments could become too variable for regular administration of a fixed annual grant; the second because of difficulties of introduction into a long established office. The scheme finally recommended was for the Office to purchase annuities for staff as they retired. On the assumptions that an annuity equal to half salary was provided, and that retirements would take place on average once every two years, the cost was estimated at around £750 per annum. This could be allowed for annually and accumulated in those years when no retirement occurred (595).

The scheme was discussed over the following year but not finally adopted until 11 Apr 1900. There were a few changes in the final version. It was specifically stated that retirement would be at age 65, unless specially extended. The annual retiring allowance was not to exceed one half average salary over the last three years of service, and there was to be an absolute maximum of £150 per annum after approved service of not less than 30 years. Evening and Sunday attendance payments were to be included in the computation of salary. There were also provisions for compensating allowances where a clerk was retired early through illness or any other reason except misconduct or incapacity (596).

The first beneficiary of the new system was Richard Strachan who retired in 1900 at the age of 65. His salary at retirement age was £333 and he was awarded an annuity worth £150 per annum (597). Strachan was one of the clerks who transferred from the Board of Trade in 1867. He had served for 12 years as an employee of the Board (9 of them in the Meteorological Department), and for the preceding 5 years with the Admiralty and felt, with some reason, that he should receive a pensionable allowance for this period as well (he claimed a working life of 50 years 3 months in all). Strachan put in an appeal to Shaw, who forwarded it to the Treasury with copies of the relevant documentation and a supporting letter (598). The result of the appeal does not appear to have been recorded although a later reference by Shaw seems to indicate a satisfactory outcome (599).

10.6 Shaw takes control

Shaw's introduction to the Council had been less than welcoming and the introduction he had to his duties at the Meteorological Office itself was scarcely more inviting. In particular Galton was at pains to point to what he regarded as the impossibility of his task (600). Shaw spent his

early months as Secretary making a thorough review of the whole working of the Office, and by May 1900 had produced an unofficial report on his first impressions. This made two main points. First, there was a comparatively large staff of well paid clerks qualified only for routine work, and consequently stifling more wide ranging activities. Second, the Office was out of touch with advances in meteorology and other sciences. His proposed solutions were: (a) to replace some of the clerkships, as they came vacant, by lower paid boys and women, preferably the latter since a higher standard of education could be asked for the same salary; and (b) to use the consequent savings to employ some four "Special Inspectors", preferably new graduates, on a part time basis to undertake definite investigations that were suggested by work passing through the Office in the ordinary way. The report was never published and is not mentioned in the Council minutes, but Shaw circulated it to at least some Council members. Three responses are to hand. Strachey and Wharton had no objections to the ideas in principle, although the former wondered how the staff replacements could be implemented in practice and thought the cost would be too high until this was done; Galton showed a flash of his old enthusiasm and strongly supported Shaw's wish to form a "... special scientific staff ..." (601). And the involvement of trained scientists took a further step forward the following year when R. Waley Cohen of Emmanuel College, Cambridge, was temporarily engaged by the Office to investigate seasonal variations of temperature at the four principal observatories (602).

In his second year as Secretary, Shaw produced another memorandum on the work of the Office and this time he did present it officially to the Council. It was mainly concerned with internal re-organization of some of the routine work, especially in the telegraphic and observatory branches, but it also called for a much improved method of dealing with external enquiries. Ideally Shaw thought there should be a separate

department for the purpose, housed in a large central room containing both library and museum and with a librarian in charge; this was, perhaps, impractical but some provision should still be made within the present accommodation. He also suggested several topics for investigation under the heading of special researches. These included further work on atmospheric electricity; the growth of secondary depressions; earth temperatures; streamlines; and radiation from clouds. He renewed his call for a Special Inspector to carry out some of the research projects mentioned. Most of the proposals were agreed, including the formation of a Statistical Branch for the supply of information to enquiries, although the idea of a Special Inspector was not immediately accepted (603). But Shaw got his way in the end. There is no record of further discussion on the subject, but on 14 Mar 1902 the Chairman and Secretary were authorized to appoint a Scientific Assistant to the Secretary whose duties were to be mainly in connection with scientific investigation. The appointment was to be for one year on probation at a salary of £200 per annum, rising to £300 the following year if re-appointed. The specialist scientific status of the post was emphasized by its lack of any significant managerial role. In the absence of the Secretary executive control was to remain with the Marine Superintendent, and in his absence with the Chief Clerk (604). It was perhaps natural that Shaw should look to the alumni of his former college, and so it was to be Rudolf Gustav Karl Lempfert, formerly of Emmanuel College, Cambridge, and at that time a master of Rugby School who was to fill the first purely scientific post within the Office establishment. He joined the Meteorological Office on 1 May 1902 (605).

One of Lempfert's first tasks was to take over the London fog enquiry from Carpenter, who was unable to continue due to ill-health (see p. 145) (606). But by far his greatest contribution to meteorology at this time was his collaboration with Shaw in a massive investigation of the surface

trajectories of air moving over large distances. Their findings were published in a seminal work that gave "... conclusive proof of (the existence of) Dove's and FitzRoy's two main air-currents, and a new cyclone model ..." although it was a further five years before a more "... generalized, clear-cut model ..." appeared (607). In fact Shaw and Lempfert succeeded "... in establishing the frontal nature of the depression, but did not carry the work through to its logical conclusion ..." because of Shaw's conviction that the origins of a depression lay in the upper atmosphere (608).

The techniques of weather forecasting in 1905 had not advanced since Abercromby's day. Indeed C.K.M. Douglas, one of the best known British synoptic meteorologists of the mid-twentieth century, thought it would

"... be difficult to prove that ... pre-1914 forecasts for 24 hours periods were ... better than could have been obtained by statistical methods based on persistence with some reversion to the normal ..." (609).

Shaw himself was astonished to find little interest in forecasting among the Council members (610). The regular forecasts were still produced by the same forecasters using the same methods as in the 1870s (success rates for warnings and forecasts during the period 1893-1902 are given in tables 10 and 11) (611). Forecasting was still very much a two dimensional problem and significant advances in technique were not really possible until the advent of more information about the structure of the atmosphere in the vertical. This was to follow but the first improvements were to come from further developments in the communications system.

10.7 The expansion of communication and observing networks

That synoptic meteorology can only be as good as its communications is a truism that few people who work in the field would query. The comparative success of weather forecasting in the eastern United States had been, to a very real extent, due to the simple fact that in middle latitudes the normal progression of weather systems is from west to east and America possessed a good network of observation stations linked by telegraph and largely situated to the west of the main areas of population. There was also much more public money available to meteorology than there was in Europe (a comparison of the financial support given to various national meteorological services is given in table 12). To follow the weather systems satisfactorily, and to extrapolate their movements, was comparatively simple and effective when compared to the situation the other side of the Atlantic where the area to the west was a vast expanse of open ocean devoid of observations. Attempts to overcome this difficulty by using the trans-Atlantic telegraph, and even anchored vessels linked to the land network by telegraph, had been tried and found unsatisfactory (see p. 98); but improvements and extensions to the overseas telegraph links were on the way. In April 1898 Capt Chaves, Superintendent of the Observatory at Ponta Delgada in the Azores, attended a Council meeting. He reported that new cables were being laid from America to Europe via the Azores. The Portuguese Government was making the relevant concessions conditional upon the telegraph companies agreeing to transmit meteorological reports free of charge (612). And the opening of yet another line of communication was foreshadowed some six years later when the Danish Government announced that they were making arrangements for a cable to Iceland and the Faeroes. The Council were quick to negotiate for transmission of meteorological reports and the cable duly opened in 1906 (613).

The biggest breakthrough in meteorological communications came with the introduction of the wireless. Again the lead came from the western side of the Atlantic where Reginald A. Fessenden developed a weather radio system in 1902 (614). It was some years before the lower resourced European services could compete, but in 1906 arrangements were made for receipt of weather messages by wireless from Royal Navy vessels (615). A move towards more routine reception of messages came three years later when the Meteorological Office and the Deutsche Seewarte joined in a four month trial programme, with two meteorological telegrams per day being received from Atlantic liners. The first such message recorded was from the Allan Line vessel "Corsican" on 10 Jun 1909, reporting from 51N 15W at 7 am, this was received by the Meteorological Office at 2.15 pm the same day (616).

Routine investigations of the upper atmosphere were slow to get under way in Britain. Manned balloon flights were anathema after the Saladin disaster (see pp. 143-144), but experiments were begun using kites and unmanned balloons both in Britain and Europe during the late nineteenth century, and recording instruments for use in aerological soundings were gradually developed and refined (617). The Meteorological Council showed little interest in participating in any international programme of observations however, and additional Government money was not available. Even a request from the International Meteorological Committee for collaboration in making Cirrus cloud observations was turned down (618). The earliest British work using kites was by E. Douglas Archibald around 1882, but the first systematic programme was due to W.H. Dines who made his initial experiments from aboard a ship off western Scotland in 1902 (619). Dines, and later C.J.P. Cave, commenced an extensive programme of upper air observations soon afterwards. This was carried out privately, although with Meteorological Office backing and support. Work on the upper air was also inaugurated in the north of England by the Manchester

University physics staff under Schuster and Simpson (620). It was Shaw who gave true recognition to the inventive but diffident Dines, and who first realized the value of such instruments as his brilliantly designed pressure tube anemograph (621).

The programme of full surface observations within Britain continued under four quite separate bodies. The work of the Meteorological Office was considerably enhanced in Scotland by the Scottish Meteorological Society, and elsewhere in the British Isles by the Royal Meteorological Society, both societies receiving a small payment from the Office for work rendered on its behalf. There was also Glaisher, who continued to supply observations gratis to the Registrar General. Yet even the remarkable, if irascible, Glaisher had to come to an end sometime and in 1902, at the age of 93, he at last relinquished his self-imposed task (see pp. 163-164). The work devolved upon the Meteorological Office and Shaw took the opportunity to call a meeting between the Office, the two Societies and the Registrar General's Office, to try and get uniformity in the presentation of results (622). Agreement was obtained, but the Scots insisted upon retaining control over Scottish observations (623).

The Scottish meteorologists had always been proud of their complete independence in handling Scottish observations but, although it was still some time in the future, they eventually had to bow to the inevitable and to economic pressures. In 1913 much of the work of the Society was transferred to the Meteorological Office, and the latter opened a special branch office in Edinburgh. Initially the Scottish Society retained its separate identity, and had considerable influence on the administration of the Edinburgh office, but in 1920 even this had to be relinquished and the Scottish Meteorological Society went out of existence, all its records and papers being transferred to the Meteorological Office, Edinburgh, which retains them to the present day. Elsewhere in the

British Isles the observational work of the Royal Meteorological Society had already been absorbed by the Meteorological Office in 1911, but the Society remained firmly in being and it has, of course, retained a strong and vigorous role within the meteorological life of this country (624). The British Rainfall Organisation also maintained a separate identity until 1919 when it was transferred in toto to the Meteorological Office. In taking over this work the latter also accepted the legal obligation of continuing to

"... maintain and develop the system of voluntary observation of rainfall in the British Isles ... (and to) ... continue publication of an annual volume under the short title of 'British Rainfall' ... on similar lines and in similar form and no less complete than ... for recent years ..." (625).

10.8 Formalizing the staff structure

The position of the staff had changed dramatically with the introduction of superannuation, but otherwise their working conditions varied little as the Office moved into the twentieth century. The Shaw re-organization of 1901 improved promotion prospects by creating one new first class clerkship and raising the salary limit on two others. A formal memorandum was also approved by the Council setting out the qualifications required from anyone seeking appointment as a clerk. As well as "... general competence, good character, good handwriting etc ..." knowledge or skill was desirable in (presumably "some of" rather than "all of" although this was not specified): (1) general meteorology and geography; (2) ocean meteorology and practical navigation; (3) foreign languages; (4) telegraphy; (5) shorthand, typewriting, book-keeping; (6) arithmetical computation, including the use of tables and formulae, and of calculating machines and apparatus; (7) draftsmanship; (8) construction and use of meteorological instruments. The salary of a

grade 4 clerk started at £75 per annum with the maximum of the grade 1 scale at £275 and, exceptionally, at £300. Office hours were 9 am to 5 pm (1 pm on Saturdays), with the Forecast Branch working shifts of 8 am to 4 pm and 1.30 pm to 8.30 pm in alternate periods. The holidays were 3 weeks in summer and 8 days (presumably at other times) in addition to public holidays (626). Encouragement was given to staff learning certain additional skills as the establishment became more "mechanised". The Office now had a typewriter and was prepared to loan £5 to staff seeking to become proficient in typing and shorthand (627). Installation of a telephone had to wait a few more years (628).

10.9 The wider aspects

Shaw had maintained the links with the international meteorological world that had been made by his predecessor, although the Council never showed any great enthusiasm for multi-national ventures. He was duly elected a member of the International Meteorological Committee upon becoming head of the Office, which was no more than would be expected, but he also succeeded Mascart when the latter retired as President of the International Committee in 1907 (629). The Office also continued to be active in assisting polar exploration, supplying instruments and collaborating in the working up of results and observations for the various major expeditions that took place around the turn of the century. The "heroic" era of Antarctic exploration was beginning and the Council minutes for this period record work performed on behalf of the Borchgrevink Antarctic Expedition, Bruce's Scottish National Antarctic Expedition and also Capt. R.F. Scott's first Antarctic Expedition aboard the "Discovery" (630).

CHAPTER 11

BEN NEVIS AND THE METEOROLOGICAL GRANT COMMITTEE

11.1 Clement Wragge and the start of observations from the Ben

The earlier disagreements with the Scottish Meteorological Society that led to the Treasury Committee enquiry of 1876-77 had scarcely been resolved, and Buchan had only recently been introduced to the new Council to learn his duties as Inspector for Scotland, when a proposal was received from Milne Home suggesting the establishment of an observatory on the top of Ben Nevis. It took just a fortnight for the Council to turn the idea down flat on financial grounds (631). But the Scottish Society were determined to pursue the project and in 1881, as an interim measure, they secured the services of Mr Clement Wragge to undertake the remarkable task of ascending to the top of the mountain every day over a period of five months, making weather observations at set times and places, including the summit, as he did so. These observations were duly telegraphed to the Meteorological Office and appeared in the Daily Weather Report.

With this achievement under their belts the Society contacted the Meteorological Council again, affirming their commitment to an observatory on the Ben, acknowledging an earlier offer by the Council to contribute £100 per annum towards the running expenses were such an observatory ever erected, and soliciting a contribution towards the expenses of Wragge's work. The Council responded with £100, but insisted that this was a one-off payment and would not be renewed unless a permanent observatory was established. They also indicated that they were trying to assess the possible value of a high level station for indicating changes in the

weather, and asked if there was any information on Scottish weather that might help them form an opinion (632). There is no record of this being forthcoming.

11.2 The foundation of the summit observatory

Nonetheless the Scottish Society determined to press ahead with building the observatory and sought more support from the Council, trying the diplomatic approach to gain it. The Duke of Richmond and Gordon, who was now President of the Society, wrote a personal letter to Smith in May 1882.

Broadly, the Society were preparing to vest the property of the observatory in the Royal Society of Edinburgh as trustees, and to retain its management within the Council of the Scottish Meteorological Society. They wished to strengthen their Council by adding four members, three as representatives of the Royal Society, including the President, and Smith himself as Chairman of the Meteorological Council. The members of the augmented Scottish Council were to become the Directors of the Ben Nevis Observatory. Smith declined the invitation on the grounds that attendance at meetings in Scotland would be "... virtually impossible ..." so he would be unable to participate in any of the decisions regarding the observatory (633).

The remarkable story of the financing, building, maintaining and manning of the Ben Nevis Observatory has been told elsewhere, and is somewhat outside the scope of the present work (634). The formal opening took place on 17 Oct 1883 and the Meteorological Council duly accepted its obligation to pay £100 per annum to help with the running costs. Mr R.T. Omond was appointed as Superintendent of the Observatory whilst arrangements were made with a Mr Colin Livingstone for daily observations at Fort William near the foot of the Ben. Buchan offered to forward the observations from Fort William and the Ben by telegraph as required, and also to supply any

other information that might be wanted by the Meteorological Office, but the Meteorological Council declined the provision of regular telegraphic reports. The cost of receiving three reports per day would be £120 per annum and this might not be justified. However Omond was requested to send occasional telegrams to the Office when any striking change of conditions or phenomenon of great interest occurred (635).

11.3 Early troubles

The wording of these letters was courteous and helpful, but in less than three months the tone of the exchanges had altered. On 15 Jan 1884 the Press Association issued a circular stating that they received the only telegraphic reports from Ben Nevis Observatory and would be willing to take subscriptions for the supply of information. Some two weeks later a letter arrived from Buchan, officially notifying the Council of an agreement made by the Scots to supply observations from Ben Nevis to the Press Association. Scott immediately queried the Office's position and, in reply, Buchan asserted that there would be no interference in the receipt by the Office of telegraphic information from the summit. Scott was next instructed to ask the Press Association for an explanation of their circular and he received an uncompromising reply. The Association's agreement with the Scots gave them exclusive rights to immediate publication of the Ben Nevis reports; they had no objection to the information being used for scientific purposes but "... under no circumstances ..." could they agree to its inclusion in the Meteorological Office compilations issued to the press. Scott replied that this was "... distinctly contrary ..." to the arrangement between the Office and the Scottish Society, and also sought urgent clarification from Buchan. The latter's response, dated 19 Mar, pointed to the Council's earlier disinclination to receive regular reports on the grounds of expense. The arrangement over occasional reports of striking changes or phenomena of

great interest stood, and the Meteorological Office were at liberty to publish these as they wished. The Scottish Society had been inundated with requests for information from the Ben Nevis Observatory and the Press Association had offered £100 annually for the 9 am and 9 pm reports to be telegraphed daily; this might increase in future years and the Directors of the Observatory felt they could not afford to turn down such a source of income. Presumably the Council were satisfied with this reply because they promptly approved the £100 grant to the Observatory for the year 1883-84 (636).

11.4 The rift widens

The satisfaction was short-lived. On 14 Apr 1884 Scott again wrote to Buchan. He had just received a letter from Omond who claimed to have been instructed by the Directors of the Observatory not to send reports of changes until the day after the change had occurred. This clearly destroyed any possible operational value the reports might have and Scott wished to query Omond's instructions. No reply had been received by 2 May, so Scott wrote again requesting a response by the 7th in time for the next Council meeting. When it did come it was actually dated 14 May. It was also lengthy. Buchan started by expressing thanks for the £100 received for the year ended 31 Mar 1884. The instruction, which Omond had interpreted very rigidly, told him "... not to send telegrams to the Meteorological Office which might anticipate by publication the information sent to the Press Association ...". It had been issued because of representations from the Association concerning telegraphic weather reports from the Ben, which were occasionally published by the Meteorological Office prior to their own receipt of the daily reports. Buchan re-iterated at length the reasons for the agreement between the Scottish Meteorological Society and the Press Association, and pointed out that when the Directors of the Observatory had agreed to provide reports of striking changes they

thought it was to enable "... such observations ... to be scientifically studied ...". There had been nothing to show that the Office intended to publish them immediately either "... in a bare form ..." or as inferences arrived at from the data. This was at some variance with his earlier letter of 19 Mar which gave specific permission to publish (see pp. 198-199). Buchan also commented on statements in Scott's letters of 23 Feb and 31 Mar that the Council's annual £100 contribution to the Observatory was dependent upon their being able to publish observations. He pointed out that this had never been a condition of the payment, which had been agreed "... only subject to the Government paying ... (the Meteorological Council) grant ...". And he went further - the Directors of the Observatory wished him to say that it seemed "... only right that the annual contribution from the Council should be increased to £300 ...". He also asked that direct communication between the Meteorological Office and the Observatory be restricted to requests for explanations of transmitted observations. Finally the Scots offered to appoint a deputation to confer with the Council over their future relations (637).

Feelings were getting ruffled and some of the actions of both sides began to lack somewhat in tact. At the Council meeting on 21 May 1884 Scott reported having received a long telegram from Omond concerning the weather on Ben Nevis during the previous two days and had immediately written to Buchan to discontinue such late telegrams, which would be cheaper sent by mail. Simultaneously there was an argument going on between Scott and Buchan concerning the quality of observations received from the Scottish Meteorological Society. A letter from Scott dated 5 May made the bald statement that "... the observations are bad ...". Buchan's reply went into some detail over barometrical observations at five stations that the Meteorological Office had thought to be wrong. The Office had in fact pointed out 28 errors. Buchan claimed that they were mistaken in 20 of these and correct in 7, with one being doubtful. If they had made the

corrections proposed then three new errors would have been introduced for every one taken out. The tone of the exchanges showed apparent ill-feeling between the two men with nit-picking evident on both sides (638).

11.5 The Scots in the ascendancy

The Meteorological Council considered Buchan's 14 May letter on 25 Jun. Their position was a weak one. The Scots had, perhaps, moved the goalposts regarding the Council's right to publish observations received from the Ben, but there was no doubt that the conditions laid down by the Council for their contributing an annual £100 to the Observatory had been met. It was also clear that, at least for the moment, the observations from Ben Nevis were a saleable commodity. The Scottish Society was well placed to exploit the situation, and seemed intent on making the most of it. The Council had certainly understood that the information would be at their disposal to use "... as they thought fit ...", and again spoke of withdrawing the annual grant if this condition was not met; but the understanding had only been implied, and there had never been an explicit commitment by the Scots. The Council's position had been further eroded by their refusal to accept the offer of regular daily observations before the Press Association agreement was made. Their eventual response to Buchan was lengthy but lacking in substance - it could impolitely be described as regurgitated waffle - and was never likely to influence the Observatory's Directors. It was perhaps through pique that Scott was instructed to forward his own rejection of Buchan's defence of the Scottish observations together with the Council's reply (639).

The Directors of the Ben Nevis Observatory considered the reply on 4 Jul. They regretted the failure to comment on their own offer to appoint a deputation to discuss future relations, and emphasized the unconditional nature of the Council's obligation to contribute £100 annually to the

Observatory. The idea that payment of this sum should be dependent upon receipt of observations for publication was firmly rejected - such an arrangement would make the Observatory "... a mere observing station for the Meteorological Office ...". Nonetheless they wished to co-operate with the Council, insisting only upon the Press Association's right to prior publication for as long as their agreement was in force. The Directors would regard any discontinuance of the £100 grant as "... injurious to the country and to science ...". The relevant extract from their minutes was forwarded to Scott, but by the time it arrived the Council had gone into a prolonged summer recess, with no meetings being held for four months. It was eventually considered on 12 Nov, together with an extract from the minutes of the October meeting of the Directors at which a new arrangement with the Press Association had been discussed. Comment was invited from the Council. This extract had accompanied a letter from Buchan re-affirming the Scottish belief that £300 would be a more appropriate annual contribution to the Observatory. If such a sum should be forthcoming then the Directors would supply whatever was required in the quickest way available (640).

Undoubtedly the Directors of the Observatory realized that they had control of a commodity desired by a number of bodies, and their approach tended more towards the law of the market place than to the ideal of free scientific interchange. Opportunism and the wider public interest are frequently in conflict and the Directors seemed to be taking the narrower view. This was obviously to their advantage in the short term but it may well have been remembered later, when they were themselves seeking succour from others, and might have made that help just a little harder to obtain.

11.6 Conciliation - and a new disagreement

The Council had to accept the situation and gave way on almost all the points at issue. On 26 Nov they resolved to continue with the annual £100 to the Observatory and undertook "... not to publish ... observations, or to refer to them ... in a form ... prejudicial to the interests of the Press Association ...". They did at least hold firm in not actually increasing the grant although they thought it judicious to express regret at not doing so, and asked to be kept informed about any changes in the arrangements (641).

On that conciliatory note the issue went to sleep for a while, but the Meteorological Office had been monitoring the operational value of the Ben Nevis telegrams for forecasting purposes and Gaster produced a report on their findings in May 1887. The period he considered was for the whole of 1886 plus the first four months of 1887. During that time 86 warnings were issued by the Office to the Scottish coasts, but only 19 telegrams were received from Ben Nevis. Of these 17 had arrived after a warning had been issued and the other 2 "... in no way influenced ..." the decision to warn. Gaster noted that the Ben Nevis observations were being investigated by Buchan and commented on the possibility of this eventually resulting in a system of benefit to the Office, but at present the telegrams were giving "... no assistance ...". A copy of Gaster's report was forwarded to Scotland and produced a prickly and somewhat evasive reply from Buchan. This seemed to imply that because there was no specific mention of storms in the Council's request for occasional messages of significant changes, then the latter could not be expected to give any assistance in forecasting them (642).

The reason for at least some of Buchan's ire soon became apparent. The original draft of Gaster's report had been forwarded to Scotland. This described the signals as "... absolutely useless ...". A copy of the same draft had also been provided to the Treasury and was quoted by the Financial Secretary, William Jackson, in replying to a House of Commons question during the debate on the Meteorological Office vote. A profuse apology was forthcoming and the offending words were withdrawn. It was claimed that a correction had been made prior to the letter being despatched, but the unaltered draft had then been sent in error. The correction had changed the original undiplomatic wording to the somewhat blander statement that the summit observations gave "... no assistance ..." in the forecasting of storms. The apology was followed by an expression of the Council's wish to assist the work on Ben Nevis as much as their resources might allow; they would "... take an early opportunity ..." to address the Directors on the subject (643). A copy of this letter was also forwarded to the Treasury. A further olive branch was offered when Buchan was appointed as replacement to Stokes when the latter resigned from the Meteorological Council (see p. 176).

11.7 The Fort William Observatory

The appointment of Buchan led to an immediate improvement in the lines of communication. The Council learned of the prospects for establishing a permanent recording observatory at Fort William. This would give better facilities for comparing conditions at the summit and foot of the Ben and its scientific value was accepted. Granted that such an observatory was in fact erected, the Council offered to supply and install in it the recording instruments from the old Armagh Observatory, and also to provide an annual grant of £250 towards its maintenance, on the same general terms as were applied to Falmouth. This grant could not be pledged indefinitely but would be continued, as far as possible, for at least five years, on the

understanding that at two years notice the arrangement could be terminated or modified, and always dependent on the annual Meteorological Office grant being received from the Treasury. The £100 grant to the summit Observatory would be continued under the same terms as before. Not surprisingly this offer was accepted with alacrity by the Scots, provisional upon funds becoming available to build an observatory at Fort William. There was expectation of a surplus from the forthcoming Edinburgh International Exhibition and this might well be applied to the purpose (644).

Confirmation that £1,000 would in fact be made available from the surplus funds of the Exhibition came early in 1889. The building of the Fort William Observatory was to go ahead and acceptance of the Meteorological Council's offer was confirmed (645). The Observatory became fully operational on 14 Jul 1890 (646).

11.8 Financial problems

The Ben Nevis Observatories operated in tandem for several years but cost of upkeep became a recurring difficulty. By 1898 the financial position had reached a critical point, and in August of that year the Meteorological Council was officially informed by the Treasury of their imminent closure. If any public funds were to be made available they would have to come from the Council's own grant. The Council was in the middle of organizing its superannuation scheme (see pp. 184-187) and made clear its complete inability to allow for additional expenditure on behalf of Ben Nevis. The Treasury was equally clear that there was no more public money on offer (647). The situation appeared desperate but the date of expected closure was to be extended by one year with the aid of a £500 donation from Mr Mackay Bernard of Kippenross, a brewer by profession and a keen amateur meteorologist (648).

It was obvious that the Scottish Meteorological Society had been far too sanguine about their ability to supply the ongoing funding necessary once the observatories were in full operation. As a minimum requirement they now sought to extend the period of combined observation by the two observatories to ten years, and made a somewhat optimistic appeal to the Council for a grant of £1,000 in order to keep them going until the autumn of 1901. It was a hopeless request and the Council almost inevitably turned it down, although they agreed to maintain the annual £250 grant to Fort William until that time. They also gave formal notice that the grants would then cease. However Scott did make one more unsuccessful attempt to obtain further funding from the Treasury, pointing out that the Meteorological Council could do no more to help unless their own grant was increased by £1,200 (649). A desperate final bid came when the Scots approached the Treasury direct with a request that they increase the Council's grant so that the latter would be able to help in further financing of the observations, but the Treasury's attitude remained unyielding. At this point Mr. Mackay Bernard fortunately proved even more prodigal producing a further £500, sufficient to carry the full programme on for a further year (650).

Further donations from Bernard and from a number of anonymous donors eventually enabled the observatories to be funded up to 1902, and with this outside assistance the Council continued with their grants. But that was to be the limit of their commitment, and the Directors of the Observatories were again given notice that the grants would terminate, this time in Dec 1902. A further and final extension came with the appointment of the Meteorological Grant Committee in Dec 1902 (see p. 208), the Council agreeing to continue with their funding until the Committee had had time to report (651).

The whole affair had become too big for the Council to handle. The interests of the Scottish people, who had donated generously to the appeal for funds to erect an observatory on the summit, and the sense of national pride engendered by its very existence, had all become entangled with the more mundane issue of its objective scientific value. This made it wholly unrealistic for the Meteorological Council to be considered responsible for funding from a limited grant. The observatories had never been a part of the Council's programme and it would have completely distorted the whole work of the Meteorological Office if they had contributed realistic sums towards their full maintenance. That there was value in the investigation of meteorological condition on the top of the country's highest mountain is probably true, but the Scottish Meteorological Society appears, not for the first time, to have been at least partially motivated by patriotic fervour.

This obscured more sober judgments, and they did not plan for the future financing of the project in any realistic way. Opinion upon the value of the actual observations would seem to have been split largely on nationalistic lines, with the most eminent of scientists showing signs of being influenced by other than purely objective criteria. Lord Kelvin, a Scot, a Director of the Ben Nevis Observatories and a member of the Council of the Scottish Meteorological Society, was stout in his defence of the observatories and expressed himself as in complete agreement with a statement that they "... were of the highest utility in the development of meteorology and in framing forecasts of storms and weather ...". Sir Arthur Schuster, from a less committed background, having been born in Frankfurt the son of a German Jew who migrated to England to escape the Prussians at the end of the Seven Weeks War, thought that by 1903 "... the problems which could with convenience be carried out at Ben Nevis Observatory have been dealt with ...". But, of course, he was not looking through Scottish eyes (652).

11.9 The Meteorological Grant Committee

If scientists could not agree about science then there was little hope for the politician. The agitation from Scotland was too strong for the Government to sweep under the carpet and so they did the next best thing. For the second time in its history the Meteorological Office found itself at the focus of a Parliamentary Committee of Enquiry, inaugurated by the Treasury, and resulting from the actions of the Scottish Meteorological Society. On 9 Dec 1902 the Meteorological Grant Committee was appointed

"... with instructions to inquire and report as to the administration by the Meteorological Council of the existing Parliamentary grant, and as to whether any change in its appointment is desirable in the interest of Meteorological Science, and to make any further recommendations which occur to them with a view to increasing the utility of the grant ..."

(653).

The Committee reported on 16 May 1904. Its recommendations were not unanimous and a full account is beyond the scope of the present work. Needless to say that the report forms yet another invaluable document for the meteorological historian. The results of the inquiry were far reaching. Its first two recommendations were the most important. Registration under the Joint Stock Companies Act should be cancelled and the Office reconstituted as a department under the Board of Agriculture and Fisheries; and the Council should be abolished and the Office placed under the executive control of a man of science as Director, who would be responsible to the Board of Agriculture and Fisheries and assisted by an advisory board (654).

11.10 A new regime and the end for Ben Nevis

Action was taken on both recommendations, but only partially in each case. Moves to end the anomalous position of the Office in relation to the Companies Act were promptly forthcoming, but the earlier reluctance by the 1877 Treasury Committee to see the Office resume as an integral part of the Civil Service was repeated (see p. 136). The Council was, indeed, abolished and the overall management vested in a Meteorological Committee consisting of the Director of the Office as Chairman, two members nominated by the Royal Society, the Hydrographer of the Navy ex-officio, and one member each appointed by the Board of Trade, the Board of Agriculture and Fisheries, and the Treasury. The members of the Meteorological Committee were to be unpaid and meet not less than four times a year, with the Director responsible for administration of the Office. These changes put the Director in a much more powerful and independent position than the Secretary had held formerly, and this was reflected in a salary scale rising from £800 to £1000 per annum after five years. The grant-in-aid was unchanged at £15,300 per annum and was to be administered by the Committee, who would have the power to delegate at their discretion to the Director. With the consequent savings resulting from the reorganization there would be around £1,400 per annum extra for the actual work of the Office. Staff were to be appointed by the Committee on the recommendation of the Director. Appointed as Members of the Meteorological Committee were:

Dr W.N. Shaw, F.R.S., Director (on salary scale maximum)

Capt Arthur M. Field, R.N., Hydrographer to the Navy

Capt A.J.G. Chalmers, Professional Officer, Marine Department,
Board of Trade

Dr W. Somerville, Assistant Secretary, Board of Agriculture and Fisheries

Prof G.H. Darwin, F.R.S., University of Cambridge

Prof A. Schuster, F.R.S., University of Manchester

Mr G.L. Barstow, nominated by the Treasury (655).

The future of the Office at last saw the direction of its daily operation come under the control of a leading scientist who had a fair degree of autonomy in steering its work along the paths of his choice, subject to the requirements of the public interest and the overriding fiscal constraints. Within ten years the emergence of aviation and the outbreak of the First World War were to have dramatic effects upon the perception of meteorology and to the level of resources allocated to it. Shaw was able to use his enhanced powers to good effect and the Meteorological Office grew rapidly in size and scientific stature over the succeeding decades, but the story of that growth will have to wait a further work on the subject. Transfer of control to the new Meteorological Committee was originally scheduled for 1 Apr 1905, but in the event the Committee did not actually meet for the first time until 31 May, the final meeting of the Council being held on 12 Jul (656).

The outcome for the Ben Nevis Observatories was less satisfactory. The Meteorological Grant Committee had remarked that apparently only £350 per annum was required for their maintenance and "... every effort should be made to provide this sum ..." (657). Somewhat surprisingly the Treasury relaxed their earlier attitude and agreed to place £350 at the disposal of the Scottish Meteorological Society annually for the Observatories (658). But the Directors of the Observatories had at last realized the full scale

of a commitment to keep them open. Unless the full cost could be covered there was no alternative to closure. The sum required was approximately £1,000 per annum. It was a bitter pill for the Scots to swallow but there was never any hope that the Treasury would agree to such a level of expenditure. A decision to close the observatories in Oct 1902 had originally been taken in June of that year, and this was later extended by two more years (659). Final confirmation of this latter date was given on 24 Mar 1904 and the later change of attitude by the Treasury was well short of what was required for its reversal. The last observation from the summit was made at noon on 1 Oct 1904 (660).

CHAPTER 12

SUMMARY AND CONCLUSIONS

12.1 The early background

The Meteorological Office or, more strictly, the Meteorological Department of the Board of Trade, had been born into a period of British history that was in many ways unique. It was a period of relative peace, of rapidly increasing population and of growing prosperity (661). At a time when much of continental Europe was recovering from the traumas of 1848 England was entering what W.L. Burn termed "the age of equipoise", a span of roughly a generation between about 1852 and 1867. This

"... was not the same England as that of 1842 or 1872. Something of the passions ... which had found expression in Chartism ... (and) the bitter controversies over the Corn Laws ... had abated ... (and) there was less of that single-minded vehemence which characterized and perhaps nearly destroyed an earlier England ... But in 1867 ... the surface of things could be seen as almost intact. The England of ... the upper-middle class ... where purchase of commissions had ceased ... and talent counted for rather more than birth and connection, was still a little distant" (662).

It was within this developing world of expansion and increasingly meritocratic competition that the Meteorological Office spent its earliest years. Its evolution was closely associated with contemporary attitudes towards the rapidly increasing scientific activity of the latter half of the nineteenth century, and neglect of its story by science historians is surprising (663).

The original decision to found the Department appears to have been made on a purely ad hoc basis. It was one of a number of solutions to specific problems that arose in the mid-nineteenth century as expansion and technology began to overtake the infra-structure of a less complex age (664). The Department's responsibilities were limited and the type of science it was intended to pursue strictly circumscribed. Had a more emollient character than FitzRoy been given command then the whole history of British meteorology would have been different. The statistics produced by the Department were of value to navigators but FitzRoy's vision sought a much wider role, and by influence, circumstances, and sheer strength of character, he was able to break the bounds of his original brief and obtain authorization for a pioneering venture into the provision of storm warnings for shipping. His later extension of this practice to include the issue of routine forecasts was, to his eyes, a mere extension of the warning service although he never received official sanction to do so. The financing of the infant Department was largely constrained within the Board of Trade vote, but there was an additional allowance from the Admiralty during the early years and small sums were charged for the sale of publications and instruments (665).

12.2 The Meteorological Committee in theory

The aftermath of FitzRoy's suicide and publication of the subsequent Galton Report led to a complete transformation in the nature of the Meteorological Office, the name given to the Department following its divorce from the Board of Trade. The change was led by Galton and Sabine with the Royal Society as the medium. The governing Meteorological Committee was made up entirely of Fellows of the Royal Society who gave their services gratis in the interests of science. In fact the original concept of the Committee was rather a cosy one. The Galton Committee and the Royal Society between

them had persuaded Government to provide a substantial sum annually for the study of meteorology, and the architects of the reorganization saw no reason to expect significant outside interference in the way they used it.

The situation was markedly different from that which had existed in 1854. Then the call to fund work on marine meteorology had been overtly based on possible commercial advantage to the world's largest maritime power, whatever the private wishes of some of the men calling for that funding might have been. FitzRoy's concern for his fellow mariners had deflected a considerable portion of the funds away from their original purpose and into the cause of community service. His main opponents came from amongst the ranks of the scientists themselves. One of the most obdurate had been Francis Galton, and when he was nominated as chairman of the committee appointed to investigate the Meteorological Department he was able to guide it into making a recommendation that the steps of the new Office should be turned more towards the path of pure scientific rectitude. The Meteorological Committee did retain a commitment to compilation of marine meteorological statistics (although Galton did his best to relinquish it), but the apparent upshot was a gain of substantial Treasury backing for an experimental arrangement which left them free to pursue their investigations of the weather over the British Isles, using the proposed chain of observatories, without the requirement for any other public duty.

12.3 The Meteorological Committee in practice

The cosiness disintegrated immediately under the weight of protest that followed cessation of the storm warnings. The failure to foresee this chorus of dissent is not less than astonishing, and provides ample testimony to the myopia that can afflict more theoretically minded scientists when confronted by unexpected practical applications of their work. Less excusable was the indifference of government officials, who

acquiesced in the cessation of a service of proven value without making allowance for the possible consequences of that cessation to its users. This was a classic case of how insufficiently thought out and, indeed, irresponsible reduction of government involvement in public activities can lead to complications far outweighing the gain from any marginal reduction in expenditure.

The first months of the Meteorological Committee must have been disturbing. The controversy over warnings had actually been instigated before it came into existence but its members had to bear the full brunt of the pro-warning lobby's fury. Simultaneously they were engaged in a wrangle with the Treasury over the amount of their funding. The removal of the Office from within the Civil Service in 1867, and its financing by a grant-in-aid, coincided with a period of concern in official circles over the cost of science and the growing expectation that this should be met through public funds. The Treasury did not relish the prospect, and the proposed meteorological vote was an appreciably large one. There was anxiety about its possible ramifications, especially as the responsible officers did not have the expertise to make rational decisions about scientific projects. The British education system was not geared to producing administrators who were knowledgeable about science, and the state of panic engendered within the conservative portals of the finance departments is not difficult to imagine. Roy MacLeod has given a perceptive account of the poor official's plight (666). Repeated Treasury insistence that the Meteorological Office vote was only experimental, and that under no circumstances could its staff be considered as Civil Servants, doubtless stemmed from a desire to limit the possible repercussions of an over ready allocation of funds to these "mysterious" purposes.

The Office did obtain a small income from sales of daily and monthly weather reports and other publications, but its prices were not economic and no attempt was made to operate as a commercial concern. Charges were levied for certain services, such as extraction of records, but these were arranged entirely on an ad hoc basis and the sums asked were only aimed at covering the costs of extra staff time that had to be worked. Similarly, a charge made for the harvest forecasts from 1899 was restricted to covering the cost of the relevant telegrams. The whole of the financing of the Office's routine services had, therefore, to come from its grant and this was increased from time to time as commitments grew, the provision of regular evening forecasts for the morning editions of newspapers being a case in point (667). (Average expenditure for the periods 1870-1875 and 1898-1903 is shown in Tables 13 and 14).

12.4 Public money, science and scientists

That money was always available for meteorology in such relatively full measure is, prima facie, surprising. Clearly the internal Treasury feeling was hostile but approval seems to have come from higher levels. A popular conception of the Victorian era is that it "... came as near laissez-faire as has ever been practicable in a modern state ..." (668). But, as has been noted earlier (see p. 28), this is a gross over-simplification of the reality. The requirement for publicly funded services was recognized on a case-by-case basis as the complexities of society grew. A laissez-faire rhetoric was accepted but, although this could provide an initial barrier to the provision of public funding, it was frequently broken down by determined lobbying, and the social conscience of the day was more easily aroused than is the popular belief. Some scholars have seen the birth of modern welfare concepts in this era, and within it many of the advantages

of caring community collectivism came to the fore, to act as a counterweight to the more self-centred, exploitative "enterprise culture" that also existed (669).

Another surprising factor was the readiness of leading scientists to give their time to a science with the apparently low prestige of meteorology. The reason for this devotion is not at all clear, although the potential for advantage to be gained from a thorough understanding of weather processes is obvious. The actual outcome of their efforts was less desirable and supports the contention that committees are inefficient bodies for issuing other than the broadest of policy directives. Scott never had sufficient authority himself to do more than supervise the most routine day-to-day operations of the Office. Even relatively minor matters had to be referred to the ruling body, and it is a fact that the period of greatest stagnation for the Office was coincident with its direction by this distinguished but ageing body of men. The dynamic that ensued when Shaw took over in 1900 was salutary. Although still nominally under direction of the Council until 1905 he was able, even in that early period, to acquire much greater authority by virtue of his scientific and personal prestige. The major reorganization that took place in 1905 was to give the principal officer much greater autonomy, and the subsequent development of the Office bears adequate testimony to the greater decisiveness in direction that has resulted.

12.5 The place of meteorology and the Meteorological Office within the community

But it was to remain outside the Civil Service until after the First World War, when the various meteorological organizations that had been developed by the armed services were brought together under the overall Office umbrella, along with much of the work of the Scottish and Royal

Meteorological Societies and the British Rainfall Organization. This conglomerate was absorbed into the newly formed Air Ministry, a military department, in 1920, very much against the wishes of Napier Shaw (670). Both the Devonshire Commission of 1875 and the Meteorological Grant Committee of 1905 had recommended that the Office be returned to the ranks of public service, but both had been rejected. It would seem that this still reflected a subservient position for the science, although the grant did increase slightly during the period of recession that characterized mid to late Victorian England. The somewhat bizarre decision to incorporate the Meteorological Council under the Companies Act in 1891 was terminated sixteen years later on the recommendation of the Meteorological Grant Committee. Legal matters, such as the lease of premises, were taken over at this time by trustees for the Meteorological Committee, these being appointed as the Permanent Secretary of the Treasury and the Director of the Meteorological Office (671).

It was the gradual legitimization of weather forecasting, and the growing number of activities for which the forecasts proved beneficial, that provided meteorology with the platform it needed in order to raise its profile and so become accepted as an unquestioned recipient of public funding. The potential benefits of accurate weather prediction are immense, and successive generations of meteorologists worldwide have used this in their negotiations with the guardians of their respective public purse strings to help provide the science with steadily increasing financial backing.

12.6 Science versus practice

Science in general, and meteorology in particular, has long been riven by the recurring argument between theory and practice, between pure and applied, and between science and related technology. This theme has run

through the story of meteorology and instances of the division have recurred several times in the preceding narrative. The first and most traumatic phase has been mentioned earlier in this chapter. It was exacerbated by the almost spectacular differences between the principal adversaries. Galton - cold, dessicated, narrow and unsympathetic was at a distant remove from the impulsive, arrogant, but warm and humane FitzRoy. Not only were their characters at different poles, they were also in complete disagreement over their attitude to religion and were on opposite sides in the great science versus belief debates of the time. Galton was the arch agnostic, a strong supporter of Huxley and the Darwinian theory, and the antithesis of a literalist believer like FitzRoy. It is more than probable that there was personal antagonism between the two men, and that Galton used his chairmanship of the investigating committee as a vehicle to attack his opponent. Many of the Galton Report's criticisms were well founded, but they went completely over the top in their attack on FitzRoy's earliest attempts at forecasting, and the retrospective perceived value of his work has suffered in consequence. Sabine's position was somewhat emigmatic. His initial backing for FitzRoy appears to have been maintained until at least 1863, but he was probably responsible for the appointment of Galton to the investigating committee and later gave his full support to its findings, doubtless influenced by the advantages he could see emanating from the recommendations. By this time, of course, Sabine was in his late seventies and probably less in command than formerly. It is noteworthy that references by Scott to FitzRoy's prognostic attempts were invariably couched in sympathetic terms, and it seems that he had a full realization of his predecessor's achievement.

The initial role of the Meteorological Department provided some satisfaction for both theoretician and applicator. A recurrent theme of nineteenth century meteorologists was despondency at the lack of a fundamental hypothesis. They longed for a unifying theory similar to that

produced in astronomy when the idea of elliptical orbits was applied to planetary motion. Meteorology sought its Kepler, and until he was forthcoming the main occupation of the pure meteorologist was a Baconian collection of weather observations, and this the Department certainly did over areas of the globe (the oceans) where information was sparse. The potential commercial value to the seafaring merchant also provided ample justification to practical users of science, and both sides of the pure/applied divide were satisfied at this level of commitment. It was ironic that the apparent victory of the pure (Galton) faction led to a situation where research had effectively no place within the Office until Shaw took over in 1900. Funding for a research programme was, in fact, provided by the Meteorological Council after 1877, but the work was done on a contract basis that remained outside the ambience of the Office, and so any resultant stimulation was lost on the staff who worked there.

Science is built upon research and it would seem a fundamental concept that removal from all contact with research work in a field will have a stultifying effect upon those engaged upon related but more routine tasks - whether these be in a university or a government department. Certainly that seemed true of the Meteorological Office during this period, and it was probably responsible for at least some of the decline that took place in British meteorology. Regrettably, and despite Shaw's efforts, a high level of research commitment did not become enshrined within the Office structure until after the Second World War. It is not coincidental that the prestige of the Office did not reach the highest levels until during the same period (672).

The dictum that advances in science are necessarily preceded by related advances in its mirror image twin, technology, is often true, and never more so than in respect of operational weather forecasting (673). Until the electric telegraph came into widespread use it was simply impossible to

use a network of observing stations as a forecasting tool. The weather always arrived well before the observations! Similar complementary technological advances have been proven necessary throughout the history of meteorology, from development of the original instruments to present day advances with radar and satellites and the arrival of the mega-computer.

12.7 The evolution of meteorology

The resultant evolution in the status of meteorology is a subject worthy of a more detailed study than can be given here. Shaw, indeed, claimed it as being the oldest of the sciences with physics, applied mathematics and astronomy as mere derivatives (674). This somewhat optimistic view was well out of favour in the second quarter of the nineteenth century, which was a period identified by Cannon as amongst the most deterministic in the history of science (675). Forbes and Whewell, inter alios, were agreed that study of the weather at this time could not be considered as a distinct science in its own right, and the latter's remark that meteorology was "... scarcely yet a science ..." met with general approval (see p. 11); indeed it is difficult to think of the random collection of observations that then went on under the name of meteorology as deserving of such a prestigious categorization (676).

Whewell's statement provokes an obvious question: what, indeed, are the criteria that need satisfying for an area of study to be accepted as a science in its own right? The problem is complex and a full consideration is well beyond the scope of this thesis, but a brief look at the case of meteorology in relation to the foregoing narrative would seem pertinent. For an area of study to attain the status of a separate science the possession of a coherent, identifiable and distinctive sphere of interest would appear to be fundamental. But for a palpably separate character to exist then there must also be the sort of internal communications network

associated with the development of learned societies devoted to its study, and to the publication of journals in which news of investigations and discoveries in the field might be disseminated. Additionally it needs to acquire a strong enough identity for not only its exponents but also for society as a whole to recognize its workers as a distinct group with common interests, possessing a definite place within that society, and influencing, and being influenced by, its values and judgments. And it must acquire recognition within universities and colleges, so leading to the formation of separate departments devoted to its study (677).

The period covered by the present narrative saw meteorology attain nearly all of these criteria. Elizabeth Garber has described this development as an advance from the status of "... a mere appendage of physics ..." to that of an independent science looking to physics only for its basic principles. She considered this advance as having been dependent upon the idea of weather forecasting for its social and financial support (cf. p. 218) (678). More recently Thorne has referred in Kuhnian terms to modern meteorology as a mature science governed by a single paradigm; an account of its eventual emergence as a more "exact", mathematically based, science has also been given by Graham Sutton (679).

The main criterion still unsatisfied at the end of the nineteenth century was that of university recognition but, with somewhat fortuitous exactness for the sake of this analysis, at least within Britain, a small meteorological department was founded at Manchester University in 1905 by the Professor of Physics, Arthur Schuster. This was formed within the physics department of the university, and its first head was George Clarke Simpson, who was to serve as meteorologist to Robert Falcon Scott's last Antarctic expedition in 1911-12 and to succeed Shaw as Director of the Meteorological Office in 1920. Schuster also established, at his own

expense, a readership in meteorology at Cambridge University which was held successively by Ernest Gold and G.I. Taylor between the years 1907-15 (680).

In 1905, at the time we leave this study, both the science of meteorology and the Meteorological Office itself were still at a low ebb, but with a new organization and a respected scientist at the helm a period of steady growth was to ensue. The requirements of aviation and of the First World War were to have dramatic effects within the next decade. Regrettably the story of this period, and of the subsequent transformation of the Office into the institution we know today, will have to await a further study. The author hopes that he will be able to find both the time and the resources to make it.

References

Note.

The minutes of the Meteorological Committee 1867-77, the Meteorological Council 1877-1905, and the Meteorological Committee thereafter, are all shown as: [year] Minutes. They are held as bound volumes in the National Meteorological Library.

Chapter One

1. G A Wainwright, The sky-religion in Egypt, Cambridge, 1938.
2. Thales theory was noted in: Seneca (4BC-65 AD), Naturales Quaestiones, c 63AD, English translation Thomas H Corcoran, Loeb Classical Library, London, 1971, vol 2. p. 35.
3. See: Howard Frisinger, "Meteorology before Aristotle", Bull. Amer. Met. Soc., 52, (1971), p. 1079.
4. Ibid, pp. 1079-1080.
5. Aristotle, Meteorologica, English translation H D P Lee, Loeb Classical Library, London, 1952.
6. Ibid, pp. 1-11.
7. See: Sir Napier Shaw, Manual of Meteorology, vol 1, Cambridge, 1932, pp. 63-83, and Patrick Hughes, "The mythology of meteorology". Edis (Nov, 1978), pp. 11-13.
8. Seneca, op cit (note 2), p. 81.
9. See: Cicely M Botley. "A founder of English meteorology", Quart. J. R. Met. Soc. 61, (1935), p. 346, and Howard Frisinger, The history of meteorology to 1800, New York, 1977, pp. 30-31.

10. For example, Patrick Hughes, op cit (note 7), p. 13. This records that feudal astrologers were sometimes called upon to predict the weather for military campaigns. Failure could lead to the death of the unsuccessful forecaster.
11. Leonard Digges, A prognostication of right good effect, London, 1555, imprinted in London within the blacke Fryars by Thomas Gemini.
12. See: Shaw, op cit (note 7), p. 109.
13. See: Frisinger, op cit (note 9), p. 33 for Bacon's importance to meteorology.
14. Mentioned in, for example, Helmut E Landsberg, "Using early weather records", Weatherwise, 34, (1981), pp. 196-201.
15. Frisinger, op cit (note 9).
16. See, for example, R Inwards, Weather lore, London, first edition 1898.
17. See: Frisinger, op cit (note 9), p. 36.
18. W E K Middleton, Invention of the meteorological instruments, Baltimore, 1969.
19. For a comprehensive account of the barometer see: B Bolle, Barometers, Watford, 1982.

20. Frisinger, op cit (note 9), pp. 36-37.
21. Ibid, pp. 52-53.
22. Ibid, p. 100.
23. Ibid, p. 101. More comprehensive accounts of the Accademia can be found in: Richard Waller, Essayes of natural experiments, written in Italian by the secretary of that academy. Englished by Richard Waller, London, printed for Benjamin Alsop at the Angel and Bible in the Poultry, over-against the church, 1684; or, for a rather more modern work, in: W E K Middleton, The experimenters, Baltimore, 1971.
24. Phil. Trans. Roy. Soc., 32, (1723), pp. 422-427.
25. See: Thomas Sprat, History of the Royal Society, London, 1667, pp. 173-179.
26. Phil. Trans. Roy. Soc., 35, (1728), pp. 390-402. See also: Howard Frisinger, "Isaac Greenwood: pioneer American meteorologist", Bull. Amer. Met. Soc., 48, (1967), pp. 265-267.
27. See: J A Kington, "The Societas Meteorologica Paletina, an eighteenth century meteorological society", Weather, 29, (1974), pp. 416-426, and Frisinger, op cit (note 9), p. 101.
28. W E K Middleton, A history of the theories of rain, London, 1965, pp. 82-83.

29. In eds. W F Bynum, E J Browne and Roy Porter, Dictionary of the history of science, London, 1983, p 378, the span of time given is c 1550-1700. Colin A Russell, Science and social change 1700-1900, 1983, p. 13, is more specific noting the period as that between the emergence of De revolutionibus orbium coelestium by Copernicus in 1543 and Newton's Philosophiae naturalis principia mathematica in 1687.
30. See, for example, Middleton, op cit (note 28), pp. 112-132, 199-200.
31. J Dalton, Meteorological observations and essays, Manchester, second edition 1834, pp. 127-128.
32. Middleton, op cit (note 28), pp. 89, 131.
33. For the ubiquitous Darwin see: D G King-Hele, Erasmus Darwin, London, 1963; and "Erasmus Darwin, grandfather of meteorology?", Weather, 28, (1973), pp. 240-250. Also D.N.B.. The story of the society is told in: Robert E Schofield, The Lunar Society of Birmingham, Oxford, 1963.
34. Erasmus Darwin, "Frigorific experiments on the mechanical expansion of air", Phil. Trans. Roy. Soc., 78, (1738), pp. 43-52.
35. For Howard and his contribution to meteorology see: ed. D F S Scott, Luke Howard his correspondence with Goethe and his continental journey, York, 1976, esp. pp. 1-6; Brian J R Blench, "Luke Howard and his contribution to meteorology", Weather, 18, (1963), pp. 83-92; and John A Day and Frank H Ludlam, "Luke Howard and his clouds: a contribution to the early history of cloud physics", Weather, 27, (1972), pp. 448-461. Also D.N.B.

36. Luke Howard, Seven lectures on meteorology, Pontefract, 1837.

Howard's cloud classifications were proposed in: Essay on the modification of clouds, London, 1804, and amplified in The climate of London (3 vols), London, 1833.

37. See: Peter R Cockrell, "The Meteorological Society of London 1823-73", Weather, 23, (1968), pp. 357-361; R A S Ratcliffe, "The story of the Royal Meteorological Society", Weather, 33, (1978), pp. 261-268; and for an earlier account, G J Symons, "The history of English Meteorological Societies 1823-80", Quart. J. R. Met. Soc., 7, (1881), pp. 65-98.

38. Rev. Prof. William Whewell, B.A.R. Plymouth, 1841, pp. xxxii-xxxiii, (Presidential address).

Chapter Two

39. Edmund Halley, "An historical account of trade winds and monsoons observable in the seas between and near the tropics, with an attempt to assign the phisical (sic) cause of the said wind", Phil. Trans. Roy. Soc., 16, (1686), pp. 153-168.

40. George Hadley, "Concerning the cause of the general trade winds", Phil. Trans. Roy. Soc., 34, (1735), pp. 58-62.

41. See, for example: Edward N Lorenz. "A history of prevailing ideas about the general circulation of the atmosphere", Bull. Amer. Met. Soc., 64, (1983), pp. 730-734, and refs.

42. This phenomenon is now generally termed the Coriolis effect after Gaspard Coriolis, a French mathematician who was the auther of a paper on accelerations in rotating co-ordinate systems, "Memoire sur les equations du mouvement relatif des systemes de Corps", J. Ecole Polytechnique, 15, (1835), pp. 142-154. The accreditation thus given to Coriolis is challenged by C L Jordan in: "On Coriolis and the deflective force", Bull. Amer. Met. Soc., 47, (1966), pp. 401-403; also H E Landsberg, "Why indeed Coriolis?", Bull. Amer. Met. Soc., 47, (1966), pp. 887-889; and Harold L Burstyn, "The deflecting force and Coriolis", Bull. Amer. Met. Soc., 47, (1966), pp. 890-891.

43. J Dalton, Meteorological observations and essays, Manchester, 1793. Dalton's acknowledgement of Hadley was contained in the preface to the second (1834) edition of this book.

44. This was apparently contained in: I Kant. Anmerkungen zur Erläuterung der Theorie der Winde, 1756, a reference quoted in: J Hann, Lehrbuch der Meteorologie, Leipzig, 1901, p. 466.
45. See: Shaw, op cit (note 7), pp. 299-300. H W Brandes's charts were presented in: Beiträge zur Witterungskunde, Leipzig, 1820; his "centripetal" or inwards flowing theory of winds was mentioned in this publication and expanded in: Dissertatio physica de repentinis variationibus in pressione atmosphaerae observatis, Leipzig, 1826.
46. H W Dove, "Einige meteorologische Untersuchungen über den Wind", Ann. Phys. Chem., 87, 1827, pp. 545-590. For Dove see: D.S.B.
47. Dove's full formulation of his theory was published as: H W Dove, "Das Gesetz der Stürme", Monatsbericht der Preussischen Akademie der Wissenschaft, 52, 1840, pp. 232-239.
48. David Ludlum, "The Espy-Redfield dispute", Weatherwise, 22, 1969, pp. 224-229, 245, 261. For Redfield see D.S.B.
49. William C Redfield, "Remarks on the prevailing storms of the Atlantic coast of the North American states", Amer. J. Sci. Arts, 20, 1831, pp. 17-51.
50. Buys Ballot's Law states that if an observer in the northern hemisphere stands with his back to the wind, then the atmospheric pressure is lower to his left hand side than to his right whilst in the southern hemisphere the converse is true. The law was first stated in "Note sur les rapports de l'intensité et de la direction du vent avec les écarts simultanés du baromètre", Comptes rendus, 45, 1857, pp. 765-768.

51. Shaw, op cit (note 7), p. 295.
52. Henry Piddington, The sailor's horn book for the law of storms, London, 1848, p. 8 (footnote). Piddington derived cyclone from the Greek word for the coil of a snake. The references to the early proposers of circular wind flows around storms are on pp. 1-2.
53. J P Espy, The philosophy of storms, Boston, 1841. For Espy see: D.S.B..
54. Redfield, op cit (note 49), p. 48.
55. Quoted from: Redfield to Loomis, 2 Dec 1837, in N Reingold, Science in nineteenth century America, New York, 1964.
56. The acceptance of the interconvertibility of heat and energy, and so the birth of the science of thermodynamics, was still some little time in the future. See, for example; D S L Cardwell, From Watt to Clausius, London, 1971. The significance of Espy's work is well covered in: J E McDonald, "James Espy and the beginnings of cloud thermodynamics", Bull. Amer. Met. Soc., 44, (1963), pp. 634-641.
57. See, for example: Gisela Kutzbach, The thermal theory of cyclones, Boston, 1979, esp. pp. 19-44.
58. A D Bache, Fourteenth Smith. Inst. Ann. Rep., 1859, pp. 108-110.
59. For Reid see D.N.B.; also obit. notice in Proc. Roy. Soc., 9, (1859), p. 544. Reid was at this time a Lieut-Col, R.E., who had had a distinguished career during the Peninsular War under Wellesley and Burgoyne, and had also served at the Battle of New Orleans.

60. There are apparently three folio volumes of correspondence between Reid and Redfield that are held in the library of Yale University.
61. W Reid, An attempt to develop the law of storms, London, 1838.
62. William C Redfield, "On the courses of hurricanes", Amer. J. Sci. Arts, 35, (1838), pp. 1-23.
63. W Reid, The progress of the development of the law of storms, London, 1849. His ideas concerning possible prognostications came on p. 3. Redfield had hinted at differences between tropical and extra tropical storms in his 1838 article (see note 62). Reid's work also featured prominently in: R Methven, Narratives written by sea commanders illustrative of the law of storms, London, 1851, to which Reid contributed a preface.
64. See: Kutzbach, op cit (note 57), pp. 15-16.
65. See: Piddington, op cit (note 52).
66. Copies of the documents relating to the setting up of this scheme are contained in the introductory pages to: Henry James, Instructions for taking meteorological observations at the principal foreign stations of the Royal Engineers, London, 1851, in particular a letter from Viscount Palmerston, then Foreign Secretary, dated 30 Apr 1851; and addressed to H.M. Consuls overseas shows that the whole project was widening. The original circular letter from the Colonial Office, dated 29 Nov 1838 and headed "Downing Street" is shown as inclosure 4 to the Foreign Office letter. These letters are on pp. 23-28.

67. For Burgoyne see D.N.B.; also, at greater length, Hon. G Wrottesley, The life and correspondence of Field Marshal Sir John Burgoyne, Bart., London, 1873. The important part played by officers of the Royal Engineers in general, and by Reid in particular, in the development of Britain and its colonies during this period is emphasized in: W L Burn, The age of equipoise, London, 1964, p. 224.

68. For James see D.N.B.. He was to achieve much greater fame later as the Director-General of the Ordnance Survey.

69. Glaisher claimed that the form adopted by James was a copy of that used by the Society. He also thought that

"... the instructions drawn up by Capt James are good as far as he has followed the information I gave him, and are erroneous very frequently in parts where the information was not furnished to him ..."

Reports of the Brit. Met. Soc. 1851-61, A.G.M., 25 May 1852, p. 6.

Despite Glaisher's criticisms Napier Shaw traces a direct link between James's publication and the Observer's Handbook of the Meteorological Office in 1926 (and hence to that of the present day), Shaw, op cit (note 7), p. 137. Glaisher and the British Meteorological Society will be dealt with more fully below (see p. 29).

70. The proposals and all the relative correspondence can be found in: "Papers respecting the proposed plan for making meteorological and hydrological observations at sea", P.P. 1852-53, LX, pp. 441-463. For Maury see: D.S.B.

71. See: Charles C Bates and John F Fuller, America's weather warriors, College Station, Texas, 1986, pp. 5-6.

72. See, for example: M F Maury, Astronomical observations made during the year 1846 at the National Observatory, Washington, vol II, Washington, 1851, pp. 41-42.
73. In his renowned magnum opus Maury quotes an independent source as calculating a possible saving to U.S. commerce of £2.25 million per annum on trade with South America, Australia and the Far East, and between east and west coast ports of the United States, on outward voyages only. M F Maury, The physical geography of the sea, London, 1855, introduction p. viii (footnote).
74. Burgoyne's letter could not have reached Maury before 17 Nov 1851, and most probably not before 19 Nov. Maury's lengthy and detailed reply was dated 21 Nov. See: Observation plan papers, op cit (note 70).
75. A few years later Burgoyne had to be recalled to Britain from the war zone in the Crimea due to his differences with the French, see: Hon G Wrottesley, A history of the family of Wrottesley of Wrottesley co. Stafford, Exeter, 1903. Presumably Burgoyne did not think of the Anglophone Americans as true foreigners!
76. The whole of this correspondence is contained in op cit (note 70).
77. Reid, op cit (note 6), p. 430.
78. The story is well told in: Roger Prouty, The transformation of the Board of Trade 1830-1855, London, 1957, esp. pp. 30-51.

79. "First report from the select committee on shipwrecks", P.P. 1843, IX, pp. 19-34. FitzRoy sat as a Tory M.P. from 1841-1843 but later changed his political views, espousing the Liberal cause; see: FitzRoy to Norton Shaw (Secretary R.G.S.) 7 Nov 1853, R.G.S. Library MS.

80. For Wrottesley see D.N.B.. When Burgoyne was recalled to Britain from the Crimea (see note 75) Wrottesley objected to the manner in which this was announced in Parliament, thereby inducing the Government leader in the Lords to deliver "... a very eloquent eulogium ..." on Burgoyne in the House. See: Wrottesley, op cit (note 75), pp. 379-380. Wrottesley's third son married Burgoyne's daughter in 1854 and became his A.D.C. the following year.

81. J D Forbes, "Report upon the recent progress and present state of meteorology", B.A.R. Oxford, 1832, pp. 196-258, and "Supplementary report on meteorology", B.A.R. Glasgow, 1840, pp. 37-156.

82. The background to this observational programme is given briefly in: John Cawood, "Terrestrial magnetism and the development of international collaboration in the early nineteenth century", Ann. Sci., 34, (1977), pp. 551-587.

Chapter Three

83. The text of Wrottesley's speech is contained in Hansard, 3rd series, 126, cols. 522-543, it was also published separately later. Inglis raised the subject in the Commons on 13 Jul 1853. The delegation to Graham consisted of Wrottesley and Inglis together with the Earl of Harrowby, the Earl of Rosse, the Bishop of Oxford, Mr James Heywood, M.P., Col Edward Sabine and Sir Roderick Murchison, see B.A.R. Hull, 1853, report of the Parliamentary Committee, p. xxxii. For Beechey, Graham and Inglis see D.N.B..

84. The salient points of the conference are covered in: "Abstract of copy of report of conference held at Brussels respecting meteorological observations", P.P. 1854, XLII, pp. 443-474. The participating nations were: Belgium, Denmark, France, Great Britain, Netherlands, Norway, Portugal, Russia, Sweden and the U.S.A..

85. Britain declared war on Russia on 28 Mar 1854.

86. Hansard, 3rd series, 130, col. 270. The question was put by Mr J Heywood, F.R.S. (Lancashire N.) and replied to by Sir James Graham. For Heywood see: F Boase, Modern English biography, V, London, 1965, p. 647.

87. The Board of Trade was becoming a conglomerate of remarkable diversity at this time with a variety of technical and semi-scientific enterprises being taken under its wing. See: Prouty, op cit (note 78). The difficulties between the Board and its source of adequate finance,

the Treasury, are mentioned in: Maurice Wright, "Treasury control 1854-1914", in ed. Gillian Sutherland, Studies in the growth of nineteenth century government, London, 1972, pp. 195-226.

88. Hansard, 3rd series, 134, col. 1006.

89. The growth of Royal Society influence on the Government is described in: Marie Boas Hall, All scientists now, Cambridge, 1984, see esp. pp. 176-181.

90. See: R FitzRoy, "Memorandum on Maury's plan - ocean statistics - mode of proceeding in office", 3 Feb 1854, P.R.O. BJ 7/2; and FitzRoy to Sabine, 3 Feb 1854, P.R.O. BJ 3/78. To the latter FitzRoy added the strange footnote "... I reserve other topics and private feelings ..." (FitzRoy's underlining). That FitzRoy was nominated by Wrottesley is mentioned specifically in: Encyclopaedia Britannica, 9, 9th edn., pp. 271-273, article on FitzRoy by J.K. Laughton. For FitzRoy see H.E.L. Mellersh, FitzRoy of the Beagle, London, 1968; and D.N.B..

91. See: FitzRoy to Sir Baldwin Walker (surveyor of the Navy), 28 Oct 1853, National Maritime Museum MS, and FitzRoy to Beaufort; 1 Nov 1852 (2 letters), 6 Dec 1852 and 8 Feb 1853, Hydrographic Office Library MS 379, 383, 384 and 409. For Beaufort see: A Friendly, Beaufort of the Admiralty, London, 1977, and D.N.B..

92. The date is given in Tennant (Board of Trade) to Secretary, Treasury, 22 Nov 1856, P.R.O. BT 3/50, 778. This letter gives details about military officers holding civilian appointments with the Board. No other record has been traced.

93. The present day Parliament Street was at that time divided into two roads - Parliament Street and King Street - by a line of buildings, one of which was occupied by the Meteorological Department. See: L Jacobs, "A short history of former homes of the Meteorological Office", Meteorol. Mag., 102, (1973), pp. 48-50. A somewhat earlier picture showing the division of Parliament Street is shown as the frontispiece in: S Foreman, Shoes and ships and sealing wax. An illustrated history of the Board of Trade 1786-1986, London, 1986. The accommodation is mentioned in Booth (Board of Trade) to Trevelyan (Treasury), 1 Sep 1854, P.R.O. BT 3/47, 681.

94. Farrer (Board of Trade) to Trevelyan (Treasury), 27 Nov 1854, P.R.O. BT 3/47, P474, and FitzRoy's memorandum of 3 Feb 1854, op cit (note 90). It is perhaps not surprising that the industrious FitzRoy's ideas on manning levels differed from that of a career civil servant. See: Emmeline W Cohen, The growth of the British Civil Service 1780-1939, London, 1965, for an insight into contemporary Civil Service attitudes. The accumulation of materials must have been due to FitzRoy's unaided efforts prior to this date.

95. William Pattrickson was the senior of the three men, with special skills as a draughtsman, and had earlier worked on the ventilation of the Houses of Parliament. He received a salary of £180 per annum. Thomas Henry Babington and F R Townsend were both paid £81-0-7 per annum.

96. See, for example, J Bartlett Brebner, "Laissez-faire and state intervention in nineteenth century Britain", in E M Carus-Wilson ed., Essays in economic history, III, London, 1962, and the similarly titled Arthur J Taylor, Laissez-faire and state intervention in nineteenth century Britain, London, 1972. Also a brief but very clear review of the

idea in Prouty, op cit (note 78), pp. 1-2. The idea of Victorian Britain as a bastion of laissez-faire is also challenged in David Roberts, Victorian origins of the British welfare state, New Haven, 1960. Amongst several broader reviews of the period that tackle the same problem are: Geoffrey Best, Mid-Victorian Britain 1851-1875, London, 1971; G Kitson Clarke, The making of Victorian England, London, 1962, and Burn, op cit (note 67).

97. See: Cawood, op cit (note 82). The influence of "Humboldtian science" is covered in: Susan Faye Cannon, Science in culture, New York, 1978. Supporters of terrestrial magnetism for primacy in scientific internationalism are referred to: D Brunt, Physical and dynamical meteorology, Cambridge, 1939, introduction p.xxiii. There are, of course, other arguments!

98. For Glaisher see: J L Hunt, "James Glaisher", Weather, 33, (1978), pp 242-249 and D.N.B.. For a brief history of the Royal Meteorological Society see: Ratcliffe, op cit (note 37), pp. 261-268. The British Meteorological Society was itself preceded by Meteorological Society of London (see note 37).

99. The concern about possible links between meteorology and medicine is still seen as topical. See, for example, Ann Kent, "Under the weather?", The Times, Thu Jul 30 1987, p. 11.

100. The original Kew Committee included Herschel, Cassiot and Reid; Sabine was a prominent member for many years. The work of Kew is covered, inter alia, in: R H Scott, The history of the Kew Observatory, Richmond, Surrey, London, 1885. (also published in Proc. Roy. Soc., 38, (1885)); L Jacobs, "The 200 years story of the Kew Observatory",

Meteorol. Mag., 98, (1969), pp. 162-171; and O J R Howarth, The British Association, a retrospect, London, 1931, pp. 155-169. Acquisition of the Observatory by the Association, prompted by Sabine, is described in: J B Morrell and A Thackray, Gentleman of science, Oxford, 1981, pp. 348-349.

101. The letter was dated 22 Feb 1855 and is reproduced in full in a number of publications, for example: R FitzRoy, The weather book, London, 1863, app. D; Proc. Roy. Soc., 7, (1855), pp. 342-361; and P.R.O.. BJ 7/4. The full correspondence relating to the letter, including replies by foreign meteorologists consulted by the Royal Society, is also contained in BJ 7/4. It is, perhaps, noteworthy that an article by FitzRoy, which describes the work of an apparently fully functioning department, actually preceded the date of the Royal Society letter by some two weeks: R FitzRoy, "Account of the steps recently taken by H.M. Government for promoting the regular observation of meteorological phenomena at sea". R. Astronom. Socy., Mon. Not., 15, (8 Feb 1855), pp. 156-158.

Chapter Four

102. R FitzRoy, Report of the Meteorological Department of the Board of Trade (private), London, 1855.
103. Ibid, p. 3. No record has been found to say who these agents were or what experience they were required to possess. By 1 Mar 1857 agents had been appointed at Bristol, Hull, Liverpool, London, Newcastle, Plymouth, Southampton, Aberdeen, Dundee, Glasgow, Greenock, Leith, Belfast, Cork and Dublin. A set of instruments consisted of: 1 barometer, 6 thermometers, 1 thermometer stand, 4 hydrometers and 1 azimuth compass; total value £13-17-0. See: 1857 Report, P.P. 1857, XX, Apps. E and F.
104. Fitzroy to Herschel, 4 May 1858, Royal Society Library, Herschel correspondence, Hs 7.252.
105. Hooker to Darwin, 2 May 1865, Cambridge University Library, Darwin correspondence.
106. Buys Ballot to Galton, 13 Aug 1866, University College, London, Library, Francis Galton papers, 190. For Buys Ballot see: D.S.B..
107. This was pointed out by Francis Galton in: F Galton, "On an error in the usual method of obtaining meteorological statistics", B.A.R. Nottingham, 1866, pp. 16-17. An account of FitzRoy's modification of Maury's work is given in The Athenaeum, 29 Dec 1855, p. 1536.
108. See, for example, M Deacon, Scientists and the sea, London 1971, p. 290.

109. R FitzRoy, Barometer manual, London, 1858 (and many editions). The FitzRoy barometer is well described, inter alia, in B Bolle, Barometers, Watford, 1982, pp. 47-49, 54-61, 218-219.
110. Third number of meteorological papers, London, 1858. The second, and much enlarged edition of Dove's work, also translated by R H Scott, carried a dedication to FitzRoy. It was published in Britain as: H W Dove, The law of storms, London, 1862.
111. Names familiar to the modern meteorologist, such as Negretti and Zambra, and Casella, feature prominently in the lists of instrument makers that supplied the Department.
112. 1857 Report, op cit (note 103), pp. 11-13 of the report.
113. For Sullivan see: H N Sullivan, The life and letters of Admiral Sir B J Sullivan, K.C.B., 1810-1890, London, 1896, and D.N.B.. It is a reflection of Sullivan's respect for FitzRoy that he declined to assume overall control of the Meteorological Department, although nominally it came under the Marine Department at the Board of Trade.
114. See p. 22 and note 79. FitzRoy's encounter with the pampero is recounted in: Anon., "Admiral FitzRoy", Good Words, 7, (1866), pp. 406-413.
115. FitzRoy apparently introduced the term "synoptic" into meteorology to describe charts showing observations made simultaneously. His derivation of the term is given in: FitzRoy, op cit (note 101), p 103.

116. See, for example, J B Conacher, The Aberdeen coalition 1852-55, Cambridge, 1968.
117. See: Mellersh, op cit (note 90), pp 225-230.
118. See: FitzRoy to Sir J Emerson Tennant (Joint Secretary of the Board of Trade), 28 Jan 1859, P.R.O. BT 5/67.
119. The whole of the correspondence relating to the Pattrickson incident is contained in P.R.O. BT 5/67.
120. See: J C Sainty, Office-holders in modern Britain, III, Officials of the Board of Trade, London, 1974.
121. See: Shaw, op cit (note 7), pp 302-303. The development of Le Verrier's organization is well covered in: John L Davis, "Weather forecasting and the development of meterological theory at the Paris Observatory, 1853-78", Ann. Sci., 41, 1984, pp. 359-382. Also see: H Landsberg "Storm of Balaklava and the daily weather forecast", Sci, Monthly, 7, (1954), pp. 347-352. For Le Verrier see: D.S.B..
122. C H D Buys Ballot, "On the system of forecasting the weather pursued in Holland", B.A.R. Newcastle 1863, pp. 20-21. A historical perspective on Buys Ballot's Laws is given by Jacques Dettwiller, "A propos de la loi de Buys Ballot" (in French), Met. Mar., 115, (1982), pp. 46-53.

123. John Ball, "On rendering the electric telegraph subservient to meteorological research", B.A.R. Swansea, 1848, p. 13. Ball later became M.P. for Carlow in Ireland and was responsible for the question that provoked mirth in the Commons at the time the decision to found the Meteorological Department was announced (see p.25 and note 88).

124. See: Patrick Hughes, A century of weather service 1870-1970, New York, 1970, pp 5-6.

125. "Report of the Commission on Lights, Buoys and Beacons", P.P. 1861, XXV, p. 595, reply by J F W Herschel, dated 24 Jan 1860, to the question: "Supposing the telegraph to be extended to certain lighthouses and light-vessels at salient points of the coast, what is the meteorological information which it would be most desirable to transmit to passing ships, and how and in what form could it be most readily received and communicated by light-keepers?". The question was asked of 50 'scientific men' only 10 of whom replied. FitzRoy's answer was "Height of barometer, wind and weather expected, received from Coast Guard by telegraph from other places, or from their own means or knowledge".

126. Reported inter alia in the Athenaeum, 10 Dec 1859, p. 777.

127. See: 1862 Report, P.P. 1862 LIV, ch. 1, para. 9; R FitzRoy, "An explanation of the meteorological telegraphy and its basis now under trial at the Board of Trade", R. Inst. Gt. Britain, Proc. 3, (1862), pp. 444-456; also ibid. FitzRoy's accounts both give the date of the Buckingham Palace meetings as early 1860 but this is contradicted by the date of the Athenaeum article. FitzRoy, writing two years after the event, was probably in error.

128. See, for example, Alexander McKee, The golden wreck, London, 1961. That FitzRoy was well acquainted with the "Royal Charter" is brought out in Vice-Adm C R Moorsom to FitzRoy, 19 Nov 1855, P.R.O. BJ 7/1, no 7. A memorial to those who lost their lives as a result of the disaster still stands on the cliff top just north of the village of Moelfre.

129. R FitzRoy, "Remarks on the late storms of 25-26 Oct and 1 Nov", Proc. Roy. Soc., 10, (1860), pp. 222-224.

130. See: R FitzRoy, "On British storms", B.A.R. Oxford, 1860, pp. 39-44. The "Royal Charter" was, in fact, equipped with copies of Maury's charts - see Moorsom's letter to FitzRoy (note 128). The ascription to Maury's instructions that was given by FitzRoy is not a contradiction of the aims attributed to Maury on p. 20. Maury was certainly interested in safety at sea even if his main contribution had been principally concerned with the commercial profitability of shipping. With FitzRoy the priorities were reversed.

131. Ibid, p. 42.

Chapter Five

132. See: Davis, op cit (note 121), p. 365.
133. 1862 Report, op cit (note 127), describes the setting up of the observational network. Working details are given in FitzRoy, op cit (note 101), app. A. This was not the first such network in England. In 1848 Glaisher organized telegraphic weather reports that appeared for a few weeks in the Daily News, whilst in 1851 he set up another telegraphic reporting scheme and produced weather charts at the Great Exhibition in London. These were sold to the public at 1d each. See: W Marriott, "The earliest telegraphic daily meteorological reports and weather maps", Quart. J. R. Met. Soc., 29, (1903), p. 124.
134. Ibid, 1862 Report, ch. 2.
135. 1863 Report, P.P. 1863, LXIII, pp. 27-92, App 1, the data used for the comparison of weather experienced with warnings issued came from a variety of sources including newspapers, statements from ports and, of course, the reports from the Department's own weather reporting network.
136. FitzRoy described his warning system and signals in, inter alia: op cit (note 101) esp. pp. 217-219, 347-350; 1862 Report, op cit (note 127); and Rear-Adm FitzRoy, "Weather reports and forecasts in the daily newspapers", The Lifeboat, V, (1862), nos. 45-46, pp. 121-124; 145-149. The aeroclinoscope was shaped something like a semaphore railway signal and was aligned from highest pressure to lowest pressure of the recording stations, with the inclination of the semaphore set relative to the difference in the recorded pressure readings.

137. 1864 Report, P.P. 1864, LV, pp. 125-207, p. 12, notes the Duke's generosity; Lady Kay-Shuttleworth is mentioned in FitzRoy to Capt John Washington (Hydrographer to the Navy), 15 Nov 1861, Hydrographic Office Library MS.

138. 1863 Report, op cit (note 135), App. 2, showed 76 out of 89 recipients as " ... definitely favourable ..." to use of the instruments, the other 13 having "... no decided view ..."

139. 1862 Report, op cit (note 127), ch. 1, para. 14.

140. Ibid, ch. 1, para. 17, and FitzRoy, op cit (note 101), pp. 170-171. Many of FitzRoy's writings contained extensive passages copied verbatim one from another.

141. In May 1856 the Department occupied 15 rooms with a total space of 3,094 sq. ft. and a request was made for a further 900 sq. ft., James Booth (Board of Trade) to Alfred Austin (Dept. of Works and Public Buildings), 9 May 1856, P.R.O. BT 3/50, no 370. The expansion had continued.

142. For Symons see: D.N.B.. For Strachan see obit. notice, Meteorol. Mag., 59, (1924), pp. 94-95. The *Symons Memorial gold medal*, instituted on the former's death, remains the most prestigious award in the gift of the Royal Meteorological Society.

143. 1862 Report, op cit (note 127), ch. 1, para. 18. FitzRoy also makes the same point at ch. 9. paras. 44-46.

144. FitzRoy, op cit (note 101), p. 194.

145. Cyclone 'horns' consisted of a number of concentric circles inscribed on celluloid, or other transparent material, and carrying arrows showing cyclonic flow (anti-clockwise in the northern hemisphere).

146. FitzRoy's charts delineated pressure by lines drawn across the chart with a separation from the appropriate parallel of latitude equivalent to the pressure at each point along it. The representation of pressure on weather charts caused difficulties until reduction of pressure to mean sea level was universally accepted. Laplace had formulated the relationship between height and pressure as early as 1805 but its application to a comparison of simultaneous observations was far from easy, and a number of methods were used for indicating pressure on charts before representation of the mean sea level pressure field became standard practice after 1860. Shaw notes that Koppen proposed reduction to 106 metres as the mean level of the 1000 mb surface, see: op cit (note 7), p. 221.

147. FitzRoy, op cit (note 101), and 1862 Report, op cit (note 127).

148. Ibid, (note 101), app. N.

149. See: FitzRoy to Herschel, 2 Nov 1860, Harvard University Library MS, no 70, in which FitzRoy refers to a conversation he had with Loomis and Henry James.

150. See: Kutzbach, op cit (note 57), esp. pp. 11-16.

151. 1863 Report, op cit (note 135), para. 13.

152. Galton, cousin of Charles Darwin and founder of the science of Eugenics, was at this time deeply involved in meteorological studies. His principal book on the subject was: F Galton, Meteorographica, London, 1863, and he also suggested use of the term 'anticyclone' in: F Galton, "A development of the theory of cyclones", Proc. Roy. Soc., 12, (1863), pp. 385-386. For Galton see: F Galton, Memories of my life, London 1908; D W Forrest, Francis Galton, the life and work of a Victorian genius, London, 1974; and D.N.B.. The term 'scientist' is probably acceptable by this time, its introduction being generally attributed to William Whewell in 1834, see: Sydney Ross, "'Scientist': the story of a word", Ann. Sci., 18, (1962), pp. 65-86.

153. See, for example: 'B', ed., The science of the weather, Glasgow, 1867; and Christopher Cooke, Admiral FitzRoy: his facts and failures, London, 1867. The activities of the Astro-Meteorological Society are mentioned in: C E Britton, "Forgotten English meteorological societies", Quart. J. R. Met. Soc., 61, (1935), pp. 343-346, an article that also acknowledged a Copernican Meteorological Society. It is highly probable that the astro-meteorological interests of its secretary, W H White, led to the demise of the Meteorological Society of London in 1843, its successor the British Meteorological Society being formed seven years later, see: Symons, op cit (note 37). The Astro-Meteoric Journal was a short lived publication devoted to the subject which appeared during 1867-1869. A lunarist view is given in: S M Saxby, Saxby's weather system, London, 1864.

154. The brochure is described in: Shaw, op cit (note 7), p 305; and William Marriott, "An account of the bequest of George James Symons, F.R.S., to the Royal Meteorological Society", Quart. J. R. Met. Soc., 27, (1901), pp. 258-259.

155. The answers to a questionnaire concerning the efficacy of the warnings that was addressed to maritime centres showed, according to FitzRoy, that out of 56 responses 46 were "decidedly favourable", 7 were "qualified" and 3 "decidedly unfavourable", see: 1862 Report, op cit (note 127), app. A stringent independent check (by the author) of the raw data was marginally less favourable - the figures were respectively 38; 12; 4 (two replies must have "got lost" somewhere), but the result still shows impressive support for FitzRoy.

156. "Correspondence between the Board of Trade and the Royal Society on the subject of meteorological observations, telegraphy and forecasts", P.P. 1863, LXIII, pp 95-97. The letters were T H Farrer (joint Secretary. Board of Trade) to W Sharpey (Secretary, Royal Society), 27 Feb 1863, and Sharpey to Farrer, 27 May 1863.

157. Relevant leading articles appeared in The Times on 11 Apr 1862 (p. 9, cols. 3-4), 30 Jun 1862 (p. 11, col. 6) and 18 Jun 1864 (p. 11, cols. 4-5). Mellersh, in op cit (note 90), pp. 278-279, argued that these articles were critical, but it is difficult to sustain this view even though some critical remarks were included. Amongst the magazine articles were, inter alia: Anon., "Admiral FitzRoy on the weather", The intellectual observer, 3, (1863), pp 103-109; and, J F W Herschel, "The weather and weather prophets", Good words, 5, (1864), pp 57-64. Contemporary articles attacking FitzRoy are not readily in evidence.

158. The Athenaeum, 1811, (1862), pp. 49-50; 1838, (1863), pp. 80-81; and 1852, (1863), pp 556-557. Beardmore's remarks appear in : Proc. Brit. Meteorol. Soc., 1, (1861), pp. 2-8.

159. Queen Victoria made a practice of consulting FitzRoy before her frequent trips to the Isle of Wight, see: Anon. op cit (note 114). Letters notifying FitzRoy of his election by the Academie are contained in the Farrer papers, County Archives, Dorchester.

160. The subject of the professionalization of science within Britain during the nineteenth century would be too large a digression to be considered here. See, for example, the discussion in: Russell, op cit (note 29), esp. pp. 174-234. FitzRoy's biographer, Mellersh, held the view that he had something of an inferiority complex as regards his scientific standing. Certainly his manner towards Herschel bordered on the obsequious at times, even allowing for Victorian modes of expression, see: Herschel-FitzRoy correspondence in the Royal Society Library, and the series of letters between the two from 23 Oct to 29 Nov 1860 held at Harvard University. Some scientists were rather dismissive of his scientific ability, for example J D Hooker's "... 1/2 - scientific pluck ...", Hooker to Charles Darwin, 2 May 1865, Cambridge University Library, was indulgent if scarcely respectful. Francis Galton's "... failed in scientific solidity ..." was somewhat less friendly, see: Galton, op cit (note 152), 1908, pp. 232-233.

161. The criticism came in The Times, 18 Jun 1864 (p. 11, cols. 4-5); the commendation in the Athenaeum, 1838, (1863), pp. 80-81.

162. "Weather forecasts", P.P. 1864, LV, pp. 341-428. FitzRoy dissociated himself from the report in a letter to The Times, 9 Jun 1864 (p. 11, col. 6). The Wreck Department formed part of the Marine Department of the Board of Trade, see: Guide to the contents of the P.R.O., II, London, 1963; no other details of the Department are to hand.

163. The Meteorological Department's verifications were carried out by Babington, see: appendices 1863 Report, op cit (note 135), and 1864 Report, op cit (note 137). For Farrer see D.N.B..
164. The Times, 18 Jan 1864 (p. 7, col. 2). FitzRoy wrote an earlier letter on the same subject also published in The Times, 1 Jan 1864 (p. 7, col. 1).
165. For evidence implicating Saxby see: The Meteorological Magazine, 1, (1854), pp. 18-19. This magazine apparently went out of publication after its fourth edition. It was published by Williams and Strachan of London (see p. 46).
166. Hansard, 3rd series, 175, cols. 401-402.
167. See: The Times, 14 May 1864 (p 10, col. 3). For Smith see: Elizabeth Inglis-Jones, Augustus Smith of Scilly, London, 1969, and D.N.B.
168. The articles appeared in Courier des Sciences and Bulletin International, two Paris magazines. FitzRoy devoted two pages of his 1864 Report to a refutation of their contents, op cit (note 137), app. G.
169. Much of the evidence for this does come from FitzRoy-related sources, for example: 1862 Report, op cit (note 127), ch. 10, para. 65; 1863 Report, op cit (note 135), para. 7-10; 1864 Report, op cit (note 137), app. H; but see also, for example: Davis, op cit (note 121); and, covering developments in Italy: C Matteucci, "Di un servizio meteorologico speciale", Nuova antologia di scienze, lettere ed arti, 33, (1867), pp. 708-722.

170. FitzRoy's salary was increased from £600 to £800, the whole of which was charged to the Board of Trade vote instead of the 50:50 split between the Board and the Admiralty that had been the system prior to this. FitzRoy was now on an equal footing to the other naval officers employed by the Board, including Sullivan, see P.R.O. BT 3/64, 379, 20 Jul 1863. Copies of the commissions promoting him to Rear Admiral and to Vice Admiral on the reserve list, dated 14 Feb 1857 and 12 Sep 1863 respectively, are held in the Dorset County Record Office, Dorchester.

171. R FitzRoy, Narrative of the surveying voyages of H.M.S. "Adventure" and H.M.S. "Beagle", 2, London, 1839, pp 671-672. FitzRoy also committed himself to a literal interpretation of the Creation as described in Genesis.

172. That FitzRoy could take a comparatively detached view of the Darwinian controversy is shown in a relaxed account of the famous debate at the British Association meeting in 1860 at Oxford, see FitzRoy to Washington, 11 Jul 1860, Hydrographic Office Library MS.

173. FitzRoy died leaving an estate of £3,400 with debts of £5,400, The Times, 10 Jul 1865, (p. 10, col. 6).

174. See: Anon., op cit (note 114), p. 412.

175. See: ibid; and Mellersh, op cit (note 90).

176. FitzRoy's predecessor in command of the "Beagle" was Capt Pringle Stokes. Amongst accounts suggesting a religious motive for FitzRoy's suicide are: A Moorhead, Darwin and the "Beagle", London, 1971, p. 212; and Charles Lewson's fascinating solo play, In the seventh circle, unpublished, which deals exclusively with FitzRoy's last hour of life. The idea that his meteorological work was responsible was put forward by, inter alia: Lord Stanley, The Times, 3 Sep 1866 (p. 10, col. 5); FitzRoy's wife, see Mellersh, op cit (note 90), p. 286; and the Royal Society obituary writer, see Proc. Roy. Soc., 15, (1866), p. xxiii.
177. Minute by T M Gibson, President of the Board of Trade, 9 Jun 1866. P.R.O. BT 5/74, 315.
178. The Athenaeum, 1960, (1865), p. 686. Also mentioned in Hooker to Darwin, op cit (note 105).
179. Details of the Babington family are contained in: Collectanea topographica et genealogica, 8, London, 1843, pp. 332-333; Anna Maria Babington, Memorials, journal and botanical correspondence of Charles Cardale Babington, Cambridge, 1897, (a family tree is contained in a pocket of the volume); and D.N.B..
180. Evan's F.R.S. was gained by his work on the effects of magnetism in iron ships, see: D.N.B.. Galton and Farrer have been noted earlier.
181. "Report of a committee appointed to consider certain questions relating to the Meteorological Department of the Board of Trade", P.P. 1866,LXV, pp. 329-418. (This committee will be referred to below as the "Galton Committee" and the report as the "Galton Report", or simply as "Galton").

182. For the comments and conclusions mentioned see: ibid, pp. 335-363.
183. See: FitzRoy to Washington, 24 Aug 1860, Hydrographic Office Library MS.
184. See: Galton Report, op cit (note 181), pp. 343-344, 362-370. The need for self-recording observatories arose from the difficulties encountered at the meeting of international meteorologists that was incorporated into the 1845 meeting of the British Association. Agreement as to standard times of observation could not be reached and the only way to obtain comparable observations was to have a continuous record. See: B.A.R. Cambridge, 1845.
185. Galton to Sabine, 16 Mar 1866, Royal Society Library, Sabine correspondence, Sa 586.
186. G J Symons, "The Meteorological Department of the Board of Trade", (Symons's) Mthly. Meteorol. Mag., 1, (1866), pp. 67-68.
187. "Weather forecasts", op cit (note 162).
188. This was probably Thomas Milner Gibson (President of the Board of Trade) to FitzRoy, 10 May 1862, Farrer papers, Dorset County Record Office, Doncaster, or related correspondence.
189. Galton Report, op cit (note 181), pp. 356-357.

190. See: 1868 Minutes, pp. 93-94, draft of letter to the Board of Trade; and "Eighth Report of the Royal Commission on scientific instruction and the advancement of science", P.P. 1875, XXVIII, pp. 484, 529, R H Scott in reply to Qs 13,933 and 14,459. The Commission was popularly known as The Devonshire Commission.
191. Galton Report, op cit (note 181), app. 7.
192. See: D A MacKenzie, Statistics in Britain, Edinburgh, 1981, pp. 63-68.
193. University College, London, Library, Francis Galton papers, 118/1. On a copy of the Galton Report, in the margin against the section containing the derived maxims, is an undated note in Galton's handwriting stating "Babington withheld information". It is probable that this was inserted in 1875 when Galton was asked to serve on a further committee appointed to inquire into the Meteorological Office.
194. See: the conclusions reached by Ruth Schwarz Cowan in "Nature and nurture: the interplay of biology and politics in the work of Francis Galton", in: William Coleman and Camille Limoges, eds., Studies in the history of biology, 1, Baltimore, 1977, pp. 133-165, esp. pp. 133-135; and Forrest, op cit (note 152), esp. the quote of Clements Markham pp. 68-69. Galton's character is also mentioned in Raymond E Fancher, "Francis Galton's African ethnology and its role in the development of his psychology", B.J.H.S., 16, (1983), pp. 67-79.

195. See the margin notes on his own copy of the Galton Report, probably inserted around 1875, op cit. (note 193). There is some evidence that the committee was not wholly unanimous in all its opinions although the final Report was signed by all three members. The failure by Galton to include Evans in his praise for the work of Farrer in connection with the Report is not otherwise readily explicable, see: Galton, op cit (note 152), p. 233. Differences over the naval role in meteorology were also evident. In his 16 Mar 1866 letter to Sabine, Galton noted that "We did not recommend the ocean statistics to go to the Admiralty because ... It appeared ... certain to Mr Farrer and myself that the regular scientific progress would be perpetually interrupted by calls to some special returns to meet supposed current wants ..." (my underlining) op cit (note 185).

196. C Abbe, "The progress of science as illustrated by the development of meteorology", Smith. Inst. Ann. Rep., (1907), Presidential address, pp. 289-290; Shaw, op cit (note 7), p. 9; Sir George Simpson, "FitzRoy and weather forecasts", Meteorol. Mag., 84, (1955), pp. 167-173.

197. Symons, for example, referred to his "... total lack of management ...", op cit (note 186), p. 67. Other evidence is not lacking.

198. "Synoptic chart", "weather forecast", "north and/or south cone", and "gale warning" are all terms emanating from FitzRoy. He also wished to change the name of the science itself to "metrology", see: FitzRoy to Herschel, op cit (note 104).

199. T Bergeron, "Synoptic meteorology: an historical review", Pageoph., Basel, 199, (1980/81), p. 446. The article is a reprint from the Rossby Memorial volume, ed. B Bolin, The atmosphere and sea in motion, New York, 1959.

200. The list of eulogies is a long one. Amongst the varied and distinguished list of eulogizers were: John Phillips, President of the British Association and holder of the chair of geology at Oxford, see: B.A.R. Birmingham, 1865, Presidential address; Lord Stanley in The Times, 3 Sep 1866, (p. 10, col. 5); the anonymous authors of the article "Admiral FitzRoy", op cit (note 114), and of the Royal Society's obituary notice, op cit (note 176); and even, if somewhat grudgingly, the Galton Committee, op cit (note 181), p. 371.

Chapter Six

201. The last forecast appeared in The Times on 28 May 1866. The following day no meteorological information appeared at all, whilst on the 30 May the ordinary weather report was published, but without the embellishment of a forecast.

202. The Board of Trade letter was Farrer to President, Royal Society, 30 Aug 1866. A copy was forwarded to the Admiralty who responded in W G Romaine (Secretary, Admiralty) to Secretary, Board of Trade, 4 Sep 1866. See: "Return of the establishment and cost annually from 1 Jan 1862 to 31 Dec 1866 of the Meteorological Department of the Board of Trade, and the annual cost of the proposed arrangements of the Royal Society for carrying on meteorological observations, and copy of the arrangements with the Royal Society", P.P. 1867, LXIII, pp. 497-512, letters on pp. 500-501.

203. W Sharpey (Secretary, Royal Society) to Secretary, Board of Trade, 27 Oct 1866, ibid, pp. 501-502.

204. Galton Report, op cit (note 181), p. 367.

205. Ibid, pp. 368-369.

206. This point is specifically made in Galton's letter to Sabine, 16 Mar 1866, op cit (note 185).

207. This dichotomy is covered, insofar as it effects meteorology, in a perceptive account by G B Tucker, "Research and services: differing attitudes within the science of meteorology", Weather, 31, (1976), pp. 104-113.
208. Farrer to Secretary, Treasury, 8 Nov, 1866, "Return of establishment", op cit (note 202), p. 503.
209. Scott's reply to Sabine's proposal was dated 29 Oct 1866. This referred to the proposal as having been received "last Wednesday". The 29 Oct was a Monday so that the date the proposal was received must have been 24 Oct. 1867 Minutes, p. 3. The Royal Society letter was dated 27 Oct (see note 203).
210. Board of Trade Circular, 29 Nov 1866, see: "Return of establishment", op cit (note 202), pp. 503-504.
211. George Ward Hunt (Financial Secretary, Treasury) to Secretary, Board of Trade, 30 Nov 1866. see: ibid, p. 505.
212. Royal Society Minutes of Council, 3, 13 Dec 1866, pp. 346-347.
213. Biographical details of the members of the Meteorological Committee, who were all Fellows of the Royal Society, may be obtained in D.N.B..
214. Simmonds was temporarily appointed "... to carry on the business of the Meteorological Department ..." on 7 Dec 1866, P.R.O. BT 5/74, no. 323.
215. 1867 Minutes, p. 2.

216. Scott's permanent appointment to this position is recorded in: Proc. Roy. Dublin. Soc., 102, 6 Jul 1865 to 27 Jan 1866, p. 96.
217. No biography of Scott is extant nor does he rate a mention in D.N.B.. Sparse information about his career is given in: Who was who 1916 -1928. Although he was a Fellow of the Royal Society there does not appear to be an obituary notice of Scott in the Society's publications, although an obituary, written by Sir Napier Shaw, appeared in: Nature, 97, (1916), pp. 365-366.
218. Details of the Brodrick family are given in the Benyon papers held in the Berkshire County Record Office, Reading, ref. D/EBY/F48 and F49. See also Debrett's Peerage.
219. The Brodrick holdings are listed in: John Bateman, The great landowners of Great Britain and Northern Ireland, London, 1883, p. 309.
220. See: A C London (Tait was then Bishop of London) to Earl Granville, 8 Dec 1859, Benyon papers no. 95, op cit (note 218).
221. For example, FitzRoy to Scott, 21 Aug 1861, Benyon papers no. 113, op cit (note 218).
222. See: H W Bellairs, Familia de Bellairs, Oxford, 1899, p. 27 and family tree opp. p. 32.
223. The proposed duties were outlined in Galton to Sabine, 16 Mar 1866, see pp. 58-59 above and note 185.

224. Details of Stewart's remuneration are contained in the annual reports of the Kew Committee which were published as part of the British Association Reports. For example: B.A.R. Liverpool, 1870, pp. xlvi-xlix. For further background on Stewart see: D.N.B.
225. See: Henry G Lennox (Secretary, Admiralty) to Secretary, Board of Trade, 28 Nov 1866, "Return of establishment", op cit (note 202), p. 503.
226. See: A T Bench, "Reminiscences of the Meteorological Office, 1898-1910", Meteorol. Mag., 110, (1981), pp. 323-329. FitzRoy had started the idea of marking the observation books he received, and giving rewards to those considered "excellent", at the start of his campaign to collect marine statistics.
227. Sabine to Secretary, Board of Trade, P.R.O. T1/6754A/19916.
228. The date of Scott's accession is noted in the 1867 Report, P.P. 1867-8, LXIII, p. 300. Simmonds resignation and the adoption of the new title are both recorded in the 1867 Minutes, p. 16.
229. Farrer to Secretary, Treasury, 8 Feb 1867, P.R.O. T1/6754A/19916. Ironically, of course, Farrer had been a member of the Galton Committee that had recommended continuance of the warnings.
230. See, for example, D S L Cardwell, The organisation of science in England, London, 1972, esp. p. 107.

231. R M MacLeod, "Science and the Treasury: principles, personalities and policies 1870-85" in : ed, G L'E Turner, The patronage of science in the nineteenth century, Leyden, 1976, pp 115-161, the quotation is on p. 141.
232. This is P.R.O. Treasury file T1/6754A/19916 (see notes 227 and 229).
233. George Ward Hunt was at this time M.P. for Northamptonshire (North) and Junior (Financial) Secretary to the Treasury; in the following year he was to succeed Disraeli as Chancellor of the Exchequer. Welby was Private Secretary to the Junior Secretary but was to follow Hamilton, Lingen's successor, as Permanent Secretary in 1885. See D.N.B. for both men.
234. The two letters were Thomas Gray (Board of Trade) to Secretary, Treasury, 12 Mar 1867, P.R.O. T1/6754A/19916, and George A Hamilton to T H Farrer, 10 Apr 1867, see: "Return of establishment", op cit (note 202), p. 509.
235. George Ward Hunt to T H Farrer, 17 Apr 1867, see: "Return of establishment", ibid, p. 510.
236. See: Thomas Gray to Secretary, Treasury, 6 Apr 1867, and accompanying notes, one undated, one of 10 Apr, P.R.O. T1/6754A/19916, corr. no. 5933; the Treasury and Board of Trade letters of 20 and 29 Apr respectively are printed in the 1867 Minutes, pp. 43-44.
237. This was at 13 Ashley Place, Westminster. The Committee usually met in the Meteorological Office, at 2 Parliament Street, at this time.

238. Robert H Scott to Thomas Gray, 23 Apr 1867, P.R.O.
T1/6754A/19916. The letter began by acknowledging "... the receipt of a letter ... dated April 15th 1867, enclosing a copy of one from the Treasury dated April 10th in reply to one from the Board of Trade of February 8th. Also of a second letter dated April 17th enclosing a copy of one from the Treasury of same date in reply to one from the Board of Trade of March 12th ..."!
239. 1867 Minutes, p. 41.
240. 1867 Minutes, p. 43.
241. The letter was actually corrected twice, firstly at the Committee meeting on 29 Apr, following the modification to the Treasury letter of 10 Apr, *secondly at the meeting on 6 May following the amendments to the Board of Trade letters of 15 and 17 Apr and the Treasury letter of 17 Apr.* 1867 Minutes, pp 41-44.
242. Farrer to Secretary, Treasury, 23 May 1867, P.R.O.
T1/6754A/19916 ref. M3408.
243. Hunt to Farrer, 5 Jun 1867, P.R.O. T1/6754A/19916 ref. M4524.
244. Note Welby to Shelley, 6 Jun 1867, filed with the letter referenced in note 243.
245. Scott to Gray, 18 Dec 1867, and Gray to Secretary, Treasury, 19 Dec 1867, P.R.O. T1/6754A/19916 ref. M9423.
246. Note, Welby to Hunt, undated, filed with the letter referenced in note 229.

247. This was stated by Scott in evidence given to the Devonshire Commission in Apr 1874. See: Eighth Report of the Devonshire Commission, op cit (note 190). Scott was replying to Q 13,867 by the Chairman T H Huxley, p. 477.

248. See: Hamilton to Farrer, op cit (note 234).

249. William Law (Treasury) to Secretary, Board of Trade, 27 Apr 1868, see: 1868 Minutes, p. 35. (Treasury underlining).

250. 1868 Minutes, pp. 35, 37.

251. Eighth Report of the Devonshire Commission, op cit (note 190), pp. 479, 487. Scott's replies to Qs 13,904 and 13,972.

Chapter Seven

252. P.R.O., BJ 1/98.

253. It was primarily for work on this latter subject that Staff Commander F J Evans R.N., a member of the Galton Committee in 1866, was most probably elected a F.R.S..

254. Baxendell to Sabine, 22 Mar 1867. The letter was reproduced in full in the Manchester Courier, 26 Mar 1867. In evidence to the Devonshire Commission Sabine later pointed to the change in Government as a reason for the decrease in expected funding of the Meteorological Committee, see "Fifth Report of the Royal Commission on scientific instruction and the advancement of science", P.P. 1874, XXII, p. 245, answer to Q 11,230. This does not accord with the facts. The Earl of Derby's Conservative Government succeeded Earl Russell's Liberal ministry on 6 Jul 1866, but the approach by the Board of Trade to the Royal Society for advice was not made until the end of August. The Treasury's apparent acceptance of the Society's recommendations was dated 30 Nov (see pp. 65-68 and 79-81 above).

255. See: "Copy of the memorials or communications to the Board of Trade respecting the discontinuance of storm signals as heretofore practised by the Board of Trade", P.P. 1867, LXIV, pp. 185-203; and "Storm signals, further return", P.P. 1867, LXIV, pp. 205-208. In all 40 letters are listed, including replies.

256. Hansard, 3rd series, 185, cols. 1029-30. For further details of Sykes see: D.N.B.

257. The official British Association Report gives only perfunctory coverage to this debate but it was covered more fully by Symons. See: B.A.R., Dundee, 1867, p. 27, and (Symons's) Mthly. Meteorol. Mag., 2, (1867), 21, pp. 99-105. For Buccleuch (Walter Francis Scott) and Belcher, the distinguished if irascible navigator, see D.N.B., Don was President of the Dundee Chamber of Commerce.

258. A lesson from Victorian times that has still not been learned. The recent disasters of the "Herald of Free Enterprise" and the Kings Cross station fire both provide strong prima facie cases of cost cutting and profit enhancing practices that were introduced to the detriment of public safety.

259. See also: Tucker, op cit, (note 207).

260. See: Farrer to Scott, 31 May 1867, 1867 Minutes, p. 49.

261. The only evidence for this appears to be in Scott's evidence to the Devonshire Commission, Eighth Report, op cit (note 190), p. 529, Scott in reply to Q 14,461.

262. 1867 Minutes, pp. 27-28.

263. See: Scott to Secretary, Board of Trade, 8 Jun 1867. In: "Storm warnings", P.P. 1867 LXIV, pp. 209-210; also 1867 Minutes, p. 53.

264. See: Gray to Scott, 11 Jul 1867, and Scott to Gray, 15 Jul 1867. In: "Storm warnings", P.P. 1867-8, LXIII, p. 391; also 1867 Minutes, p.57.

265. R H Scott, Weather charts and storm warnings, London, 1887, p. 145.
266. See: Scott to Gray, 15 Jul 1867, and C Cecil Trevor (Board of Trade) to Scott, 5 Aug 1867. In: "Storm warnings", op cit (note 264), pp. 391-392; also 1867 Minutes, pp. 57-59.
267. Elphinstone to Duke of Richmond, 22 Oct 1867. In: "Storm warnings", ibid, pp., 392-393. For Elphinstone see: F. Boase, Modern English biography, London, 1965.
268. See: 1867 Minutes, pp. 75-76. The idea of using Toynbee's semaphores had not been abandoned by the Committee at this stage as is shown by letters from Robert C May, the manufacturer of the signals, p. 77.
269. Scott to Farrer, 7 Nov 1867. In: "Storm warnings", op cit (note 264), pp. 394-395; also 1867 Minutes, pp. 76-77.
270. Farrer to Scott, 13 Nov 1867. In: "Storm warnings", ibid, p. 395; also 1867 Minutes, p.81.
271. Scott to Farrer, 22 Nov 1867. In: "Storm warnings", ibid, pp. 399-401, the draft circular was enclosure 2 to this letter; also 1867 Minutes, p. 83.
272. This was the system that had irritated FitzRoy when it was instituted by the Board without reference to him in 1861 (see pp. 51-52). The request from the Committee is contained in Scott to Farrer, 19 Nov 1867. In: "Storm warnings", ibid, pp. 395-396; also 1867 Minutes, p. 81.

273. 1867 Report, op cit (note 228), p. 314.
274. "Wrecks and casualties", P.P. 1871, LXI, p. 681.
275. 1867 Report, op cit (note 228), p 308.
276. The system adopted is described in, for example, the 1868 Report, P.P. 1868-9, XXIII, pp. 71-72. This was broadly the same as that originally proposed by Scott in his report of 3 Jun 1867, 1867 Minutes, p. 49.
277. See: 1868 Minutes, pp. 85, 93-94; and Eighth Report of the Devonshire Commission, op cit (note 190), p. 484, R H Scott in reply to Q 13,933; and p. 530, R H Scott in reply to Q 14, 463.
278. 1873 Minutes, pp. 71-72, 76; and 1874 Minutes, p. 4. The recommendations that were adopted by the Vienna Congress had been proposed by a sub-committee of three appointed at an earlier international meteorological conference at Leipzig in 1872. The three appointees were Buys Ballot (Netherlands), Neumayer (Germany) and Scott. The sub-committee's recommendations were published separately as: Report on weather telegraphy and storm warnings, London, 1874. A firm recommendation by the sub-committee in favour of storm warnings was presumably fully supported by Scott.
279. See: Eighth Report of the Devonshire Commission, op cit (note 190), p. 530, Scott's reply to Q 14,465.
280. See, for example: Scott, op cit (note 265), pp. 141-144.

281. Some contemporary views on this subject are expressed in replies to a questionnaire published as part of the Report on weather telegraphy, op cit (note 278). In particular the answers by Strachan, Symons, Toynbee and Vernon (all British) pp. 51-55.

282. See: Scott, op cit (note 265), pp. 140-141. Scott also pays due respect to FitzRoy's contribution in : R H Scott, Storm warnings, London, 1883. The text of this publication was originally delivered as a lecture in connection with the Great International Fisheries Exhibition, being published separately later.

283. FitzRoy was rather ambiguous on this point and on a number of occasions he denied that the work had stopped, for example in his 1864 Report, op cit (note 137), pp. 127-128. The Galton Report specifically referred to the work having ceased, op cit (note 181), p. 334.

284. 1867 Minutes, pp. 4-5. The list of duties was drawn up by Capt Richards, the Hydrographer.

285. See: Galton Report, op cit (note 137), pp. 337-340.

286. 1867 Minutes, pp. 12-31.

287. Details of Toynbee's re-organization are contained in: 1868 Minutes, p. 99, and 1873 Minutes, p. 79.

288. 1867 Report, op cit (note 228), pp. 301-302.

289. Remarked by Maury in his comments on a preliminary draft of the Square 3 data for the month of January, 1872 Minutes, p. 56.

290. 1873 Minutes, pp. 42-43.
291. The comments are presented in the 1872 Minutes, pp. 52-59.
292. 1875 Minutes, pp. 27-28.
293. 1868 Report, P.P. 1868-69, XXIII, pp. 67-68.
294. For example: Capt H Toynbee, Meteorology of the North Atlantic between 40°-50°N, non-official 2, London 1869; Physical geography of the Atlantic 20°N-10°S and 10°-40°W, non-official 10, London, 1876.
295. See: Shaw, op cit (note 7), pp. 188, 221. For example Koppen, the distinguished Russian meteorologist who later moved to Germany, advocated reduction of pressure to 106 m above sea level as the mean altitude of the 1000 mb level.
296. Alexander Buchan, The handy book of meteorology, Edinburgh, 1867. Buchan advocated the use of isobarometric lines on pp. 140-141. The second edition of the same book was published in 1868; in it Buchan described the use of isobarometric lines for analyzing storms in chap 12, and produced three charts of mean sea level pressure over the world showing the mean pressure distribution during January, July and annually.
297. 1869 Minutes, p. 1. The comments were made by Miller.
298. See: 1869 Minutes, p. 69. The Committee decided that in future papers published under their authority should be in two series (i) official and (ii) non-official. The paper eventually saw the light of day as: Capt H Toynbee, The use of isobaric curves, London, 1869.

299. This was mentioned by a later member of the staff in: Bench, op cit (note 226), p. 324. The article was written long after the events that it describes actually took place and cannot be regarded as a true primary source. Bench quotes one of the pamphlets as being titled "Go down, proud stomach"; another was published as Capt H Toynbee, The basest thing in the world, London, 1891, in which seven further pamphlets by the same author are listed, as well as Weather forecasting for the British Isles (undated). (The basest thing was concern for oneself).

300. See: 1867 Minutes, pp. 67, 78.

301. 1868 Minutes, pp. 28, 33.

302. 1871 Minutes, pp. 51, 54.

303. See: Scott, op cit (note 265), p. 16.

304. 1868 Minutes, pp. 1-2, 11.

305. 1869 Minutes, pp. 6, 9, 15.

306. This was in evidence to a Treasury Committee appointed to enquire into the Meteorological Office. See: "Report of the Treasury Committee appointed to inquire into the conditions and mode of administration of the annual grant in aid of meteorological observations", P.P. 1877, XXXIII, pp. 731-957; esp. p. 772, answers by Scott to Qs 553-559.

307. Galton Report, op cit (note 181), pp. 363-366.

308. Sabine to Secretary, Board of Trade, 15 Jun 1865, op cit (note 212), 15 Jun 1861, pp. 255-261.
309. 1867 Minutes, p. 2.
310. For a contemporary account of Kew Observatory see: Scott, op cit (note 100).
311. See: Galton Report, op cit (note 181), p. 368, for Galton's comments. The Meteorological Committee's estimate was given in: Sabine to Secretary, Board of Trade, 21 Jan 1867, P.R.O. T1/6754A/19916; also in "Return of establishment", op cit (note 202), pp. 506-508.
312. See: 1867 Minutes, pp. 9-10.
313. 1867 Minutes, pp. 30, 33, 60.
314. A detailed description of the instruments and mode of recording is given in the 1867 Report, op cit (note 228), pp. 321-359; Robinson's anemometer is described in G J Symons, "Anemometers", (Symons's) Mthly. Meteorol. Mag., 17, (1867), pp. 63-66; a full account of the Beckley-Robinson (or Kew model) anemometer appears in B.A.R. Leeds, 1858.
315. 1867 Minutes, pp. 30, 60, 88.
316. Kew Observatory was something of a drain on the Association's resources. See: A D Orange, "The beginnings of the British Association 1831-1851", in R M MacLeod and P M D Collins (eds), The Parliament of science, Northwood, 1981, p. 56; Morrell and Thackray, op cit (note 100), pp. 522-523; and Howarth, op cit (note 100), p. 154.

317. 1867 Minutes, pp. 67, 71.
318. 1869 minutes, p. 103. The offer was made following the receipt of a letter of resignation from Stewart dated 8 Oct 1869, the resignation to take effect from the end of the financial year.
319. B.A.R. Liverpool, 1870, p. xlix.
320. 1871 Minutes, pp. 39-40.
321. 1867 Minutes, pp. 35, 58, 61, 71.
322. 1868 Minutes, p. 18, and 1868 Report, op cit (note 293), p. 76.
323. 1867 Minutes, pp. 60, 71, 94.
324. 1867 Minutes, pp. 63, 67.
325. 1868 Minutes, p. 32.
326. 1867 Minutes, pp. 16, 61, 63, 94.
327. Eight observatories are mentioned in the estimates submitted by the Meteorological Committee at the time of the re-organization during early 1867. See: Sabine to Secretary, Board of Trade, 21 Jan 1867, op cit (note 311).
328. 1867 Report, op cit (note 228), p. 319.
329. 1867 Minutes, pp. 59-60.

330. 1867 Report, op cit (note 228), p. 320.
331. 1868 Minutes, p. 31.
332. 1867 Minutes, p. 73.
333. 1868 Minutes, p. 28.
334. 1867 Minutes, pp. 37, 45, 65, 82, 85.
335. 1868 Minutes, pp. 23, 37, 54, 62.
336. 1868 Minutes, pp. 61, 72, 73.
337. Eighth Report of the Devonshire Commission, op cit (note 190), pp. 533-534. Glaisher in reply to Qs 14,515-14,517. He quoted the height of the Aberdeen thermometer screen as "... 48 feet above the ground and close to a stone wall..."
338. The best method of doing this was considered in detail and set out in the 1868 Minutes, pp. 48-49.
339. Scott presented a report to the Committee on 29 Nov 1869 in which he recommended quarterly publication of reproductions of the traces produced by the self recording instruments, see: 1869 Minutes, pp. 105-106. The decision to publish lithographed copies was taken on 10 Jan 1870, see: 1870 Minutes, p. 1.

340. Stewart's side in this episode was very strongly taken in: Sir Arthur Schuster, Biographical fragments, London, 1932, although it must be remembered that Schuster had risen under Stewart at Manchester University. The unequivocal accusation by Scott came in: Scott to Prof. G G Stokes, 2 Nov 1885, University Library, Cambridge, archives, Stokes correspondence Add. MS 7656, letter MC 163. Scott, of course, was very close to Sabine.

341. See D.N.B..

342. See: 1873 Minutes, p. 77. This was also mentioned by Stewart in evidence given to the Devonshire Commission. Eighth Report of the Devonshire Commission, op cit (note 190), p. 491, Stewarts reply to Q 14,021.

343. 1874 Minutes, pp. 1, 26, 89.

344. 1867 Report, op cit (note 228), pp. 358-360.

345. Sir Napier Shaw, "The march of meteorology", Quart. J. R. Met. Soc., 55, (1934). pp. 101-120, see p. 105.

346. Sir David Brunt, "A hundred years of meteorology", The advancement of science, 30, (1951). pp. 1-11, esp. p. 8.

347. See Scott's memorandum of 3 Jan 1867 to the Committee and also Farrer to Richards, 4 Jan 1867, 1867 Minutes, pp. 2-3.

348. Proc. Roy. Dublin. Soc., op cit (note 216), p. 96. See also pp. 71-72 above.

349. 1867 Minutes, pp. 7, 16. Despite the Committee's refusal to consider an incremental scale for Toynbee they did, in fact, give incremental rises to the clerks.
350. 1868 Minutes, p. 32.
351. 1869 Minutes, p. 15.
352. 1867 Minutes, p. 11.
353. The table is taken from the 1867 Minutes, pp. 16, 19.
354. 1867 Minutes, pp. 28, 30.
355. Under the new regime all appointments were on a year to year basis emphasizing the experimental nature and impermanence of the Meteorological Office during this period. The re-appointments are noted in the 1867 Minutes, p. 70.
356. 1874 Minutes, p. 38.
357. Eighth Report of the Devonshire Commission, op cit (note 190), p. 488. The table is from the information supplied by Scott in reply to Q 13,991 (taken from the Civil Service Estimates 1874-75 and other sources).
358. The letters were: Scott to Thomas Gray, 4 Feb 1868, and Gray to Scott, 12 Feb 1868. See: 1868 Minutes, p. 15.

359. George Russell (Office of Works) to Scott, 24 Feb 1869; Scott to Russell, 25 Feb 1869; and Scott to Gray, 1 Mar 1869. See: 1869 Minutes, p. 19.

360. 1869 Minutes, pp. 40, 41, 51, 52.

361. See also: Jacobs, op cit (note 93). The number was changed from 116 to 63 Victoria Street in 1888.

362. Sir Napier Shaw to Sir Frederick Sykes, 16 Nov 1920. Shaw correspondence now held in the University Library, Cambridge.

363. The report of the inquiry is given in the Treasury Committee Report, op cit (note 306).

364. W Law to Secretary, Board of Trade, 27 Sep 1873, 1873 Minutes, p. 51.

Chapter Eight

365. See: op cit (note 212), 21 Mar 1867, p. 361.
366. Spottiswoode, Hirst, Busk, Lubbock, Hooker, Tyndall, Huxley and Frankland to Sec of the Royal Society, 8 Apr 1867, see: ibid, 22 Apr 1867, p. 468. For the X-Club see: Roy M MacLeod, "The X-Club a social network of science in late-Victorian England", Notes and records of the Royal Society of London, 24, 1969, pp. 305-322.
367. "Copy of letter addressed to the Board of Trade by the Meteorological Committee appointed by the Royal Society, at the request of the Government, on the subject of the relations of that Committee with the Government", P.P. 1868-69, XLVII, pp. 749-752. The letter was dated 22 Apr 1869.
368. For Airy see D.N.B.; also W Airy ed., Autobiography of Sir George Biddell Airy, Cambridge 1896.
369. See: Hall, op cit (note 89), pp. 155-156. See also p. 29 above.
370. See: 1871 Minutes, p. 61; also Eighth Report of the Devonshire Commission, op cit (note 190), p. 480, Scott in reply to Q. 13,913.
371. This was the letter quoted in note 367.

372. The whole of the correspondence and debate concerning the Airy affair is contained in the 1872 Minutes, pp. 1-10. It was also reviewed at some length by the Devonshire Commission, see their Eighth Report, op cit (note 190), pp. 479-481, Qs 13,912-13,915 put to Scott by T H Huxley, the chairman.

373. Airy, ed., op cit (note 368), p. 396.

374. See, for example, D S L Cardwell, op cit (note 230), pp. 119-126, and Roy M MacLeod, "Resources of science in Victorian England: the endowment of science movement, 1868-1900" in : ed. Peter Mathias, Science and society 1600-1900, Cambridge, 1972, esp. pp. 126-127. For Strange see: D.N.B.

375. The eight reports are found as follows: First P.P. 1871 XXIV, p. 643; Second, P.P. 1872, XXV, p. 1; Third, P.P. 1873, XXVIII, p. 637; Fourth, P.P. 1874, XXII, p. 1; Fifth, P.P. 1874, XXII, p. 51; Sixth, P.P. 1875, XXVIII, p. 59; Seventh, P.P. 1875, XXVIII, p. 337; Eighth, PP 1875, XXVIII, p. 417.

376. Eighth Report of the Devonshire Commission, op cit (note 190), pp. 423-424.

377. Fifth Report of the Devonshire Commission, op cit (note 254), pp. 177-179, esp. in answer to Qs 10,330 and 10,342-10,343.

378. Ibid, pp 252-267. See also pp. 106-107 and note 342 above.

379. Ibid, pp. 345-369, esp. Milne Home's answer to Q 12,527, p. 358.

380. Ibid, pp. 244-251 (Sabine) and pp. 370-374 (Farrer), esp. Farrer's answer to Q 12,639.
381. Eighth Report of the Devonshire Commission, op cit (note 190), pp. 477-490.
382. Ibid, pp. 522-540, esp. in answer to Qs 14,444-14,447 and 14,454-14,467.
383. Ibid, pp. 507-513, esp. in answer to Qs 14,217, 14,254, 14,288-14,289 and 14,294-14,296.
384. Ibid, pp. 492, 497 in answer to Qs 14,035-14,036 and 14,103-14,104.
385. Ibid, pp. 495-496, in answer to Qs 14,075-14,090.
386. Ibid, pp. 532-536, esp. in answer to Qs 14,515-14,524 and 14,549.
387. Glaisher to Register General, 3 Feb 1873, quoted in ibid. app. 2, pp. 546-547.
388. Ibid., pp. 446-448, "Remarks on the foregoing evidence", esp. para. 3.
389. Ibid, pp. 469-472.
390. See: 1867 Minutes, pp. 55-56.

391. See: J B Morrell. "The patronage of mid-Victorian science in the University of Edinburgh", p. 23, in: The patronage of science in the nineteenth century, B.S.H.S. conference, held at the Royal Society, 14 Apr 1972. Also published in: Science studies, 3, pp. 353-388.
392. See: "Memorial of the Scottish Meteorological Society to H M Board of Trade", 18 Jul 1866 in: "Copy of all memorials or communications to the Board of Trade respecting the discontinuance of storm signals as heretofore practised by the Board of Trade", P.P. 1867 LXIV, pp. 185-208, esp. p. 187.
393. See: 1867 Minutes, p. 56.
394. Johnston to Scott, 16 Oct 1868, and Scott to Johnston (draft approved), 1868 Minutes, pp. 69-70.
395. Scott to Scottish Meteorological Society, 2 Nov 1868, 1868 Minutes, p. 81.
396. The letters from the Treasury, Board of Trade, Scottish Meteorological Society and Office of Works were all presented, and the Committee's responses were drafted, at their meeting of 1 Mar 1869. 1869 Minutes, pp. 19-21.
397. Johnston to Scott, 9 Mar 1869, 1869 Minutes, p. 23.
398. The exchange of letters comprised: Scott to Johnston, 19 Jan 1870; Thomas Stevenson to Scott, 7 Mar 1870, and Scott to Stevenson, 22 Mar 1870 (draft approved), see: 1870 Minutes, pp. 24-25.
399. 1870 Minutes, pp. 35-36.

400. The letter was Johnston to Scott, 9 May 1870, which appears in the 1870 Minutes, p. 51. The relevant extract from the minutes of the Scottish Council's 26 Apr meeting is also printed on the same page.
401. Eighth Report of the Devonshire Commission, op cit (note 190), pp. 482-484. Contained in Scott's very lengthy reply to Q 13,932.
402. Treasury Committee Report, op cit (note 306). This point was strongly emphasized in the exchange of questions and answers between Milne Home (who was a member of the Treasury Committee) and Stevenson (who was called to give evidence), p. 821, Qs 1,436-1,446. Johnston had died in 1871.
403. The deputation is mentioned in the Fifth Report of the Devonshire Commission, op cit (note 375), p. 258, answer by Milne Home to Q 12,527; also in W E Baxter (Treasury) to the Marquis of Tweeddale (Pres. Scottish Met. Soc.), 4 Aug 1873, see 1874 Minutes, pp. 5-6. Playfair's interest is evident from Gray to Scott, 23 Mar 1870, and Gray to Playfair, 5 Apr 1870, pp. 32, 37.
404. Scott to Johnston, 10 and 16 May 1870, and Johnston to Scott, 13 May 1870, 1870 Minutes, pp. 51-52.
405. 1872 Minutes, p. 39.
406. Eighth Report of the Devonshire Commission, op cit (note 190), esp. pp. 482-484 in replies to Qs 13,929-13,932 (see note 401 above).
407. 1872 Minutes, p. 43.

408. Scott to Secretary, Scottish Meteorological Society, 9 Nov 1872, see: 1872 Minutes, p. 88.
409. See: 1872 Minutes, p. 88.
410. H J Hanham, Scottish nationalism, London, 1969, p. 81.
411. Scott to Stevenson, 10 Dec 1872, 1872 Minutes, pp. 88-89.
412. 1872 Minutes, p. 89.
413. 1873 Minutes, p. 2. A copy of the resolution was duly forwarded to Edinburgh.
414. 1873 Minutes, pp. 6-8.
415. 1873 Minutes, pp. 12-13.
416. Gray to Director, Meteorological Office, 20 Mar 1873, enclosing a copy of Tweeddale to Secretary, Board of Trade, 12 Mar 1873, 1873 Minutes, pp. 16-17.
417. Scott to Gray, draft approved 31 Mar 1873; Gray to Scott, 28 Apr 1873; and Stevenson to Assistant Secretary, Marine Dept., Board of Trade, 2 May 1873. See: 1873 Minutes, pp. 19, 26, 34.
418. See: Stevenson to Scott, 17 Jan 1874, enclosing Tweeddale to Secretary Treasury, 9 Jul 1873, and Baxter to Tweeddale, 4 Aug 1873. Scott's reply was drafted 19 Jan 1874. A copy of the Scottish memorial was forwarded with an enclosing letter Stevenson to Scott, 30 Jan 1874. 1874 Minutes, pp. 5-6, 14-15.

419. The initial overture came via the Board of Trade in Robert James Mann (President, Meteorological Society) to Gray, 4 Feb 1874, see: 1874 Minutes, p. 18. Negotiations were finally concluded by Symons (Secretary, Meteorological Society) to Scott, 23 Feb 1875, see: 1875 Minutes, p. 19. The move followed preliminary enquiries from the Board of Trade and the Treasury about the supplying of returns for the Registrar General. See: 1872 Minutes, pp. 63, 86; and Eighth Report of the Devonshire Commission, op cit (note 190), appendices pp. 544-547.
420. 1875 Minutes, pp. 1, 20-21.
421. 1875 Minutes, p. 32.
422. Noted in the 1875 Minutes, p. 54.
423. Treasury Committee Report, op cit (note 306), pp. 733-734.
424. See Galton Report, op cit (note 181) and pp. 56-57 above.
425. Farrer's reluctance is apparent in a written note on the back of a letter W H Smith (Treasury) to Farrer, 10 Nov 1875, P.R.O. BT 13/8, file E2805.
426. For members of the Committee see D.N.B.. The appointments are noted in the Treasury Committee Report, op cit (note 306), pp. 733-734.
427. Treasury Committee Report, ibid, p. 734, extract from minute of 29 Nov 1875. For Milne Home see: F Boase, Modern English Biography, 1, London, 1965.

428. Treasury Committee Report, ibid, pp. 733-734.
429. Ibid. The list of witnesses is given on p. 740; the Royal Society letter responding to Maxwell's request for comments appears as Appendix IV, pp. 889-890.
430. Ibid. The actual report is at pp. 735-738., see esp. para. 3.
431. Ibid. The relevant recommendations are on p. 735 in paras. 4-7 of the Report. Evans's objections are given in his answers to Qs 625, 629-647, 672-674; Richards's support for the idea is shown in his answers to Qs 703-708, 725-732, 764-799, although his answer to Q 714 shows him unwilling to insist on its implementation against the Hydrographer's wishes.
432. Ibid, pp. 735-736, paras. 8-9
433. Ibid, app. 4, pp. 889-890.
434. Ibid, pp. 736-737, paras 10-19.
435. Ibid, pp. 737-738, para. 22.
436. This recommendation was not specifically spelled out in the Report but was inferred in "Outline of duties of future Council", ibid, p. 739. It was certainly implemented with vigour.
437. Ibid, p. 737, para. 21.
438. Ibid, p. 739. The ascription of authorship is given at p. 736, para. 24.

Chapter Nine

439. 1877 Minutes, p.20. It should be noted that this conflicts with the interpretation given in Hall op cit (note 89), p. 159. Hall ascribes the resignation of the Committee as being directed towards constituting the Meteorological Office within the Government service. This would seem to be erroneous. At no time was such a proposal given significant support, and the constitution of the Office following the Treasury Committee Report was no more related to the Government service than it had been between 1867-1877.

440. See G G Stokes (Secretary, Royal Society) to Scott, 9 Jul 1877. 1877-78 Minutes, p. 1.

441. For Stokes see D.N.B., also, for example, Arthur Schuster and Arthur E Shipley, Britain's heritage of science, London, 1918, pp. 123-125.

442. For Smith see Alexander Macfarlane, "Henry John Stephen Smith", in eds. Mansfield Merriman and Robert S Woodward, Lectures on ten British mathematicians of the 19th century, New York, 1916, pp. 92-106, and Keith Hannabus, "The mathematician the world forgot", New Scientist, 97, (1983), pp. 901-903; also D.N.B..

443. Airy told the Treasury Committee that meteorology was "... in a state in which it cannot be called a science at all ...", Treasury Committee Report, op cit (note 306), p. 794, in answer to Q 940. Glaisher's views have been noted above, pp. 119-120.

444. The supplementary vote of £2,000 is noted in William Law (Treasury) to Secretary, Meteorological Office, 18 Aug 1877, see 1877-78 Minutes, p. 16; the insertion of £14,500 in the Civil Service Estimates is noted in the same ref. p. 76.
445. 1877-78 Minutes, p. 2.
446. See the Report of the Committee on Land Meteorology and the two letters Smith to Buchan, 31 Jul 1877, and Buchan to Smith, 30 Aug 1877, 1877-78 Minutes, pp. 11-12.
447. Treasury Committee Report, op cit (note 306), p. 737, paras. 17, 21.
448. The Rothschild proposals were presented in Cmnd 4814. "A framework for Government research and development", London, 1971. The proposals are discussed inter alia in Philip Gummett, Scientists in Whitehall, Manchester, 1980, esp. pp. 195-199.
449. 1877-78 Minutes, pp.13-14.
450. Galton's supposed move away from meteorology is mentioned in: Cowan, op cit (note 194), p. 150; and in: Forrest, op cit (note 152), p. 81.
451. Treasury Committee Report, op cit (note 306), pp. 835-842, esp. in answer to Qs 1700-1720 and 1733-1810.

452. The various reports are to be found in the relevant minutes of the Meteorological Council. The Scott-Stokes correspondence is held in the archives of the University Library, Cambridge, in the Stokes collection, Add. MS 7656, mostly under serial nos. MC 1-207 and S 291-305.

453. Quoted from Sir Napier Shaw's reply when presented with his portrait at the time of his retirement, 22 Jun 1921. The text of Shaw's reply at this ceremony is contained in the Shaw papers now held in the University Library, Cambridge.

454. 1890-91 Minutes, pp. 20-21.

455. Capt. Abney's involvement is first noted in the 1878-79 Minutes, p. 72; his proposals for carrying out the project are given in the 1879-80 Minutes, pp. 1-2. Abney was a prominent pioneer in the advancement of practical photography and was a Rumford medallist in 1882. See D.N.B.. The experiments were also mentioned in Shaw, op cit (note 345), p. 106.

456. Shaw, op cit (note 453).

457. The first manned flight in a Montgolfier balloon took place on 21 Nov 1783, the first aeronauts being Francois Pilatre de Rozier and the Marquis d'Arlandes. See, for example, John and Beryl Kington, "When the air-age lifted off", Geog. Mag., 60, (1983), pp. 587-590.

458. There are many references to these early balloon flights, for example Shaw, op cit (note 7), pp. 207, 222-223, 266, and op cit (note 345), p. 106; and James Glaisher, "Scientific experiments in balloons", in Lectures delivered before the YMCA in Exeter Hall, Nov 1862-Feb 1863, London, 1863, as well as in Meteorological Society and Kew Committee

reports. The formation and disbandment of the Balloon Committee of the British Association are noted in B.A.R. Aberdeen, 1859, p. 289 and B.A.R. Manchester, 1861, p. 250.

459. 1880-81 Minutes, pp. 81, 91. Russell's work is described in: Peter Brimblecombe, The big smoke, London, 1987, esp. pp. 145-153.

460. Templer's report and correspondence relative to the tragedy are reproduced in the 1881-82 Minutes, pp. 100-103.

461. 1884-85 Minutes, pp. 46-47, 103, 109.

462. 1901-02 Minutes, p. 68. The British Meteorological Society was granted the title "Royal" in 1883, see Ratcliffe, op cit (note 37), p. 262.

463. See: Shaw, op cit (note 345), p. 107; also Noble to Scott, 19 Mar 1884, in the 1883-84 Minutes, p. 125, and Toynbee to Noble, 17 Apr 1884, in the 1884-85 Minutes, p. 1. Capt Noble (later Sir Andrew) made important contributions to the study of ballistics, see D.N.B..

464. 1877-78 Minutes, pp. 56, 66. Ley's appointment as Inspector is noted in the 1878-79 Minutes, p. 96.

465. Details of Ley's life are scanty. His obituary was published in Quart. J.R. Met. Soc., 23, (1897), pp. 103-105. He suffered a series of mental illnesses and died under unfortunate circumstances see: Scott to Stokes, 25 Apr 1896, University Library, Cambridge, archives, Stokes correspondence, Add. MS 7656, letter MC 196.

466. 1878-79 Minutes, p. 2.

467. 1878-79 Minutes, pp. 73, 77.
468. Rev. Clement Ley, Aids to the study and forecast of weather, London, 1880. The title of Ley's book is given in 1879-80 Minutes, p. 49; the honorarium in 1880-81 Minutes, p. 71.
469. The delays are noted in 1883-84 Minutes, p. 28, and 1884-85 Minutes, p. 47, with final approval at the latter ref., p. 86. Abercromby's remuneration is given in the same ref, p. 98, and in 1882-83 Minutes, p. 11; his complaint about its inadequacy arrived before the Council at the same time as the call for a second edition, 1885-86 Minutes, p. 80.
470. Hon. Ralph Abercromby, Principles of forecasting by means of weather charts, London, 1885. The title appears to have been first mentioned in Jun 1883, see 1882-83 Minutes, p. 28. The verbatim quotations appear in the 3rd edition of W Napier Shaw, Forecasting weather, London, 1940, pp. 131-147. The revised and updated version is Hon. Ralph Abercromby, revised and largely rewritten by A H R Goldie, Weather, London, 1934. See also Meteorological Office publication MO 225i, The weather map, London, 1956, which still contained a diagram of Abercromby's cyclone model.
471. See the obituary notice by R H Scott in Nature, 62, p. 55.
472. See: Bergeron, op cit (note 199), pp. 442-473, esp. p. 450.

473. Robert H Scott, "The nature, methods and general object of meteorology", in Modern meteorology, London, 1879, p. 186. The publication was a collection of six lectures delivered under the auspices of the British Meteorological Society in 1878.
474. Bergeron, op cit (note 199), p. 453. Aristotle's influence is noted at pp. 3-7 above.
475. T S Kuhn, The structure of scientific revolutions, Chicago, 1970, p. 5 for example.
476. The committee was not actually formed until Nov 1886. Dines work is best covered in his Royal Society obituary notice written by Sir Napier Shaw, see: Proc. Roy. Soc. A., 119, 1928, pp. xxiii-xxxii. Shaw later paid a remarkable tribute to Dines in a "strictly confidential" letter to David Brunt, 7 Apr 1934, which was in the possession of the late Miss E E Austin, Shaw's former personal assistant. The author has a copy. For the development of the Dines anemograph see: Middleton, op cit (note 18), pp. 196-203.
477. See the report by W N Shaw, 1881-82 Minutes, op cit (note 460), pp. 16-17. Shaw's involvement dated from his attendance at Council on 28 Apr 1880 to discuss his experiments, 1880-81 Minutes, p. 14.
478. The best account of Shaw's life and work is given by E Gold in Obituary notices of Fellows of the Royal Society, 5, London, 1945, pp. 203-230. See also, D.N.B.. No biography of Shaw has yet been written, a work that is long overdue.

479. The request from The Times is recorded in the 1875 Minutes, p. 70, with the memo, by Gaster quoting an estimate of £250 at p. 83. This was later upped to £500, see: 1876 Minutes, p. 64.
480. 1876 Minutes, p. 112.
481. The formation of the American service is described in Bates and Fuller, op cit (note 71), pp. 8-12. The probabilities started in 1871. The level of funding was more than ten times that in Britain. By 1899 the American budget was nearly £200,000 per annum, see: "Report of the Committee appointed to inquire into the administration by the Meteorological Council, of the existing Parliamentary Grant", P.P. 1904 Cd. 2123 XVIII, app. VI, p. 961 (see Table 12). The rules for preparation of messages of synopses and probabilities are given in the Treasury Committee Report, op cit (note 306), app. XII, pp. 922-924.
482. Report on weather telegraphy and storm warnings presented to the Meteorological Congress at Vienna 1873 by a Committee appointed at the Leipzig Conference, London, 1874, p. 14 in response to Qs 5 and 6.
483. The resumption of forecasts in 1879 is mentioned, inter alia, in Shaw, op cit (note 7), pp. 324-325, and Simpson, op cit (note 196), p. 172, whilst 1 Apr 1879 is quoted in Gaster's report on daily forecasts contained in the 1879-80 Minutes, p. 2.
484. The Times, Thu 26 Jul 1877, p. 10, col 5.
485. The Times, Thu 2 Mar 1876, p. 5, col 5.
486. See 1878-79 Minutes, pp. 48, 84-88.

487. 1879-80 Minutes, pp. 2-4.
488. The distribution list for exhibiting forecasts in London is given in the 1879-80 Minutes, p. 29; the arrangements with the Daily News in the same ref., p. 87.
489. 1880-81 Minutes, pp. 81, 90.
490. See Lingen to Chairman of the Meteorological Council, 22 Nov 1878. 1878-79 Minutes, p. 78.
491. 1880-81 Minutes, p. 81.
492. See Smith to President, Royal Society, 2 Dec 1881, and Lingen to President, Royal Society, 31 Dec 1881, 1881-82 Minutes, pp. 88c-89, 130.
493. A specimen copy of the agricultural weather forecasts issued in Leipzig was presented to the Council in Oct 1878, 1878-79 Minutes, p. 64. Agricultural meteorology had been one of the first subjects considered by the Council in 1877, 1877-78 Minutes, p. 11.
494. 1879-80 Minutes, pp. 18, 23.
495. 1899-1900 Minutes, pp. 10-11
496. R H Scott, Weather charts and storm warnings, London, 1887, the figures for warnings are quoted at pp. 152-153, for routine forecasts at pp. 166-168.
497. See: Galton Report, op cit (note 181), pp. 355-356.

498. 1877-78 Minutes, pp. 31-33, 52-55.
499. Toynbee to Smith, 30 Jul 1879, Stokes correspondence, University Library, Cambridge, archives, Add. MS 7656, MC 69.
500. 1879-80 Minutes, p. 60.
501. A good account of this international endeavour is F W G Baker, "The first international polar year, 1882-83", Polar Record, 21, 132, Sep 1982, pp. 1-11.
502. 1882-83 Minutes, p. 3.
503. The proposal for an investigation of the North Atlantic was approved by the Council in Dec 1881, 1881-82 Minutes, p. 99. Co-operation was offered by Holland, see: 1882-83 Minutes, whilst Denmark, France and Germany were also involved, see: 1880-81 Minutes, p. 78, as was the United States.
504. Hoffmeyer had commenced the issue of Atlantic charts in Sep 1873 but ran into difficulties which resulted in their discontinuance in Nov 1876. Neumayer later offered the assistance of the Seewarte and the Danish and German services recommenced their issue in 1883, see: Shaw, op cit (note 7), pp. 166, 287. Shaw quotes 1880 as the date of recommencement but the 1883-84 Minutes, p. 38, makes it quite clear that it was three years later. The earlier failure by the Council to take over Hoffmeyer's work is recorded in the 1878-79 Minutes, p. 44.
505. This work was proposed by the Hydrographer in Nov 1880, see: 1880-81 Minutes, p. 78.

506. International co-operation was demonstrated most strongly at the Meteorological Congress at Vienna in Sep 1873, see: Met Office official no. 21, Report of the proceedings of the Meteorological Congress at Vienna, 1873, (translated from official report), London, 1874; also Howard Daniel, One hundred years of international co-operation in meteorology, 1873-1973, WMO no. 345, Geneva, 1973, pp. 1-12. By contrast the British Government attitude was later described as being "... to avoid anything in the nature of international co-operation in anything ...". Strachey in answer to Q 54 by the Meteorological Grant Committee, op cit (note 481), p. 851.

507. 1886-87 Minutes, pp. 10-11.

508. 1881-82 Minutes, pp. 32, 41. Meldrum was Director of the Mauritius Observatory.

509. 1881-82 Minutes, pp. 73-76.

510. See: Treasury Committee Report, op cit (note 306), app. 1, pp. 865-866. FitzRoy had started the scheme for rewarding good observing from the outset, see, for example, FitzRoy, R Astronom. Socy., op cit (note 101). Toynbee had been one of FitzRoy's first "excellent" observers. The system was continued under the Council.

511. 1890-91 Minutes, p. 91.

512. 1884-85 Minutes, pp. 25, 31, 34-35, 45-46.

513. 1886-87 Minutes, pp. 28-35.

514. 1887-88 Minutes, p. 129.

515. 1887-88 Minutes, p. 139.
516. See also pp. 97-98 and note 299 above.
517. These were published in the Quarterly Weather Report for the 12 years 1869-80. Napier Shaw considered this "... the most ambitious meteorological publication ever attempted ...", op cit (note 345), pp. 104-105. See also note 339.
518. The total expenditure on "Observatories and other stations" for the financial year ending 31 Mar 1878 was £2,355-8-5. 1878-79 Minutes, p. 2.
519. Treasury Committee Report, op cit (note 306), p. 736, para. 13.
520. 1882-83 Minutes, p. 9. The letters to Eaton, Hann and Wild were identical and dated 16 May 1882, same ref., p. 60.
521. The replies were Eaton to Smith, 19 Jan 1882, Hann to Smith and Wild to Smith (both no date given), see 1882-83 Minutes, pp. 61-62.
522. 1882-83 Minutes, p. 88.
523. Smith's death was thought to have followed a speech he made at Oxford on a damp February night whilst he was suffering from a heavy cold. The speech was political and made in support of a widening of the franchise. See: Macfarlane, op cit (note 442), p. 105. Strachey's succession is noted in the 1882-83 Minutes, p. 100.
524. 1883-84 Minutes, pp. 1-2, 33, 37-38, 43-44.

525. Hansard, 3rd series, 182, cols. 1326-1327. Vivian was the member for Cornwall, West.
526. The resolution is reproduced in full in the 1883-84 Minutes, pp. 49-50.
527. 1883-84 Minutes, pp. 63-64.
528. 1883-84 Minutes, pp. 70-74.
529. 1883-84 Minutes, pp. 76-77.
530. The correspondence with Glasgow and Stonyhurst is contained in the 1883-84 Minutes, pp. 86-87.
531. See, for example, Ruth Hodgkinson, Science and public health, Open University course AST 281, unit 10, Milton Keynes, 1973, esp. pp. 33-45.
532. See: Reports of the British Meteorological Society 1851-61, Report of the Council read at the 7th A.G.M., 17 May 1857, p. 3.
533. Glaisher's work is noted in the Eighth Report of the Devonshire Commission, op cit (note 190), pp. 532-536, 544-547. Farr's contribution appeared in the Treasury Committee Report, op cit (note 306), app. VI, pp. 891-901, with Mitchell's memorandum at the same ref., app. V, p. 890. For Farr see D.N.B..

534. The Treasury Committee recommendation is in their Report, ibid, p. 737, paras 18, 20. The exchange regarding the possible supply of data by the Meteorological Office is in Scott to Rt. Hon. G Sclater-Booth (President, Local Government Board), 1 Aug 1877, and J F Rotton (Asst. Sec. Local Government Board) to Scott, 27 Aug 1877, see: 1877-78 Minutes, pp. 15-16.
535. See: Reginald MacLeod (Registrar-General) to W N Shaw, 25 Mar 1902, in the 1902-03 Minutes, p.1.
536. 1877 Minutes, p. 22.
537. See the Galton Report, op cit (note 181), app. 18, and the 1876 Minutes, pp. 70-71.
538. See the Eighth Report of the Devonshire Commission, op cit (note 190), p. 488, in Scott's answer to Q 13,991.
539. Salary levels prevailing at this time are discussed in, for example, Best, op cit (note 96), esp. pp. 89-90.
540. The applications by the clerks for rises are noted in the 1879-80 Minutes, pp. 51, 61. Brodie, Bell and Francis were offered £7, £5 and £5 respectively but all asked for £10. The Council allowed these increases but ruled against any further action of this sort, same ref., p. 122. This ruling was adhered to when applications for rises were made by several members of staff in the following year. The letter from the junior and temporary clerks followed, 1880-81 Minutes, pp. 22, 33.
541. 1881-82 Minutes, pp. 129-130.

542. 1882-83 Minutes, p. 4.
543. 1882-83 Minutes, p. 43.
544. Stodart's death and the Council's decision to pay a gratuity are noted in the 1880-81 Minutes, p. 22. H Treherne (Exchequer and Audit Dept) to Lingen, 9 Apr 1880, and Lingen to Chairman, Met Council, 14 May 1880, brought the rebuke that such payments were not made in the Civil Service, and Scott replied in explanation of the occurrence, same ref., p. 24. Lingen to Chairman, Met Council, 5 Jul 1880, finally allowed the two payments made but expressly forbade any recurrence of this sort of allowance, same ref., p. 35. Apparently the disadvantages of Civil Service status were to be visited on the Office staff as rigorously as the advantages were to be withheld.
545. For example both A W Green and G N Huntly passed the Civil Service exam in Oct 1882. The latter resigned but Green returned to the Office as a copyist at £2/week. 1881-83 Minutes, p.43.
546. See the 1882-83 Minutes. The decision to engage two female assistants is noted at p. 63; the employment of Misses Anderson and Harris at p. 79 and of Miss Whatley at p. 85; the fixing of the maximum salaries for female staff is also at p. 85.
547. See Bench, op cit (note 96), p. 323.
548. 1884-85 Minutes, pp. 118-119.
549. Best, op cit (note 539), pp. 89-90; R D Baxter, The taxation of the United Kingdom, London, 1869, pp. 105-106.

550. Donald Read, England 1868-1914, London, 1979, pp. 25-29; R D Baxter, National income, London, 1861.
551. See also: Mrs. Isabella Beeton, The book of household management, London, 1982, p. 8, (first pub. London, 1861).
552. This is quoted in Cardwell, op cit (note 230), p. 5, from an article by Augustus de Morgan in the Athenaeum, 6 Dec 1856. The attitude inherent in this quotation can be found many times in contemporary writings. For example, from *the same magazine in the same year* was a highly satirical article on the Cambridge examination system, unsigned, Athenaeum, 28 Jun 1856, p. 811.
553. The effects of the Northcote-Trevelyan Report are considered in some detail in, for example, Jennifer Hart. "The genesis of the Northcote-Trevelyan Report", in ed. Gillian Sutherland, Studies in the growth of nineteenth century government, London 1972; and Cohen, op cit (note 94). There are many reviews of the examination system that grew so explosively in the nineteenth century, for example, R M MacLeod, Days of judgement, Drifffield, 1982.
554. 1886-87 Minutes, Aldridge's resignation is noted at p. 45; the decision to hold an examination p. 81; details of the examination p. 98.
555. 1886-87 Minutes, p. 98.
556. 1887-88 Minutes, p. 120.

557. See 1877-78 Minutes, The quarterly rendering of accounts and receipt of grant was covered in: Scott to Comptroller and Auditor General, 19 Oct 1877; C A de Valmer (Exchequer and Audit Dept) to Scott, 24 Oct 1877; and Scott to Secretary, Treasury, 19 Oct 1877, p. 30. The proposal re the annual report is at pp. 73, 77. Treasury agreement to the latter is noted in the 1878-79 Minutes, p. 1.
558. Treasury insistence upon the exact status of the Council was evident in a Treasury to Royal Society letter of 24 May 1877, see 1877-78 Minutes, p. 73. The typewriter incident is noted in the 1878-79 Minutes, p. 25, and demonstrates even tighter Treasury control than in the Stodart incident (see p. 166).
559. For Lefroy see D.N.B.. His ad interim appointment was notified in Stokes to Scott, 4 Apr 1878, see 1878-79 Minutes, p. 1.
560. See the 1881-82 Minutes. The relevant letters are F Cavendish (Treasury) to President, Royal Society, 10 Nov 1881 and Spottiswoode (P.R.S) to Smith, 17 Nov 1881, p. 79; replied to by Smith to President, Royal Society, 2 Dec and 14 Dec 1881, pp. 88c-89.
561. Spottiswoode to Lord F Cavendish, 29 Dec 1881, 1881-82 Minutes, p. 129.
562. Lingen to President, Royal Society, 31 Dec 1881, 1881-82 Minutes, p. 130.
563. 1890-91 Minutes, p. 37.

564. 1890-91 Minutes, pp. 60, 72-73, 77-78, 88. The ramifications regarding completion of the purchase of Westwood House continued into the following financial year, see 1891-92 Minutes, pp. 5, 8.

565. See: Scott to Secretary, Royal Society, 26 Feb 1891, 1890-91 Minutes, p. 88; and M Foster (Sec., Royal Society) to Scott 18 Mar 1891, 1891-92 Minutes, p. 5. For the Certificate of Incorporation see note 566.

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566. Copies of the Articles and Memorandum of Association and the Certificate of Incorporation are contained in the 1891-92 Minutes, pp. 39-41.
567. 1884-85 Minutes, p. 36. For Wharton see: D.N.B.
568. See, respectively, the 1882-83 Minutes, p. 112; the 1884-85 Minutes, p. 94; and the 1887-88 Minutes, pp. 80, 101. For Stone, Darwin and Buchan see: D.N.B.
569. 1887-88 Minutes, p. 133.
570. The transfer of the observatory was complete by 28 Mar 1892. 1882-93 Minutes, p. 1.
571. 1892-93 Minutes, pp. 30, 32, 45, 52, 57, 59.
572. See: John B Healy (umpire) to Scott, 28 Aug 1893, 1893-94 Minutes, p. 32.
573. 1892-93 Minutes, pp. 75, 79.

574. Lockyer was also Secretary to the Devonshire Commission. He started publishing Nature magazine in 1869, shortly before the Commission was set up. The influence wielded by Lockyer is noted, inter alia, in: A J Meadows, Science and controversy, London, 1972. There are several accounts recording the changing attitudes towards science that were developing in the fourth quarter of the nineteenth century, for example, MacLeod, op cit (note 374).

575. See, for example: Edward Pyatt, The National Physical Laboratory, a history, Bristol, 1983, esp. pp. 14-20; and Russell Moseley, "The origins and early years of the National Physical Laboratory", Minerva, 16, 1978, pp. 222-250.

576. Arthur W. Rucker (Secretary, Royal Society) to Strachey, 4 Nov 1898, enclosing E W Hamilton (Treasury) to President, Royal Society, 7 Oct 1898, and the first draft of the proposed reply by the Society, see: 1898-99 Minutes, pp. 68-69.

577. 1876 Minutes, pp. 131, 135.

578. See: Scott to Rucker, 15 Nov 1898; Galton to Secretary, Royal Society, 15 Nov 1898; and M Foster and A W Rucker (Secretaries, Royal Society) to Secretary, Treasury, 28 Nov 1898. 1898-99 Minutes, pp. 70-72.

579. See: Scott to Chairman, Kew Committee, 31 Oct 1899, with enclosed memo. by Strachey; R T Glazebrook (Director, N.P.L.) to Scott, 3 Feb 1900, with enclosed minute; and W N Shaw (newly appointed Secretary, Meteorological Council) to Glazebrook, 1 Mar 1900. 1899-1900 Minutes, pp. 90-91, 97.

580. See: Moseley, op cit (note 575), p. 109; J Crichton, "Eskdalemuir Observatory", Meteorol. Mag., 79, (1950), pp. 337-340; H Barrell, "Kew Observatory and the National Physical Laboratory", Meteorol. Mag., 98, (1969), pp. 171-180; and 1900-01 Minutes, p. 119.

581. Stone's death and Shaw's first meeting are noted in the 1897-98 Minutes, pp. 8, 11. The quotation is from Shaw, op cit (note 453).

582. Shaw's consultation with Thomson and the decision to apply for a special grant are noted in the 1897-98 Minutes, pp. 69-70; approval of the suggested programme drawn up by Shaw, Wilson's attendance at Council and agreement to participate, and confirmation of the grant are in the 1898-99 Minutes, pp. 18, 23-25, 28. For Wilson see: D.N.B..

583. See: Brunt, op cit (note 346), esp. pp. 5-6; also Napier Shaw, obituary notice R H Scott, Nature, 97, (1916), pp. 365-366, and op cit (note 453).

584. This view of Shaw's personal feelings has been expressed by two people who were close to him. See: Gold, op cit (note 478), p. 207; also Miss E E Austin, Shaw's long serving personal assistant, in conversation with the author, 1982.

585. This is evident from Shaw to Strachey, 26 Jul 1898, P.R.O. BJ1/199.

586. Wharton's proposal and withdrawal are not mentioned in the Council minutes which merely record that on 19 July Wharton was "... not yet ..." in a position to recommend appointment of a new Marine Superintendent. The death of Baillie and eventual appointment of Hepworth are also noted elsewhere in the minutes. See: 1899-1900 Minutes, pp. 24, 28, 32. However, the full sequence of events can be inferred from Wharton to Shaw 19 Jul 1899 and Shaw to Wharton (draft), 21 Jul 1899. See also Shaw to R Corless, 12 May 1920. The three letters are amongst the Shaw papers now held in the University Library, Cambridge. Shaw also makes a passing reference to the incident in op cit (note 345), p. 114.

587. 1899-1900 Minutes, pp. 89-90.

588. See: Gold, op cit (note 478), pp. 207-208.

589. There had been insufficient time between the passing of the resolution and the meeting held for its confirmation. See: 1899-1900 Minutes, p. 97.

590. 1899-1900 Minutes, p. 96.

591. 1900-01 Minutes, pp. 58-59, 64-65.

592. Quoted verbatim from the Meteorological Grant Committee Report, op cit (note 481), p. 827, para 12.

593. Acceptance of Galton's resignation and notification of the appointments are contained in: M Foster (Secretary, Royal Society) to Secretary, Met. Council, 26 Mar 1901, 1901-02 Minutes, p. 1.

594. 1899-1900 Minutes, pp. 67-68, 90.

595. 1898-99 Minutes, pp. 73-78.
596. 1900-01 Minutes, pp. 2-3.
597. 1899-1900 Minutes, p. 104. For an obituary of Strachan see:
anon., op cit (note 142).
598. 1900-01 Minutes, pp. 14-16. The relevant correspondence was Shaw
to Secretary, Treasury, 29 May 1900, and Strachan to Shaw, 17 May 1900.
These letters were accompanied by a list of clerks having a similar claim
to anterior service plus extracts from the *Meteorological Committee*
minutes for 3 Jan 1867 and 8 Jan 1867 and the Council minutes for 14 Dec
1881 and 31 Dec 1881.
599. Shaw, op cit (note 453).
600. Shaw related a conversation with Galton in which the latter
crisply interrupted a show of enthusiasm with the question "Do you really
think, Shaw, that you will make anything out?". Shaw, ibid. See also Shaw
to Maj-Gen Sir Frederick Sykes (Chairman, Met. Committee), 16 Nov 1920,
reproduced in full in Meteorol. Mag., 111, (1982), pp. 298-299. The
original is in the Shaw papers, now held in the University Library,
Cambridge.
601. See: W N Shaw, "Memorandum on Meteorological Office staffing",
unpublished and undated but probably written May 1900, with three letters
in reply: Wharton to Shaw, 17 May 1900; Galton to Shaw, 10 Jun 1900; and
Strachey to Shaw undated. Shaw papers, now held in the University
Library, Cambridge.

602. 1900-01 Minutes, p. 127. The Office's part time investigator became Sir Robert Waley Cohen, a leading industrialist, see: D.N.B.
603. 1901-02 Minutes, pp. 34-37, 42-44.
604. 1901-02 Minutes, p. 140.
605. 1902-03 Minutes, p. 12.
606. 1902-03 Minutes, p. 54.
607. The work was W N Shaw and R G K Lempfert, The life history of surface air currents, M.O. 174, London 1906. The quotations are from Bergeron, op cit (note 199), p. 459. The more "clear-cut" model appeared in: W N Shaw, Forecasting Weather, London, 1911.
608. See: Sir David Brunt, "The centenary of the Meteorological Office: retrospect and prospect", Sci. Prog., 174, (1956), pp. 193-207, esp. p. 198. Shaw's conviction that the origins of the depression were around the 9 km level was emphasized in an address to a Royal Institution evening meeting. This was published as Sir Napier Shaw, Illusions of the upper air, 10 Mar 1916, esp. pp. 13-14.
609. C K M Douglas, "The evolution of twentieth century forecasting in the British Isles", Quart. J. R. Met. Soc., 78, (1952), pp. 1-21, esp. p. 4.
610. Shaw, op cit (note 345), p. 112.

611. An account of how the workings of the Office generally, and the forecast division in particular, impressed themselves upon the young Lempfert is contained in: R G K Lempfert, "Some reminiscences of the Meteorological Office of the year 1902", Meteorol. Mag., 83, (1954), pp. 161-166. Lempfert's entry into the Office was contemporaneous with that of Bench, who started as a boy clerk in the same year, and the same qualifications that apply to the latter's article also apply here (see notes 226 and 299).

612. See: 1898-99 Minutes, p. 1; and Shaw, op cit (note 345), p. 113. The Council minutes only refer to the installation of a new observatory but Shaw affirms that the cable was a major reason for Chaves's visit.

613. For the negotiations over transmission see 1904-05 Minutes, pp. 34, 96; for the opening of the cable and details of arrangements for weather messages see 1906-07 Minutes, pp. 13-19.

614. Bates and Fuller, op cit (note 71), p. 15.

615. 1906-07 Minutes, pp. 48-50. A proposal for a mobile weather ship, using a serving naval vessel steaming up and down to the west of the British Isles and reporting by wireless, was made by Lockyer to the Meteorological Grant Committee, op cit (note 481), p. 903, in reply to Q 1,365.

616. 1908-10 Minutes, pp. 54-57. The use of wireless telegraphy had earlier been suggested by the Meteorological Grant Committee, ibid, p. 837, para. 66.

617. See, for example, Middleton, op cit (note 18).

618. 1893-94 Minutes, p. 64. Two years later a request from the International Committee for the Office to participate in a scheme of cloud observations was merely referred to the Kew Committee, 1895-96 Minutes, p. 24.

619. Archibald's work is noted by Shaw, op cit (note 7), p. 207. Dines's early observations were carried out under the auspices of the Royal Meteorological Society, see Campbell-Bayard to Shaw, 31 Oct 1901, in the 1901-02 Minutes, p. 68; also the 1902-03 Minutes, p. 12.

620. The arrangements with Dines for a programme of upper air investigations, and mention of his co-operation with Cave and Simpson are noted in the 1905-06 Minutes, pp. 14, 19-21. There are several accounts of the upper air programme, for example Shaw, op cit (note 345), pp. 117-118.

621. Noted in Brunt, op cit (note 346), p. 6.

622. 1902-03 Minutes, pp. 1-3.

623. This point was firmly made by Buchan to the Meteorological Grant Committee, op cit (note 481), pp. 876-877, in reply to Qs 608-613.

624. The events resulting in the changed positions of the societies are noted in: 1910-15 Minutes, pp. 95-96, 270-272; and 1915-20 Minutes, pp. 466-468.

625. "Agreement of transfer of British Rainfall Organisation to Meteorological Office 1919", P.R.O. BJ1.200, paras. 6 and 7 of the agreement. In fact the publication of "British Rainfall" ceased with the 1968 volume and the emergence of rainfall data became subject to a more than 10 year delay for a while as the system changed. A critical letter by J Glasspoole, a long term editor of "British Rainfall", appeared in Weather, 35, (1980), pp. 278-279.
626. 1901-02 Minutes, pp. 34-36, 130-131.
627. 1900-01 Minutes, pp. 3-4. The course fee was £5-15-6. Repayment was expected within a year.
628. A graphic account of this event is given by Bench, op cit (note 226), p. 327.
629. Daniel, op cit (note 506), p. 55, annex 1.
630. See: 1900-01 Minutes, p. 137; 1901-02 Minutes, p. 18; 1902-03 Minutes, p. 3; 1903-04 Minutes, p. 108; and 1904-05 Minutes, pp. 29-31, 42-44.

Chapter Eleven

631. The proposal by Milne Home was first considered by the Council on 23 May 1878 and turned down on 6 Jun. 1878-79 Minutes, pp. 22, 36. Buchan had met the Council in Oct 1877, 1877-78 Minutes, p. 19.

632. 1881-82 Minutes, pp. 87-88, 92.

633. 1882-83 Minutes, p. 18. The invitation was contained in Richmond and Gordon to Smith, 10 May 1882; the decision not to accept was taken by the Meteorological Council collectively rather than by Smith individually. In the event, the only representative of the Royal Society appointed was Lord Kelvin, himself a Scotsman.

634. See: James Paton, Ben Nevis Observatory 1883-1904, Bracknell, 1983. The publication also includes: C T R Wilson, "Ben Nevis 60 years ago", and J C Farman and A S Thom, "Ben Nevis Observatory, a plaque unveiled". The first two of these appeared in 1954 as articles in Weather.

635. Buchan to Scott, 16 Nov 1883, officially notified the Council of the opening and undertook to forward copies of the observations regularly. Scott was instructed to reply accepting the Council's liability. 1883-84 Minutes, pp. 77-78. According to Paton, ibid, the Fort William observations were made by Mrs Wragge.

636. The correspondence relating to these exchanges is in the 1883-84 Minutes, pp. 107, 123-125. The letters reproduced in full are: Buchan to Scott, 18 Feb 1884; Scott to Manager, Press Association, 21 Feb 1884; E Robbins (Manager, Press Association) to Scott, 22 Feb 1884; Scott to Manager, Press Association, 23 Feb 1884; Scott to Buchan, 23 Feb 1884; Buchan to Scott, 19 Mar 1884; Scott to Manager, Press Association, 21 Mar 1884.

637. Scott to Buchan, 14 Apr and 2 May 1884, and Buchan to Scott, 14 May 1884. 1884-85 Minutes, pp. 13-15.

638. 1884-85 Minutes, pp. 20, 23-25.

639. 1884-85 Minutes, pp. 29-31.

640. 1884-85 Minutes, pp. 43-45.

641. 1884-85 Minutes, p. 72.

642. 1887-88 Minutes. Gaster's report is at pp. 25-26. This was enclosed with Scott to Buchan, 30 Jul 1887, and together they provoked Buchan to Scott, 8 Aug 1887, which is at pp. 44-45. It would seem that the version of Gaster's report as finally published in the minutes was the "corrected" one, see p. 204 below.

643. 1887-88 Minutes. The draft of the letter to Scotland, approved by Council, is at pp. 83-84, with the letter to the Treasury at p. 85.

644. The offer was made in Scott to Sir Arthur Mitchell (Hon. Sec., Scottish Meteorological Society), 23 Mar 1888, and gratefully accepted in Mitchell to Scott, 5 Jun 1888, 1888-89 Minutes, pp. 1-2, 23.

645. Mitchell to Scott, 21 Jan 1889, see: 1888-89 Minutes, p. 98.
646. The report of the installation of the instruments by Mr T W Baker of Kew is contained in the 1890-91 Minutes, pp. 28-29.
647. The Treasury notification came in Hanbury to Meteorological Council, 17 Aug 1898. The Council affirmed their position in Scott to Secretary, Treasury, 19 Jan 1899 (draft approved by Council 18 Jan), whilst Hanbury to Scott, 30 Jan 1899, gave a clear indication that no input of additional funds was contemplated. See: 1898-99 Minutes, pp. 31, 83-84, 89.
648. Notification of the reprieve due to Mr Bernard came in Mitchell to Scott, 2 Dec 1898. 1898-99 Minutes, pp. 78-80.
649. Mitchell to Scott, 16 Mar 1899, Scott to Mitchell, 29 Mar 1899, and Scott to Secretary, Treasury, 29 Mar 1899. See: 1898-99 Minutes, pp. 102-103.
650. The exchange of letters between the Scots and the Treasury was: Mitchell to Secretary, Treasury, 15 Jul 1899, and Hanbury to Mitchell, 25 Jul 1899. News of the second Bernardian windfall reached the Council in Mitchell to Scott, 12 Sep 1899. See: 1899-1900 Minutes, pp. 38-39.
651. Mitchell to Shaw, 21 Feb 1901 and 17 Jun 1901, gave notice of three further gifts of £500 each. 1900-01 Minutes, p. 135 and 1901-02 Minutes, p. 27. Affirmation of the Council's intention to terminate their grant to Fort William was given at p. 28 of the latter ref. The final extension is noted in the 1902-03 Minutes, p. 54.

652. See: Meteorological Grant Committee Report, op cit (note 481), pp. 906-907, Lord Kelvin in reply to Qs 1421-1424; and p. 927, Sir Arthur Schuster in reply to Q. 1852.

653. Meteorological Grant Committee Report, ibid, p. 824. Appointed to the Committee were:

Rt. Hon. Sir Herbert E Maxwell, Bart., M.P. (Chairman)

J A Dewar, M.P.

Sir W de W Abney, K.C.B., F.R.S.

Sir F Hopwood, K.C.B., C.M.G., Board of Trade

Sir T H Elliott, K.C.B., Board of Agriculture

T L Heath, Esq., Treasury

R T Glazebrook, F.R.S.

Joseph Larmor, F.R.S

654. Meteorological Grant Committee Report, ibid, pp. 836-837.

655. Treasury Minute dated 20 May, 1905, dealing with the Constitution of the Meteorological Office, P.P. 1905, Cd. 2559 LXIV, pp. 325-326. This was written following differences between the Treasury and Royal Society over the level of funding. See: 1904-05 Minutes, pp. 126-131. The savings that were anticipated resulted from cessation of the grants to the Ben Nevis Observatories (£350 per annum); the ending of the practise of supplying the Royal Navy with instruments at Meteorological Office expense (£500); and the abolition of the paid Council, offset by the Director's increased salary (£575).

656. 1904-05 Minutes, pp. 136-140; and 1905-06 Minutes, p. 1.

657. Meteorological Grant Committee Report, op cit (note 481), p. 832, para. 36.

658. See: Victor Cavendish (Treasury) to President, Royal Society, 3 Sep 1904. 1905-06 Minutes, pp. 126-127.

659. Meteorological Grant Committee Report, op cit (note 481), pp. 955-956, app. 2 and additional memorandum.

660. Paton, op cit (note 634), p. 14.

Chapter Twelve

661. For most people the horrors of the Crimean War were a remote happening which did not impinge strongly on their consciousness although they did, admittedly, serve to bring down the Aberdeen Government "of all the talents", see, for example, Conacher, op cit (note 116).

662. Burn, op cit (note 67), pp. 15-16.

663. Nearly all accounts of the Office's history have been written by meteorologists for the delectation of their fellows, for example, G A Bull, "Short history of the Meteorological Office", Meteorol. Mag., 84, (1955), pp. 163-167, and D Brunt, op cit (note 608). See also: J M C Burton, "Robert FitzRoy and the early history of the Meteorological Office, B.J.H.S., 19, (1986), pp. 147-176, and "The foundation and early years of the Meteorological Office, Weather, 38, (1983), pp. 364-368; 39, (1984), pp. 7-10.

664. The story of the Board of Trade at this time is the story of many of these "solutions", see Prouty, op cit (note 78).

665. Details of the Department's finances are given in table 1. A comprehensive list of publications is given in FitzRoy's 1863 Report, op cit (note 135), apps. 5 and 6, where it is noted that they were sold "... at the bare cost of paper and print ...".

666. MacLeod, op cit (note 231), pp. 146-148. This account contains certain minor inaccuracies but the picture it portrays of the Treasury clerk's bewilderment is excellent.

667. The increase in grant for the purpose of providing evening forecasts is covered on pp. 263-266 above. The charge for harvest forecasts is noted in the 1899-1900 Minutes, pp. 10-11.

668. This quotation is actually taken from the distinguished Marxist historian E J Hobsbawm, Industry and Empire, London, 1968, p. 197, but the idea that this conception is widely held is probably acceptable without further justification.

669. See, for example, Roberts, op cit (note 96).

670. Shaw was circumspect in not broadcasting his strong opposition to the eventual take-over by the Air Ministry but some evidence is still extant, for instance, A Crichton Mitchell to Shaw, 2 Jul 1919, contained in the Shaw papers now held in the University Library, Cambridge. The strongest evidence of all is the testimony of Miss E E Austin, Shaw's personal assistant, in conversation with the author, 1982.

671. 1906-07 Minutes, pp. 64-65.

672. Research within the Meteorological Office fell away after Shaw's retirement because Simpson, his successor as Director, did not consider that it should play any part in a public service. This information was obtained by the author in conversations with Prof. R C Sutcliffe in 1981. Sutcliffe himself became the Office's first Director of Research in 1957. One consequence of Simpson's refusal to embrace research within the Office structure was the loss of Sir Harold Jeffreys to meteorology. This is made clear in a letter from Jeffreys to the author dated 6 Jul 1983 which is in the author's possession.

673. This description of technology is taken from: Edwin Layton, "Mirror-image twins: the communities of science and technology in 19th-century America", Technology and Culture, 12, (1971). An excellent account of the pure/applied dichotomy, specifically related to the field of chemistry in the Victorian era, is Robert Bud and Gerrylynn K Roberts, Science versus practice, Manchester, 1984.

674. See: Sir Napier Shaw, "Meteorological science today", The Realist, 2, (1929), pp. 165-182, esp. p. 166.

675. Cannon, op cit (note 97), p. 225.

676. See: Whewell, op cit (note 38) and Forbes, op cit (note 81). More than 30 years afterwards Glaisher and Airy were to echo Whewell's words. See, respectively: Eighth Report of the Devonshire Commission, op cit (note 190), p. 534, Glaisher in reply to Q 14,518 said "... Meteorology is not yet a science ..."; Treasury Committee Report, op cit (note 306), p. 794, Airy in reply to Q 940 commented that "... Meteorology ... cannot be called a science at all ...".

677. For a thought provoking series of essays on the problems of new scientific disciplines see: eds. G LeMaine, R MacLeod, M Mulkay, P Weingart, Perspectives on the emergence of scientific disciplines, The Hague, 1976.

678. Elizabeth Garber, "Thermodynamics and meteorology", Ann. Sci., 33, (1967), pp. 51-65, esp. pp. 52-53.

679. J E Thornes, "A paradigmatic shift in atmospheric studies?", Prog. Phys. Geog., 5, (1981), pp. 429-440; and O G Sutton, "The development of meteorology as an exact science", Quart. J. R. Met. Soc., 80, (1954), pp. 328-338.

680. See: Obituary notices of Fellows of the Royal Society 1932-1935, 1, London, 1935, obit. notice of Sir Arthur Schuster by G C Simpson, pp. 409-423, esp. p. 417.

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Table 1. Sums voted and expended by the Meteorological Department of the Board of Trade up to 1 Dec 1865
(Pay of clerks in 1865 calculated only up to 30 Sep) (Taken from the Galton Report, app. 18, see note 181)

Date	Parliamentary vote BoT and Admiralty	Expenditure charged to vote			Salaries	Additional salaries charged to BoT establishment vote	Total expenditure
		Telegraphy and storm warnings	Instruments and incidentals				
1856-57	£4200	-	£2167	£705	£369	£3241	
1857-58	4200	-	2449	687	511	3647	
1858-59	4200	-	2287	926	400	3613	
1859-60	3400	-	1960	1031	354	3345	
1860-61	3300	£218	1388	1123	378	3107	
1861-62	3800*	1778	1908	1235	404	5325	
1862-63	4800*	2335	1249	1260	366	5210	
1863-64	4800*	2989	2377	809	929	7104	
1864-65	4270	2735	1145	247	1334	5461	
1865-66 (incomplete)	4770	1567	355	54	345	2321	
Total	41740	11622	17285	8077	5390	42374	

*supplementary vote required

Table 2. Number of ships wrecked or damaged and lives lost at sea near the U.K. coasts 1852-55 (Taken from "Report of the Board of Trade containing an abstract of the returns of wreck and casualties on and near the coast of the U.K. from 1 Jan 1852 to 31 Dec 1855", P.P. 1856, LI, pp. 395-397)

Year	1852	1853	1854	1855
Ships wrecked or damaged	1015	832	987	1141
Lives lost	920	689	1549	469

Table 3. Results of FitzRoy's storm warnings for three days in 1863

(Figures derived from Wreck Department Report - see note 162)

Date	Type of warning	Number of warnings		Gales observed	
		Galton no.	By sea area	Galton no.	By sea area
6 Jun*	N Cone over drum	72	14	17	8x
10 Jun+	Drum	72	14	31	11xx
21 Nov+	S Cone	49	9	36	9
Totals		193	37	84	28

* observations missing from four stations

+ observations missing from five stations

x only one station for sea area Fastnet and this did not report

xx only two stations reported for sea area Shannon, both giving force 7

Table 4. Results of FitzRoy's storm warnings for Dec 1863

(Figures derived from Wreck Department Report - see note 162)

Date	Type of warning	Number of warnings		Gales observed	
		Galton no.	By sea area	Galton no.	By sea area
1	Drum*	46	9	42	9
1	S Cone	26	5	25	5
2	Drum	26	6	23	6
5	S Cone*	73	14	45	12
16	S Cone x	57	10	34	10
16	Drum over S Cone	15	4	15	4
26	S Cone x	72	14	14	9
31	Drum xx	72	14	38	13
Totals		387	76	236	68

Observations missing from: x one station

* two stations

xx three stations

Table 5. Number of lives saved and lost on and near the coasts of the U.K. during the years 1861-70

(From "Wrecks and Casualties", P.P. 1871, LXI, p. 681)

Year	Lives saved	Lives lost	Total lives imperilled
1861	4624	884	5508
1862	4039	690	4729
1863	5096	620	5716
1864	3619	516	4135
1865	4162	698	4860
1866	4936	896	5832
1867	5845	1333	7178
1868	4771	824	5595
1869	5121	933	6054
1870	4590	711	5301
Totals	46803	8105	54908

Table 6. Staff appointments and salaries at the 1867 transition

(From the 1867 Minutes, pp. 16, 19)

Position	Appointment	Salary
Chief clerk	Vacant	£200 x 10 to £250
First senior clerk	Mr. J.S. Harding jun.	£150 x 10 to £200
Second senior clerk	Mr. Richard Strachan	£130 x 10 to £180 extra for instruments £50
First junior clerk	Mr. Frederic Gaster	£100 x 10 to £150
Second junior clerk	Mr. Charles Harding	£90 x 10 to £150
Third junior clerk	Mr. R.H. Curtis	£78 x 5-10-0 to £100
Mr. J.S. Harding sen. was retained as office keeper at a salary of 30 shillings/week		

Table 7. Comparison of Meteorological Office and Civil Service salaries 1874-75 (Taken from Scott's evidence to the Devonshire Commission, see note 357)

Office	Clerks	Assistant Clerks etc	Writers
Board of Trade	£200-800	£80-400	-
Charity Commission	90-650	-	-
Civil Service Commission	100-500	80-200	-
Greenwich Observatory	350*	180-250*	-
Local Government Board	90-800	250-400	-
Lunacy Commission	100-500	-	-
Patent Office	100-450	130-160	£150x
Privy Council	100-800	90-250	160-200
Registrar General	300-420	90-280	90x
Stationery Office	90-500	-	85x
Meteorological Office	100-250	50-100	-

* assistants

x average

Table 8. Comparison of gale warnings issued and actual conditions experienced 1877-85 (Taken from R.H. Scott, Weather charts and storm warnings, London, 1887, p. 153, see note 496)
(percentages)

Year	Warnings justified		Total warnings claimed as successful	Warnings not justified by subsequent weather
	By subsequent gales	By subsequent strong winds		
1877	53.3	25.9	79.2	16.4
1878	56.7	20.8	77.5	17.9
1879	50.5	25.1	75.6	20.6
1880	58.2	24.6	82.8	13.3
1881	58.6	23.3	81.9	14.8
1882	61.4	21.1	82.5	14.9
1883	56.2	21.6	77.8	20.8
1884	66.4	20.0	86.4	12.1
1885	55.3	24.0	79.3	19.5

Gales defined as Beaufort force 8 or more; strong winds as force 6 or more. The unaccounted balance apparently covers warnings issued after a gale had started.

Table 9. Comparison of forecasts issued and actual weather experienced 1879-85 (Taken from R.H. Scott, Weather charts and storm warnings, London, 1887, p. 166, see note 496)
(percentages)

Year	Complete success	Partial success	Partial failure	Total failure	Total claimed as successful
1879	28	47	20	5	75
1880	35	40	16	9	75
1881	34	44	16	6	78
1882	44	35	13	8	79
1883	48	33	11	8	81
1884	51	31	11	7	82
1885	51	32	11	6	83

The terms "complete" and "partial" success and failure are not rigorously defined.

Table 10. Comparison of gale warnings issued and actual conditions experienced 1893-1902 (Taken from the Meteorological Grant Committee Report, P.P. 1904, Cd. 2123 XVIII, p. 836, see note 481) (percentages)

Year	Warnings justified		Total warnings claimed as successful	Warnings not justified by subsequent weather
	By subsequent gales	By subsequent strong winds		
1893	60.8	28.6	89.4	7.1
1894	68.5	23.5	92.0	6.0
1895	63.3	26.4	89.7	8.0
1896	67.7	23.8	91.5	2.9
1897	60.1	31.7	91.8	4.5
1898	59.8	27.5	87.3	4.5
1899	59.3	31.9	91.2	4.8
1900	66.2	25.8	92.0	6.3
1901	62.3	26.1	88.4	7.4
1902	55.5	32.0	87.5	9.0

Gales defined as Beaufort force 8 or more; strong winds as force 6 or more. The unaccounted balance apparently covers warnings issued after a gale had started.

Table 11. Comparison of forecasts issued and actual weather experienced 1893-1902 (Taken from the Meteorological Grant Committee Report, P.P. 1904, Cd. 2123 XVIII, p. 835, see note 481) (percentages)

Year	Complete success	Partial success	Total claimed as successful
1893	59	25	84
1894	56	27	83
1895	55	25	80
1896	54	27	81
1897	55	26	81
1898	55	28	83
1899	55	27	82
1900	57	27	84
1901	58	26	84
1902	53	35	88

The terms "complete" and "partial" success are not rigorously defined.

Table 12. Comparison of levels of public financing for meteorology in some leading countries in 1899 (Taken from the Meteorological Grant Committee Report, P.P. 1904, Cd. 2123 XVIII, p. 961, see note 481, also Quart. J.R. Met. Soc., 25, (1899))

Argentine Republic	£3,365
Australia (6 colonies combined)	9,558
Austro-Hungary	5,000*
Belgium	2,000
Brazil	-
Canada	12,936
Cape Colony	600*
Denmark	4,300
France	7,300*
German Empire	-
Greece	380*
India and Ceylon	22,100*
Italy	-
Japan	7,623*
Mauritius	1,300
Netherlands	3,833
New Zealand	-
Portugal	1,783
Roumania	400
Russia	44,922
Spain	-
Sweden and Norway	3,900
Switzerland	2,200
United Kingdom	15,300*
United States of America	195,000

* Exclusive of certain allowances, e.g. free postage, telegraphy, printing or stationery

Table 13. Expenditure charged
against grant 1870-75
(Derived from Treasury
Committee Report,
P.P. 1877, XXXIII,
p. 872, see note 481)

Average annual expenditure

Administration

Salaries	£1,253
Rent, fuel, furniture etc	598
Incidentals & contingencies	280

	£2,131

Land meteorology

Observatories	2,959
Salaries	1,306
Inspections	323
Telegraphy	1,667

	£6,255

Ocean meteorology

Salaries	1,362
Instruments	726

	£2,088

Total expenditure £10,474

Sundry receipts £ 566

Net expenditure against annual grant of £10,000 £ 9,908

Table 14. Expenditure charged
against grant 1898-1903
(Derived from
Meteorological Grant
Committee Report
P.P. 1904, Cd. 2123 XVIII,
p. 838, see note 481)

Average annual expenditure

Administration

Council	£ 909
Salaries	1,646
Rent, fuel, furniture etc	867
Incidentals & contingencies	245

	£3,667

Land meteorology

Observatories	2,255
Salaries	3,099
Inspections	420
Telegraphy	2,678

	£8,452

Ocean meteorology

Salaries	1,333
Instruments	1,039

	£2,372

Special researches 886

Miscellaneous 247

Superannuation 1,212

Total expenditure £16,836

Sundry receipts £ 1,541

Net expenditure against annual grant of £15,300 £15,295

List of Figures

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FIG. 1 PRINCIPLES OF WIND STAIRS

SQUARE 338.

SOUTH ATLANTIC.
Brazilian Coast (near Bahia).

For Three Months—January, February, March.

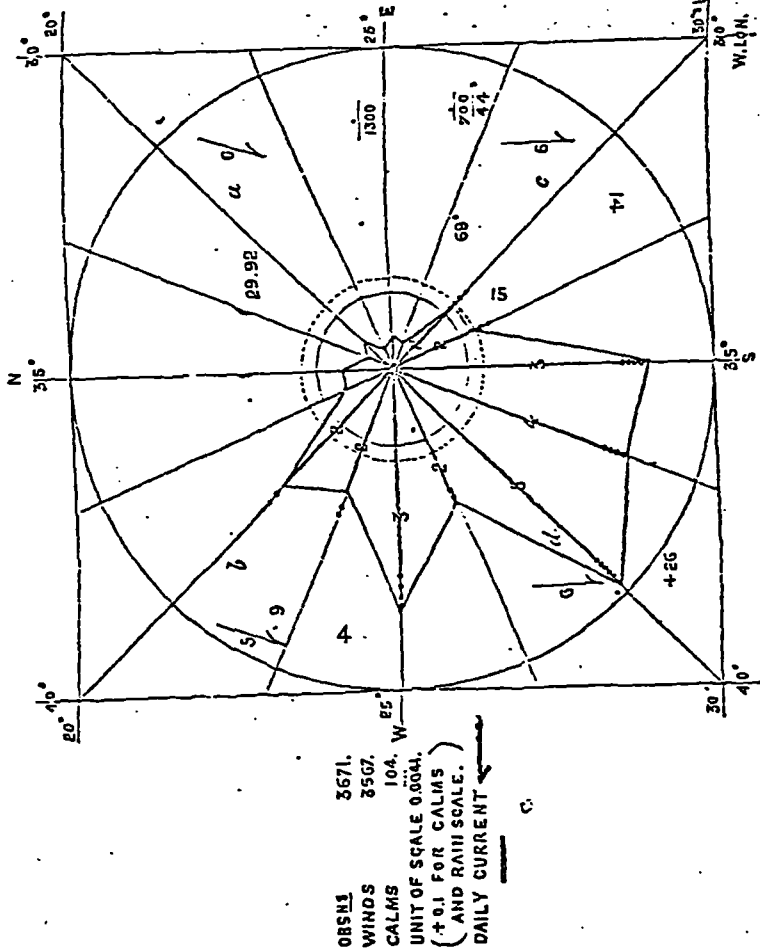
Five-inch Square: half one side (= radius of inscribed circle) has 2,500-thousandths of an inch, in which measure the unit for scale is taken.

Square 375.
Subdivided into a, b, c, d, which subdivision may be continued by quartering and lettering a, b, c, d, as e, f, g, h, &c.

SOUTH ATLANTIC.
Brazilian Coast (near Rio de Janeiro).
For Three Months—January, February, March.

Four Windroses are condensed into this Diagram; namely, those for—

- 1. Lat. 20° + 25° S. 20° + 30° S. 25° + 30° S. 25° + 30° S.
- and
- 2. Longs. 30° + 35° W. 35° + 40° W. 30° + 35° W. 35° + 40° W.



OBS. WINDS CALMS 1304.
1293.
UNIT OF SCALE 0.0057.
(+0.1 FOR CALMS, AND RAIN SCALE.)
DAILY CURRENT

OBS. WINDS CALMS 3671.
3507.
104. W
UNIT OF SCALE 0.0041.
(+0.1 FOR CALMS, AND RAIN SCALE.)
DAILY CURRENT

Log. n (2,500) = 3.3979
Log. l (001) = 5.0000
Log. n' = (439) = 0.3979
Unit of Scale = l = 0.0057 = 5.7554

Let n = number of parts in radius (= 2,500)
n' = " " longest point (radius)
l = length of one part of radius (= 001)
l' = length of unit of scale;
then n' : n :: l : l'
∴ n × l' = l = unit of scale

Temp. sea surf. 69°
Depth 1,500
No ground at 1,000
Temp. at 1,000
Variation 4
Dip 1.1

Scale of Wind:
Beaufort 1-12
and
Land 0-6

Var. (1/4 turn)
Dip (1/2 turn)
Sp. Gr. + 26
(1,000 + 1)

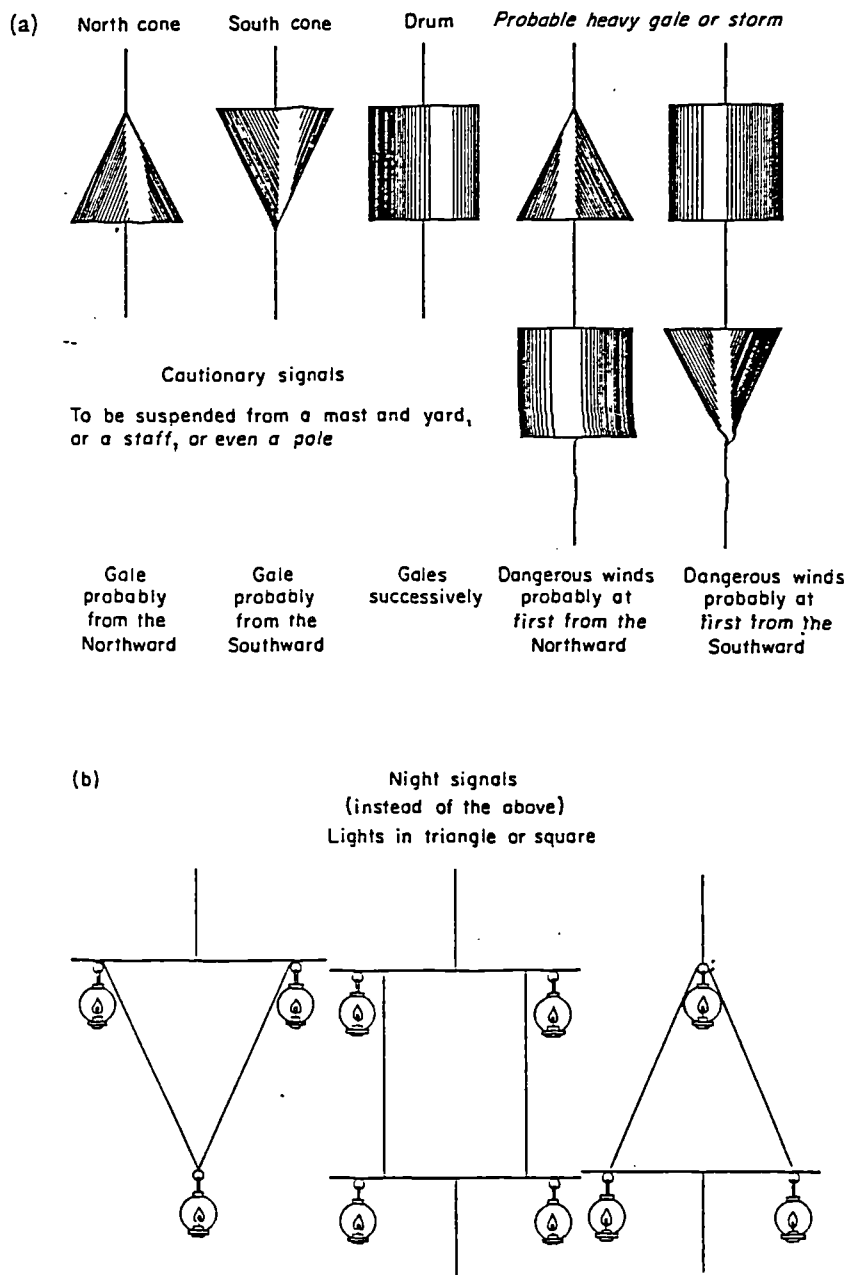


Fig. 2 Visual signals devised by FitzRoy. (a) Cautionary signals. (b) Night signals.

'Four lanterns and two yards, each not less than four feet long, will be sufficient—as only one signal will be used at night. These signals may be made with any lanterns, showing either white, or any colour, but *alike*. *Red is most eligible*. Lamps are preferable to candles. The halyards should be good rope, and protected from chafing. The lanterns should hang *at least* three feet apart'.

Figure 3. Example of a FitzRoy weather forecast

The following forecast was published in The Times, 28 Jun 1862, p. 8, col. 2. Following a list of observations from some 20 coastal stations in the British Isles, plus Heligoland, Helder, Copenhagen, Brest and Bayonne from the continent, the forecast for coastal districts was given as:

<u>Saturday</u>	<u>Probable</u>	<u>Sunday</u>
<u>Scotch</u>		
NW to W, fresh; some showers.		W to S, fresh to strong; showers.
<u>Irish</u>		
NNW to WSW, moderate to fresh.		WSW to SSE, fresh to strong; rainy.
<u>W. Central</u>		
N to W, moderate; showery.		SW to SE, moderate to fresh; showers.
<u>S.W. England</u>		
NNW to WSW, moderate; unsettled.		WSW to SSE, fresh; rainy.
<u>S.E. England</u>		
NW to SW and S, moderate; showery.		SSW to ESE, fresh; some showers.
<u>E. Coast</u>		
N to W and to S, fresh; showery.		W to S and ESE, fresh; rainy.

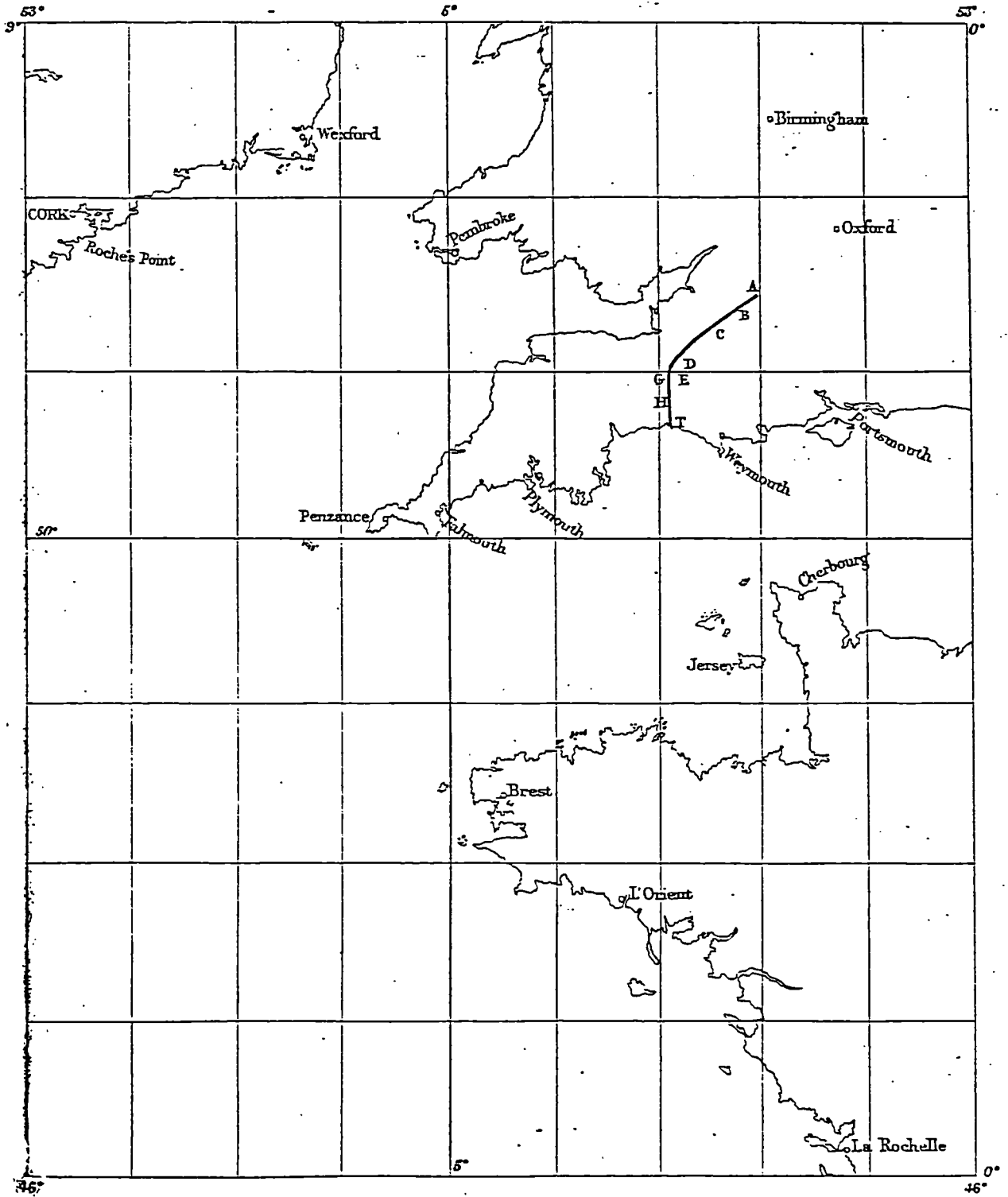


Fig. 4 MAP SHOWING TRACK OF BALLOON.

Dec. 10th 1881.

Figure 5. Examples of weather forecasts in 1885 and 1901

(a) The following forecast was published in The Times, 4 May 1885, p. 6, col. 6. Following a small chart of Western Europe for 6 p.m. the previous day (which included isobars at 0.2 in intervals and a few outline observations), and a brief review of the previous day's weather over the British Isles, the forecast was given as:

Forecasts of Weather for Monday, May 4

(issued at 8.30 p.m. on the previous day)

0. Scotland, N - Winds doubtful; weather showery and changeable.
1. Scotland, E - North-easterly winds, moderating and backing; rain at times.
2. England, N.E. - Same as no. 1.
3. England, E - Same as no. 5.
4. Midland Counties - Same as no. 1.
5. England, S - (London and Channel) - Varying winds; showery with bright intervals; thunder locally.
6. Scotland, W - Same as no. 1.
7. England, N.W. (and N. Wales) - Same as no. 1.
8. England, S.W. (and S. Wales) - Same as no. 5.
9. Ireland, N - North-easterly or northerly winds, variable; showery.
10. Ireland, S - Same as no. 9.

Warnings - None issued

By order,

Robert H. Scott, Secretary.

The forecasts were followed by 9 a.m. and 9 p.m. observations from Ben Nevis Observatory and a brief resume of the previous 24 hours weather there.

(b) The following forecast was published in The Times, 4 Jan 1901, p. 5, col. 2. Following a chart of Western Europe for 6 p.m. the previous day (similar to the 1885 chart noted in (a) above) and a small number of sunshine recordings the forecast was given as:

Forecasts of Weather for Friday, Jan 4

Scotland, N. and E.
and England, N.E. Southerly and south-westerly winds,
freshening; damper; rather milder.

England, S. (London and
Channel), E., and
Midland Counties Very light airs; foggy; gloomy;
damper; not so cold.

Scotland, W., England, N.W.
(and N. Wales), and S.W.
(and S. Wales), Ireland,
N. and S. Southerly and south-westerly winds,
increasing; milder; a little rain.

The south cone was hoisted today in Ireland, S.

The forecasts were followed by observations of the temperature and hygrometric condition of the air in London, and also by observations from London, Paris, Berlin, Vienna and Rome, all for the previous day.

The readings of the barometer in London during the previous 24 hours were also given.