2.1 Early History

2.1.1 Early observers

The written history of China goes back more than 3,000 years and it is probable that it contains some early accounts of the nature or effects of typhoons. However, the only early references that I have been able to find are dependent upon "Chü-fêng" 颶風 being synonymous with "typhoon". "Chü-fêng" means a four quarters wind, i.e., one that blows from the north, south, east and west as opposed, for example, to the steadier southwest and northeast monsoons.

Ch'ü Ta-Chün 屈大均 author of the "Kuang-Tung Hsin Yü" of 1680 mentions that in an ancient book called "Shuo Wên" of A.D. 120 use is made of a character 颶 saying ~~that it is~~ characteristic of the summer solstice in the sun-heated south. He considered that this character had the same meaning as Chü. These characters were used together as a couplet in poems, notably by the famous scholar Han Yu 韓愈 (A.D. 768-824). In one of his poems, Han Yu wrote "雷霆逼颶風" meaning:-

> " It is most horrible when typhoon winds set in; their roaring sounds can be heard in the neighbouring hills"

The great encyclopaedia "Thai-Phing Yü Lan" 太平御覽 of A.D. 983 contains a quotation from the "Nan Yüeh Chih" 南越志 of the year 465; the particular passage does not appear in any of the reconstitions of this otherwise lost book, but what we have of it now occupies only a few pages, whereas the encyclopaedia has high authority (Needham 1969); the quotation runs:-

> " Chü-fêng is often found in the Hsi-an region. Chü means winds which may come from the four quarters. Chü-fêng is also known as "winds of fear" to signify the terror they bring. Chü-fêng normally occur in the sixth and seventh months of the year (according to the lunar calendar). Three days before they start, all the birds and dogs fall silent. The worst ones come in the seventh month, and the milder ones last one or two days. Foreigners call them hei fêng (black winds)."

In the "Chronological Records on Meteorology in Japan" 1939 there are references to a typhoon in Kumano district in September 473 and to another in Yamato in September 638; they are described as having felled trees and houses. There are also Japanese accounts of typhoons raging in the 9th and 11th Centuries, they were written by the Japanese authoresses Seishonagon and Murasakishikibu respectively (Nemoto 1969).

Under the rule of Kublai Khan, Mongol forces attacked Japan in November 1279 and again on 22nd August 1281. On the first occasion the Mongols retreated but the Japanese mistakenly believed that they had been driven off by a violent storm (Arakawa 1960). In 1281 the attacking fleet from China and Korea did indeed encounter a typhoon at Kyushu and there suffered terrible loss of life. The "History of Yüan" records that more than 100,000 troops had to be abandoned. The Japanese believed that they had twice been saved by a "Kamikaze" or "divine wind" and that ever afterwards, whenever the nation was in peril, the Gods would send another "Kamikaze" to save them. The Japanese used this word for their World War II planes which were flown onto their targets with their pilots, to save Japan. The word , at that time, did not connote suicide, a meaning which came subsequently to Japan from the Americans.

Columbus was the first known European to have experienced tropical cyclones. On his first trip to the New World, during the height of the hurricane season, he was extrmely fortunate not to have encountered any. However, during his second visit he lost at least two of his ships in a hurricane in October 1495 at Isabella, Santo Domingo and was moved to write that:-

> " Nothing but the service of God and the extension of the monarchy would induce me to expose myself to such dangers."

From these early references to the severity of tropical cyclones we move on to the history of man's understanding of them. The Portuguese described their encounters with typhoons in the middle of the 16th Century, at which time they were trading on the route from Europe to Japan with ports of call in Malacca and Macau. The following is an English translation from Pinto's "Peregrinacão" of 1540 (Hobson-Jobson 1903):-

" Now having... continued our Navigation within this Bay of Cauchin-china..., being the eight of September, for the fear that we were in of the new Moon, during the which there often times happens in this Climate such a terrible storm of wind and rain, as it is not possible for ships to withstand it, which by the Chinese is named tufan ".

Portuguese "expert Pilote's" description of a typhoon is more complete than most from that period, it comes from the English (1598) edition of J.H. van Linschoten's "Discours of Voyages unto ye Easte and West Indies" and is translated from an earlier Portuguese source:-

" Nowe to understand the meaning of this word Tuffon, it is a Chinish word, which the Portingales also doe holde without altering the same, and signifieth a storme or Tempest, which you commonly finde in those voyages from China to Iapon. If you faile of it sometimes, it is not often, it commeth and beginneth from one point, and do runneth with a continual storme almost about all the points in compasse, blowing most stiffely, whereby the poore Sailers have worke ynough in hande, and in such short, that not any stormes throughout all the orientall Indies is comparable unto it, wherefore it is necessary to looke well to it, and to chose your times, that by calmes sodainely you bee not inadvisedly overtaken, as every man that hath sayled those wayes, can sufficiently shewe you, and every one or most part of them have found it to be so. "

Here, "expert Pilote" warns of "winds from all points" and the deceptive "calmes".

About a century later in his book "Geographia Naturalis" (1650) the German geographer Bernhardus Varenius became the first writer to recognize that hurricanes had a whirling nature or circular movement. A few years later the famous English master seaman and buccaneer, William Dampier, was first to conclude that hurricanes and typhoons were different names for the same phenomenon. In his "Voyages and Descriptions" (Dampier 1700) he described typhoons as "sort of violent whirlwinds" and gave the best and most complete description of them that had appeared up to that time:-

" Tuffoons are a particular kind of violent Storms, blowing on the coast of Tonquin, and the neighbouring Coasts in the months of July, August, and September. They commonly happen near the full or change of the Moon, and are usually preceeded by very fair weather, small winds and a clear Sky. Those small winds veer from the common Trade of that time of the year, which is here at S.W. and shuffles about to the N. and N.E. Before the Storm comes there appears a boding Cloud in the N.E. which is very black near the Horizon, but towards the upper edge it looks of a dark copper colour, and higher still it is brighter, and afterwards it fades to a whitish glaring colour, at the very edge of the Cloud. This Cloud appears very amazing and ghastly, and is sometimes seen 12 hours before the Storm comes. When that Cloud begins to move apace, you may expect the Wind presently. It comes on fierce, and blows very violent at N.E. 12 hours more or less. It is also commonly accompanied with terrible chaps of Thunder, large and frequent flashes of Lightning, and excessive hard rain. When the Wind begins to abate it dyes away suddenly, and falling flat calm, it continues so an hour, more or less: then the wind comes about to the S.W. and it blows and rains as fierce from thence, as it did before at N.E. and as long" .

Both Pinto and Dampier believed that the probability of encountering a typhoon varied during the lunar cycle. Pinto seems to indicate that they are most frequent around the "new moon" whereas Dampier is on the alert at "the full or change of the moon". Although tidal forces due to the moon probably affect the formation of typhoons, on some occasions, we now know from weather maps that typhoons are in existence throughout the lunar cycle and, of course, exist for many days.

In 1698 Captain Langford writing in the "Philosophical Transactions" (Langford 1698) described five West Indian hurricanes. He referred to them as "whirlwinds", described their motion and indicated how ships could put to sea with the northerly winds ahead of the storm and then be blown back with the south east winds "when his fury is over". Around this time, mariners and scholars alike were often confused by the fact that ships experienced the full fury of the winds in hurricanes or typhoons for a day or more yet were often not blown very far away from where they first encountered the winds. Thus in Dr. Blane's account of the 1780 Barbadoes hurricane (Piddington 1848) it is noted that:-

> " The ships which put before the wind during the hurricane were not carried with the velocity which might have been expected from the violence of it. A merchant ship with the crew on board was driven from her anchors at Barbadoes, all the compasses were broken, and after tossing about for two days and two nights, the people found themselves at the mouth of Carlisle Bay, the very point whence they set out, at a time when they supposed themselves 100 leagues from it."

About 100 years after Langford, Colonel James Capper of the East India Company published, in 1801, a work entitled "Observations on Winds and Monsoons". He mentioned the hurricanes that affected Madras and the Coromandel Coast of India and noted that they are felt with equal violence on the coast and out at sea. He wrote that:-

> "..... all these circumstances properly considered, clearly manifest the nature of these winds, or rather positively prove them to be whirlwinds whose diameter cannot be more than 120 miles and the vortex seems generally near Madras or Pulicat."

Whilst Capper also realized that hurricanes were whirlwinds he mistakenly took them to be local and temporary. He came very close to discovering that whirlwinds also travelled along or progressed because, in a letter he wrote in May 1760, he related an experience of Benjamin Franklin's which properly analysed could have led to such a discovery. Franklin was intending to observe the eclipse of the moon in September 1743 at Philadelphia but a "northeast storm" came up and obscured his view. From the newspaper he found that the eclipse had been visible in Boston. From correspondence he

determined that the storm (northeast winds) had arrived earlier in places southwest of Philadelphia and later in places to the northeast so that it had progressed against the direction of the wind. It was not until thirty years later that the concept of a hurricane as a travelling vortex (whirlwind) was developed.

When describing the Boston Storm of 23rd September 1815 Professor Farrar (1819) of the University of Cambridge, New England used the sentence "In these cases it appears to have been a moving vortex and not the rushing forward of the great body of the atmosphere". Farrar did not generalize his facts. It was not until 1828 that thorough scientific studies began to mature. In that year a German, Heinrich Wilhelm Dove (1828) produced evidence from European Storms to confirm that winds in cyclones blow in approximately circular paths around a low pressure centre and that the whole whirlwind moves along. He also recognized that winds in cyclones rotate in an anti-clockwise direction north of the equator and in a clockwise direction south of the equator. His model-illustrated with charts and wind arrows - did not specifically apply to tropical cyclones but was the first demonstration in the scientific literature of the cyclonic rotation of winds around low pressure centres and their bodily propagation.

In 1831 an American Naval architect, William C. Redfield published a most remarkable paper on West Indian hurricanes in the "American Journal of Science and Art" (Redfield 1831). He presented observations that he had collected over ten years and demonstrated clearly that hurricanes are great whirlwinds about a centre where the atmospheric pressure is low and the winds light or calm. He further showed that the centre of the hurricane moved along a relatively smooth path while the winds rotated around it - in the words used at that time hurricanes were "progressive whirlwinds". In his paper he produced a chart to show the progress or track of one hurricane.

During the following ten years he continued to contribute papers on hurricanes to the same journal and in 1846 he published his findings in a book entitled "On three several hurricanes of the Atlantic and their relations to the Northers of Mexico and Central America"(Redfield 1846). In his book he correctly identified the region between equator and the Tropic of Cancer as the place of origin of hurricanes and traced them westward, north and then northeast sometimes as far as Europe. He also recognized that the winds had what he called a "vorticose convergence" towards the centre, that is, they did not blow in true horizontal circles but spiralled inwards and upwards. As early as 1834 Redfield expressed the view that when the typhoons of the China Sea should be investigated they would be found to be similar to West Indian hurricanes.

In 1831 - the year that Redfield published his famous paper - a severe hurricane struck the island of Barbados and caused tremendous damage there. In seven hours, 1,477 people lost their lives and almost all the vegetation was blown away. Many buildings were completely destroyed. Lieut-Colonel William Reid of the Royal Engineers was sent out from England to take charge of the re-building of government premises. Whilst in Barbados he became very interested in West Indian hurricanes, started a correspondence with Redfield, talked and corresponded with hundreds of seamen and examined many ships' logs. He incorporated much of the information he collected into a book (Reid 1832) with the title, "An attempt to develop the law of storms by means of facts arranged according to place and time; and hence to point out a cause for the Variable Winds with the view to practical use in Navigation. " For obvious reasons the work was usually known as "Reid on the Law of Storms" . "The Law of Storms" is a phrase that was used at that time for the established facts on the characteristics and movement of hurricanes as distinct from theories on the same subjects.

Colonel Reid's greatest achievement was to bring the accumulated knowledge on hurricanes to bear on practical matters. In his book he gave instructions for mariners on how to recognize the approach of a hurricane and how to handle a ship caught in one. In 1847, when Colonel and Governor of Barbadoes he issued a memorandum (Piddington 1848) establishing a signal station at Bridgetown. When the barometer began to fall it was the responsibility of the Captain of the Port to cause a ball to be hoisted on a mast. If the pressure continued to fall and the weather looked threatening, two balls were hoisted and if the "indications became alarming" the two balls were lowered to half mast. This is the first record of a hurricane or typhoon warning system in the world.

Reid was the first to discover that not only did hurricanes in the southern hemisphere rotate in the reverse direction to those north of the equator (as indicated by Dove for cyclones in general) but their paths also showed a reversed line of curvature in that they moved westward and then curved south and southeast, whereas the path of hurricanes in the northern hemisphere curves towards the north and northeast.

An army surgeon, Dr. A. Thom of Her Majesty's 86th Regiment, who had been stationed at Mauritius, published in 1845 a valuable book on the science generally and on the hurricanes of the Southern Indian Ocean in particular (Thom 1845). Two years later a French engineer called, Keller, also wrote about the behaviour and the theory of hurricanes (Keller 1847).

In 1838, - the year that Reid published his book - he persuaded the East India Company that it would be to their profit to study the hurricanes that occur in the Bay of Bengal and the Arabian Sea. Reid was successful in getting a number of observatories established in India working under, and reporting to, a central office in Calcutta. A Captain Henry Piddington was appointed to Calcutta to direct the work of the observatories; he wasted no time and within a year published a paper on "The Hurricane in the Bay of Bengal June 1839" (Piddington 1839). During the next fifteen years he produced forty other papers and published his famous book "The Sailor's Horn-Book for the Law of Storms in all Parts of the World" (Piddington 1848)*. It was in this book that he proposed the use of the word "cyclone" for a circulation of winds around an area where the atmospheric pressure is relatively low. In his own words:-

> " I suggest that we might for this class of circular, or highly curved winds, adapt the term "Cyclone" from the Greek κυκλος (which signifies, amongst other things, the coil of a snake), as neither affirming the circle to be a true one, though the circuit may be complete, yet expressing sufficiently the tendency to circular motions in these meteors.+ "

The Oxford English Dictionary states that the Greek word which means, inter alia, "the coil of a serpent" is κυκλωμα; κυκλος has connotations of a more circular nature. Notwithstanding these doubts on the legitimacy of the origin of the word "cyclone", the term was immediately adopted by meteorologists and seaman alike and has been in use since that time. Radar photographs of rainbands in typhoons (Fig.) illustrat how inspired was his choice of the name or cyclone.

* The date of first publication. The later dates found in most books and papers refer to later editions of which there were at least four.

+ "Meteor" a word from the Greek meaning atmospheric phenomenon.

Redfield (1842) considered that the wind in the hurricane did not blow in circles around the centre but rather spiralled in towards the centre. He wrote:-

" In conformity with this view the storm figure on my Chart of the storm of 1830, was directed to be engraved in spiral or involute lines, but the point was yielded for the convenience of the engraver. "

However, it was Piddington (1845), who, in his Thirteenth Memoir , first produced evidence to prove that the winds spiralled in towards the centre. He carefully reconstructed the paths of drifting ships - some of which circumnavigated hurricane centres and some of which were blown in towards the eye - and deduced from these observations and the many observations of the large numbers of birds and insects that are sometimes found in the eye of storms, that the winds spiral inwards or are incurving. In a footnote in his book there is the following nice observation in English usage:-

" Incurvating is, I know, the English-Latin word, but Incurving is a much more manageable one for sailors. "

In his "Horn Book" Piddington provided a transparent card called a "horn dial", on which were inscribed circles to represent winds blowing around a hurricane centre. The card was designed so that mariners could lay it on their charts and estimate the bearing of a hurricane centre from their ship if they first determined the direction of the wind they were experiencing. Because he showed a circular flow of winds some writers have concluded that he was not aware of the incurving. This is not the case, Piddington considered that the circular windscale gave an approximate but adequate indication of the required directions, bearing in mind how it would be used. He noted that Redfield thought it possible that:-

" .... the incurving may amount to two points, or 22° near the centre, and my own views, as expressed above, would require fully this. "

Inspired by the observation made on board the "Charles Heddle" which scudded round and round a cyclone off Mauritius for five successive days, Piddington wrote in his report in 1845 that:-

" Everyone and every set of men who are pursuing the investigation of any great question, are apt to over-rate its importance; and perhaps I shall only excite a smile when I say, that the day will yet come when ships will be sent out to investigate the course of storms and hurricanes,....."

To Piddington, therefore, must go the credit for first conceiving the value of reconnoitring tropical cyclones. In addition, he also suggested in his sixth memoir on "Storms of the China Sea from 1780 to 1841" written in 1842, that a telegraph could be established on the east coast of China to warn shipping at Hong Kong of the approach of tropical cyclones. This very early suggestion, prior to the commercial use of the telegraph, was probably the first reference to its use for warning tropical cyclones. Although the principle of the telegraph was demonstrated by Sir William Watson in 1747 it was not until 1843 that satisfactory detectors were developed and Morse introduced his code. The first weather maps based on telegraphed observations were made in Washington in 1850. Telegraphed observations were first used in the Far East in 1865 to prepare warnings of tropical cyclones in the Bay of Bengal. Marconi took out his radio patent in Britain in 1896 but it was not until after Fleming developed his valve in 1904 that the use of radio-telegraphy for marine and meteorological use become practical. Of course, weather maps had been prepared earlier from information received by post. H.W. Brandes prepared the first in Leipzig in 1820 soon to be followed by Redfield, Reid, Espy and Piddington who used ship observations to depict the characteristic patterns of wind and pressure around tropical cyclones. Empirical rules were developed for the movement of these systems and the accompanying sequence of weather changes. The telegraph and later the radio telegraph enabled these rules to be applied to current situations so that timely warnings could be issued.

2.1.2 History of tropical cyclone theory

By the middle of the 19th Century, the essential features of the movement and low level structure of tropical cyclones had been determined. But there had been little progress in developing the theory of how they work, that is, the mechanism which causes the low pressure and violent winds. The following account of the progress towards the modern concept of a typhoon as a heat engine, whilst by no means complete, is intended to include the more significant steps in the development of the theory.

In 1841 the American professor James Pollard Espy made a significant contribution in his book on the "Philosophy of Storms". He proposed that air moved directly towards the low pressure centre of a cyclone - without spiralling - where it rose and formed cloud by condensing part of its water vapour. The released latent would make the air near the cyclone centre relatively warmer and less dense than its environment and so rise in a manner similar to warm air in a chimney, and maintain a reduced surface pressure below. He supported this theory with remarkably good calculations of the temperature of rising humid air and of some other quantities involved and hypothesised that "at the surface of the atmosphere" the rising air would blow outwards, radially, above the inflowing air. He also hypothesised that typhoons carried along in the prevailing large scale flow of the atmosphere. Espy thus gave an explanation for the low central pressure in these cyclones, the winds, clouds, rain and the movement of the cyclone as a whole but he persistently denied the possibility that the low level wind flow revolved or spiralled inwards. His insistence on this point is the more remarkable in that he admitted that his principles would still apply even if the wind did spiral inwards as, indeed, most scientists considered to have been proved by Redfield and Piddington.

The difference in the views of Redfield and Espy on the low level wind flow became a cause celebre - Espy travelled throughout the U.S.A. giving public lectures in support of his views and throwing out challenges to Redfield. Although at times the two carried on violent controversy in the press, Redfield had no real liking for public controversy and his showing on the few occasions when he entered the arena was poor. Bôcher (1888) pointed out that the two men saw the problem from different positions. Espy considered the forces involved and Redfield considered the motions or, in other words, Espy developed a theory and tried to make the facts fit whereas Redfield considered the facts

first and then attempted to construct a theory for them; this is the difference, of course, between the deductive and inductive methods of reasoning. Espy and Redfield were invited to Europe in 1841; the former readily accepted and travelled to England and France. Parts of his theory received a rather skeptical reception in England but, after an address to the French Academy, he obtained the keen support of the French savants. Partly on the strength of this enthusiastic reception he was able to obtain a U.S. Government appointment as a meteorologist from which position he continued his attack on both Redfield and his theories. Espy and Redfield never resolved their differences.

Espy's theory on the importance of heat and water vapour for establishing the low pressure and wind flows in tropical cyclones needed to be improved in detail and modified to account for the spiral inflow observed by Redfield and Piddington. This work was first attempted by Tracy (1843) in a paper entitled "The Rotary Action of Storms". He showed that, because of the earth's rotation, air flowing towards a low pressure centre would not move directly in a straight line but would rotate around the centre (see p).

The next advance was made by Professor William Ferrel (1856) in "An Essay on the Winds and Currents of the Oceans". In this paper he made distinguished contributions to the dynamic and thermodynamic theory of tropical cyclones. In 1889 he consolidated this work in a classic book entitled "A Popular Treatise on the Winds" (Ferrel 1889) in which, amongst other things, he laid down the gross features of tropical cyclone theory as we know them to-day. He offered valid reasons for the formation of the central calm or eye, and stated that "In general the velocity of the ascending current in the interior part is much greater, but over a smaller area, than that of the descending current in the exterior surrounding part over a much greater area ... ". He compared conditions found in several cyclones with those predicted by his theory. In particular, he presented a diagram showing how the low level air spirals into a tropical cyclone, rises retaining its cyclonic rotation and then, as it moves away from the centre "at some high level", turns to blow radially outward and continues to turn until, at a greater distance from the cyclone centre, the winds circulate anticyclonically. On this model the winds at high levels, at some distance from the centre, rotate in the opposite direction to those near the surface. Ferrel deduced this remarkable fact from theory but also showed that it was in accordance with Ley's observations of the motion of high cirrus clouds over cyclones. The concept that tropical cyclones should be capped by an anticyclonic outflow has been substantiated in the post World War II

years by observations made from aircraft reconnaissance flights. Some prestigous text books state, incorrectly, that this structure was quite unexpected until the advent of radio-sounding balloons (late 1930s). The gross theory of tropical cyclones was therefore established by 1889. Progress during the following fifty years was slow.

Subsequent developments are more appropriate to other chapters of this book but some landmarks can be briefly noted. Shaw (1922) considered tropical cyclones as a phenomenon restricted to areas of the oceans with high surface temperature and showed that, if their low central pressure were caused by warming of air ascending from near the ocean surface, then the ascent must continue up to 15 km or so. In spite of Shaw's calculations the opinion remained rife that tropical cyclones were a low level phenomenon. Köppen (1920) had earlier shown that an unreasonably high temperature would be required in the centre of a tropical cyclone if it were to have a depth of only 3 km or less. Haurwitz (1935) expanded on this work and introduced observations of the temperature in typhoons as measured on mountains in Japan - reported by Horiguti (1927) - to indicate that tropical cyclones should extend to at least 10 - 11 km. Nevertheless, even as late as 1950 a number of meteorologists remained unconvinced of this fact (e.g. Gherzi 1951 p.228) although individual reconnaissance flights were already beginning to show that some typhoons did extend to about 12 km. General acceptance of this feature of tropical cyclones had to await the accumulation of evidence from a large number of reconnaissance flights and radiosonde ascents.

Horiguti (1927a) was the first to show that the air temperature near sea level in typhoons over the ocean changed little in a typhoon or rose slightly its centre was approached. The potential temperature of the air was found to rise gradually towards the centre where it was about $3^{o}C$ higher than on the periphery of the storm. Depperman (1937) also showed that the air temperature of the low level air flowing into typhoons was nearly constant from the outside to the centre. However, it was not until 1944 that the implication of this remarkable fact was appreciated by Byers (1944) who pointed out that as air spirals in towards the centre of tropical cyclones it would continually expand as it moved towards lower pressure and should therefore cool (see p) and so form a dense fog. In nature this does not happen because, although the inflowing surface air expands, its temperature is maintained by taking up heat (and

water vapour) from the sea. This additional source of heat greatly increases the intensity of tropical cyclones although it forms only a small part of the total heat content of the inflowing air.

After this contribution by Byers the stage was set for a more detailed mathematical modelling of tropical cyclones as heat engines and Herbert Riehl has been a pre-eminent pioneer in this field. There are still problems in the theory of the formation of tropical cyclones but much progress has been made in making realistic mathematical models of them in the steady state.

2.2 Developments in the Far East

In this section the development of tropical cyclone warning services in the Far East is traced and some of the difficulties under which early meteorologists worked are recorded. In all cases the stimulus for starting warning services came from commercial considerations often with Chambers of Commerce taking the lead and helping financially. The safety of citizens in general was not, at first, a significant consideration. Some understanding of tropical cyclones was necessary before warning services could be initiated. The required research studies at first preceeded and later accompanied the development of warning services and this parallel development continues to this day. The research, initiation of warning services and characters concerned are introduced country by country in a sequence based mainly on the date on which each country first issued tropical cyclone warnings. I thought that it would be of interest to illustrate some of the personality clashes and political complications that are involved in this field of activity. Obviously, this could not be described in detail for all services. I elected to use Hong Kong as the vehicle for this part of the history because it is the service that I know best. The reader will therefore understand why the section on Hong Kong is relatively long.

2.2.1 India

India has a long and distinguished record in meteorology and was the first country in the Far East to establish warning systems for tropical cyclones. As early as the 18th centuary a number of officials of the British East India Company were making meteorological observations on their own account. An astronomical observatory was established at Madras in 1792 and the first astronomer Goldingham - who was also Government architect! - began meteorological observations there in 1793 and prepared a meteorological register in 1796. A continuous series of observations is available for Madras from that date onwards. During the period 1823 to 1864 several other observatories were established primarily for astronomical or magnetic work but meteorological observations were also made from time to time. Meteorological observations were started in the Calcutta Survey of India Office in 1829. At Calcutta,in 1835,

the Rev. R. Everest - not to be confused with Sir George Everest, Surveyor General (1830-1843) of mountain fame - published papers on the evolution of the seasons and on lunar/terrestial weather relationships. He later wrote on the periods of rain and drought in India between 1831 and 1838.

Official interest in the cyclones that affect the Indian sub-continent was evident in 1838 when Captain Henry Piddington was put in charge of stations specifically established to study tropical cyclones (p.). Piddington first came to India as Curator of the Calcutta Museum and was later President of the Marine Court. It was he who began the serious study of Indian cyclones publishing most of his work as memoirs in the journals of the Asiatic Society of Bengal which was active in encouraging early studies in this field. Some of his 24 memoirs, other papers on cyclones and his famous "Sailors Handbook of Storms" have been mentioned (p.). In 1847 he began to issue storm warnings from his office in Calcutta. These were the first warnings prepared in the Far East. Two English contemporaries of Piddington's, Meldrum and Alexander Thom, carried out the first studies on the storms of the South Indian Ocean.

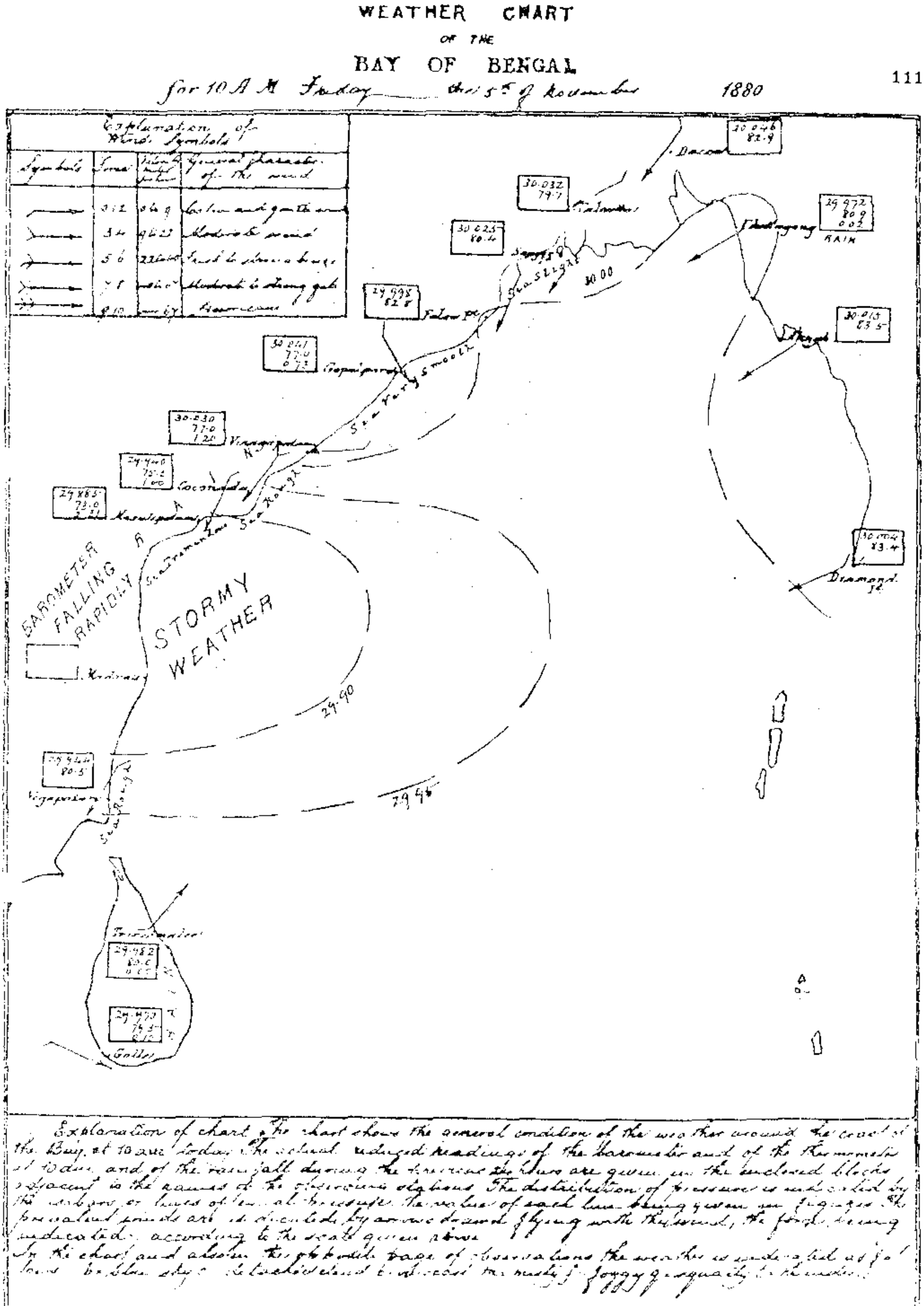
In 1842 Dr. George Buist, a remarkable man of many parts, assumed charge of the Bombay Observatory. He prepared the first weather maps in India, made balloon soundings and other studies and wrote on the "Hurricanes in the Eastern Seas from 1854 to 1859". However, he should be remembered for stressing -

"..... the need to know the points to which attention ought specially to be directed in these torrid regions which furnish the true field of meteorological enquiry; and that observers on the spot must work out these matters for themselves and not feel satisfied by following the instructors sent by the philosophers of Europe."

good counsel often overlooked by tropical meteorologists in subsequent years. After the takeover of the Indian Administration by the British Government from the East India Company in 1858 it was decided to consolidate the various groups of Indian weather observers. While negotiations to this end

where still in progress in October 1864 a devastating cyclone struck the Port of Calcutta. The associated storm surge moved up the Hooghly River causing the loss of more than 80 000 lives. After only a few weeks another cyclone ravaged Masulipatnam killing about 40 000 people. The Bengal Chamber of Commerce immediately called the attention of the Government of Bengal to the urgent need to warn the community and mariners of the approach of cyclones. A Storm Warning Committee was therefore established with H.F. Blandford as Secretary. Blanford was an internationaly recognised scientist of the Geological Survey of India which he left in 1961 for the Chair of Physics in the Presidency College Calcutta. He was Honorary Secretary of the Asiatic Society of Bengal in 1863 and so got drawn into the study of cyclones. He arranged, in 1865, to obtain meteorological observations by telegraph from stations around the northern part of the Bay and to hoist storm warning signals at the Port of Calcutta when it was threatened by cyclones. These were the first official tropical-cyclone warnings issued in India or elsewhere in the Far East. In 1866 Blandford published a report (with Gastrell) on the 1864 cyclone and in 1867 he was appointed Meteorological Reporter to the Government of Bengal.

By 1875 provincial meteorological services were operating 77 observatories around India; these were further consolidated and with the meteorological operations of the Surveyor General's Office, formed the Indian Meteorological Service that year. Blandford was the first Imperial Meteorological Reporter. He moved the Calcutta office out of town to nearby Alipore in 1877 and set up a central observatory there. The warning system was extended to the west coast in 1880 when arrangements were made for three stations on the east coast and seven on the west coast to telegraph daily weather reports to Bombay. Visual storm signals, in the form of a cone by day and three lamps at the corners of a triangle by night, were hoisted at Bombay and at five other ports between Karachi and Kumta, when directed by Bombay. In this year also the "Bay of Bengal Daily Weather Report and Chart" was first published to show the positions of cyclones and areas of rough weather (Fig. 2.1).



Weather Chart of the Bay of Bengal
(5 Nov. 1880)

DAILY WEATHER REPORT
OF THE
CALCUTTA STORM SIGNAL SERVICE
giving R.A.M. observations received on Friday the 5th November 1880

Stations	Rain	Barometer reduced to 32° and to Sea level	Change in the Barometer during previous 24 hours	Wind Dir	Wind Vel	Temperature Dry bulb	Temperature Wet bulb	Humidity	Cloud Proportions	Weather Intimate	State of the Sea	Rain fall previous 24 hours
Diamond Island	T	30 002	- 017	ENE	4	83·4	77·5	75	3			
Akyab		30 ··	···	ENE	2	83 5	77 8	77	0			
Chittagong		29 972	- 010	SSE	3	80 4	75 2	75	2			1 12
Dacca		30 046	+ 031	N E	2	82 9	78 3	81	2			
Calcutta		30 032	+ 019	ENE	2	77 7	73 9	75	8			
Saugor Island		30 025	- 010	N E	5	80 4	76 9	85	7		Sea slight	
False Point		29 990	- 007	NNE	6	82 8	76 0	75	7			
Gopalpore		30 041	+ 021	NW	1	77 0	69 4	67	10	0	Sea rough	0 73
Vizagapatam		30 030	- 023	C	3	77 0	73 0	82	10	0		1 20
Coconada		29 940	- 078	NE	19	75 5	73 5	91	9	Strong winds	Sea rough	1 60
Masulipatam		29 895	- 106	NNE		73 0	72 0	95	9	Strong winds	Sea tempestuous	2 31
Madras												
Negapatam		29 994	+ 003	NNE	2	80 5	77 5	87	2		Sea rough	
Trincomalee		29 992	- 007	S W	7	80 0	75 5	80	2			0 02
Galle		29 970	+ 013	WNW	8	77 5	77 5	91	9	0		0 10

General Remarks

Bay of Bengal 5th of November 10 a.m.— The changes of atmospheric pressure during the past 24 hours are unimportant except at the stations on the Coromandel Coast where the barometer is falling rapidly. A cyclonic storm has evidently been developing in the South of the Bay during the past three or four days & is now approaching the Coromandel Coast in the absence of the Madras weather telegram the position of the storm centre cannot be determined with certainty. Probably, as indicated by the wind direction the storm is advancing to the coast in the immediate neighbourhood of Madras and to the South. Light North-Easterly winds prevail at the head & along the East Coast of the Bay. Strong winds have set in along the Coromandel Coast Rain has fallen at the great majority of stations along the West coast of the Bay. Masulipatam reports 2.31 inches, Coconada 1.6 inches and Vizagapatam 1.2 inches. The sea is rough along the whole of the Coromandel Coast and is very high at Masulipatam

John Eliot
Actg. Reporter to the Govt. of Bengal

Bengal Daily Weather Report
(5 Nov. 1880)

In 1881 telegraphic information was being received from 84 stations in India and John Elliott (p.) the Bengal Meteorolgical Reporter proposed improvements in the storm warning service for the Bay of Bengal. These included additional descriptive and numbered signals in the visual warning code and arrangements to display them at a number of locations outside Calcutta.

On 22nd September, 1885 a small cyclone accompanied by a high storm surge devastated the settlement of Hookeytolla at False Point in Orissa. Owing to the great destruction of life and property which resulted from this storm arrangements were made to supply storm warnings to coastal ports other than Calcutta. Meteorologists at Calcutta would issue a warning that a storm was in existence in the Bay and it was then up to the port officers to supplement this warning by local observations of wind and pressure before taking action to warn the approach of a storm. In 1886 Blandford introduced a system of storm warnings for all eleven ports including those in Burma. He drew up a general system of storm signals and instructions for the guidance of port officers. The Calcutta Office was responsible for issuing storm warnings to all ports in the Bay of Bengal whilst the west coast ports were cared for by the Meteorological Reporter at Bombay. Up to 1898 two different systems of storm signals were employed in Indian ports leading to some confusion. A committee was established in that year to recommend a unified system. A detailed system was agreed for the major ports but only selected signals were to be used at smaller ports. Following the general introduction of wireless telegraphy apparatus on board ships a further simplification of the warning code was made in 1912 and implemented at all Indian and Burmese ports. Arrangements were also made to pass meteorological reports to any ships that might request them. The "India Daily Weather Report" was started on 1st September 1887.

In 1891 W.L. Dallas, Assistant Meteorological Reporter to Blandford, published a book containing a fascinating account of the history of storms in the Arabian Sea during the period 1868 to 1889. John Eliot, or Sir John Eliot as he later became, wrote a report on the May 1877 Madras cyclone and took up office in 1889 as the first Director General of Observatories. He was succeeded in 1904 by Gilbert Walker who had been Professor of Mathematical Physics at Cambridge. During the years 1922 to 1927 storm warning activities had been transferred from Calcutta to the hill station at Simla where most of the work of the India Meteorological Department was done. This move did not prove satisfactory because communication problems impaired the efficiency of the warning service. The Commission investigating the loss of the "ss Okara" in Calcutta in 1923 commented that the warning from Simla was not timely. It was therefore decided to return the responsibilities to Calcutta but, it was not until 1927 that this was eventually achieved.

A number of changes in the location of warning centres were consequent upon the cessation of World War II, ~~and the partition of the sub-continent in 1947~~. The Pakistan, Burmese and Sri Lanka (Ceylon) Meteorological Services were established with their own warning responsibilities to be followed later by the formation of the Bangladesh Meteorological Service in 197 .

At the time of writing, storms affecting the Arabian Sea, Bay of Bengal and southern and eastern parts of India are warned from centres at Bombay, Calcutta and Madras respectively. Dr. Koteswaram was the Director General from 1969 to 1975 and he took a keen interest in Indian tropical cyclones. He wrote a number of papers in this field and made great efforts to increase public awareness of the dangers of tropical cyclones. He increased the number of coastal observing stations and laid plans for the establishment of a coastal chain of 100 mm storm-warning radars. The first being established at Vishakhapatan (on the NE coast) in 1969 and the second at Madras in 1973 followed by Mitsubishi and Plessey radars at Calcutta and Paradeep (SW of Calcutta) respectively and an Indian Bharat radar at Bombay in 1975. A Cyclone Warning Research Centre on Tropical Cyclone was also established in connection with the warning centre at Madras.

In 1971 Dr. Koteswaram was elected as Vice-President of the W.M.O. and so become the first Asian to attain this office. In the same year he was appointed Chairman of the W.M.O. Executive Committee Panel of (8) Experts on Tropical Cyclones. I served on this Committee under Dr. Koteswaram when it met in Tokyo in September 1971 to prepare the Draft Plan for the W.M.O. Tropical Cyclone Project which was accepted by Congress in 1975. This project has successfully stimulated scientific research on tropical cyclones and on action to improve warning systems and preparedness around the world.

Other Indian Ocean Tropical Cyclone Centres

After partition in 1947 the Pakistan Meteorological Service was established with responsibilities for forecasting and warning tropical cyclones. The Service was responsible for warning the disastrous cyclones of October 1960 and November 1970 - the latter being perhaps the deadliest cyclone of the century (sect). This Service was futher split after the birth of Bangladesh in 1971. In Sri Lanka rainfall observations had been made since 1868 and an observatory was founded in Colombo in 1907 under a Superintendent who was head of the Meteorological Branch of the Surveyor General's Office. The demands on the Observatory increased rapidly after the war and it was found necessary to established an independent Department of Meteorology in October 1948 with the Observatory Superintendent being appointed as Director of the new Department. The usual observing, forecasting and warning services were quickly established. Sri Lanka is well south of the usual track of Bay of Bengal cyclones but in December 1964 the Department warned the most severe cyclone on record as it approached the island at a very low latitude and with a minimum central pressure of about 978 mb. The Rameswaram Cyclone as it was called crossed Sri Lanka on the 23rd December 1964 sweeping high storm surge waves over the islands of Mannar and Rameswaram drowning about 1 000 people.

Meteorological Service of Burma

Meteorological stations were established in Burma by the Indian Meteorological Department in 1881 and a Burmese Department of Meteorology was established in 1937 when Burma separated from India. ~~Rangoon is~~ The storm warning centre and ~~has been issuing~~ tropical warnings since 1938.

ISAL Rangoon

Have been issued from there

Space does not present accounts of the warning services established in the Southern Hemisphere in Australia, Mauritius and elsewhere. But acknowledgement must be made of the fine cyclone-warning services and pioneering studies and developments that have been made in Australia. Dr. Bell Gibbs who was Director of the Australian Weather Bureau from 19 to 1978 ~~had written~~ papers on tropical cyclones and took a great interest in building up the Australian contribution in this field. In the decade after 1965 advances were made on both the technical and community preparedness aspects of ameliorating damage from tropical cyclones. Dr. Gibbs was also First Vice President of the W.M.O. from 1971 to 1975 and worked hard in that Organization for many years to ensure that problems in tropical meteorology in general and tropical cyclones in particular received international attention.

2.2.2 The Philippines

MANILA OBSERVATORY

Reid and Piddington discussed typhoons of the China coast in their books and showed that they were of the same nature as the hurricanes of the West Indies and the cyclones of the Bay of Bengal and the Southern Indian Ocean but there was no observatory in the Western Pacific and nobody there was studying these storms. Reid (1838) wrote :-

> " The situation of the British Residents at Macau, affords the best opportunities for determining the tracks of the Chinese Hurricanes, and it is much to be desired that some of these gentlemen should undertake the investigation; for it must be of importance to the Commerce in which they are engaged, to endeavour to explain the laws which these tempests seem to obey."

It was not 'these gentlemen' but the Jesuits who first began to study typhoons in the Far East. On 1st January 1865 Manila Observatory was started in a very modest way, for it was then that Francisco (Faranci 1859) Colina, a Jesuit teacher of science, installed meteorological instruments in an abandoned pigeon house on the roof of the Ateneo Municipal school. He published a pamphlet containing the observations he had made during a severe typhoon in September of that year. This pamphlet caught the interest of the mercantile and shipping community which subscribed six thousand pesos to buy better instruments and set up an institute (Repetti 1948).

A Jesuit scholar, Father Frederico Faura arrived in Manila on 20th June 1866 to become the first director of the Manila Observatory. In December 1878 he arranged with the Chief of Posts and Telegraphs that observations made at telegraph stations in Luzon be sent to the Manila Observatory. With the prompt receipt of these observations Father Faura felt that he was in a position to issue typhoon warnings and the first typhoon warning ever issued to the public was released on 7th July 1879. However, it was not until the 18th of November that year that the impact of the service was appreciated, for on that day he warned that a severe typhoon would affect Manila. Vessels went to typhoon stations and the losses from the typhoon, which passed on the 20th, were relatively light; whereas places without the benefit of the warnings are reported to

have suffered severely. The preparation of typhoon warnings now became a part of the routine of the Observatory. With the laying of the Hong Kong/Manila cable in 1880 a daily exchange of weather reports took place from October of that year and Manila Observatory also passed information on typhoons.

The work of the observatory was greatly appreciated and in 1880 businessmen in Manila and Hong Kong contributed US$910 and US$350, respectively, towards the costs of operating the institution. The Spanish Government passed a royal decree on 28th April 1884 formally establishing the Manila Observatory, and thirteen stations in Luzon, as an official organization. The Spanish fathers retained their old appointments and, in particular, Father Faura remained as Director until his death in 1897. Father Jose Algué then became director and in 1904 he published his famous book 'Cyclones of the Far East' .

In the latter half of 1898 the Spanish-American war impinged upon life at the Observatory but the routine work continued and weather observations were received over a military telegraph line which the Signal Corps ran to the Observatory. Father Algué met Admiral Dewey on the flagship 'Olympia' in November 1898 and the Admiral, holding the work of the Observatory in high regard, promised to do all he could to help it to continue. Dewey remarked that, after he had cut the Hong Kong/Manila telegraph cable, he received an earnest request from an officer of the port of Hong Kong for a continuance of the typhoon warnings.

On 22nd May 1901 the Manila Observatory became a part of the American Administration and was established as the Central Office of the Philippines Weather Bureau. The Director, Father Algué, continued in office at a salary of US$125.00 per month. There were now 72 weather stations in the Philippines.

In 1908 Father Jose Coronas prepared a weather map and from that date typhoon warnings from Manila were based on such maps. It has been stated that these were the first weather maps produced in the Far East, however, it is known that weather maps were routinely plotted at Tokyo, Zikawei and Hong Kong before 1908. (See Fig.2.1) The international co-operation

manifested in the exchange of weather observations between the Spanish, the Americans and the Philippinos in Manila, the English in Hong Kong, the Portuguese in Macau, the French in Indo-China and Shanghai, the Japanese in Taiwan, Japan and Korea, the Chinese on the mainland and the Russians at Vladivostock is typical of that found in meteorology since charts of the weather were first made in Europe in 1819.

However, a meteorological storm of an unusual kind developed between Dr. Doberck, Director of the Royal Observatory of Hong Kong and Father Algué. But more of this later. In passing it is of interest to note that Father Doyle - Sub-Director of the Manila Observatory under Algué - was the son of an English army officer who had been stationed in Hong Kong.

Father Algué left Manila for Spain in 1924 and Father Miguel Selga officially became Director on 1st January 1926, a post he held until the outbreak of the War. He was the last Jesuit director of the Observatory. When the American forces were regaining control of Manila on the 14th February 1945 and the Japanese were withdrawing, the Manila Observatory was set on fire and was destroyed along with the 10,000 volumes in the library. So the Observatory ceased to exist in its old form, almost exactly eighty years after its foundation.

No account of the work of the Manila Observatory and no text on typhoons would be complete without a reference to the distinguished Father Charles E. Deppermann. He obtained a doctors degree in physics at the Johns Hopkins University, U.S.A. and spent some time at Lick Observatory and the University of California before arriving in Manila, in 1926, to carry out astronomical work. In 1932 he returned to America and Europe to prepare for work in meteorology. He visited the United States Weather Bureau and the Geophysical Institute in Bergen and the Meteorological Institute in Oslo. The influence of the famous Norwegian school of meteorology was to be seen in his later work. He arrived back in Manila in November 1932 and was appointed Assistant Director in charge of the Meteorological Division the following month. Whilst in this position he wrote many important papers on typhoons and continued his distinguished work until interned in the Philippines during the war. He was rescued by the Americans in March 1945 and was flown to the U.S.A. He subsequently returned to the Philippines to set up new seismological stations.

After the war the Philippines Weather Bureau, with the aid of the U.S. Weather Bureau, re-established its network of observing stations and weather broadcasts under Dr. Casimiro del Rosario as Director. Dr. Roman Kintanar replaced Dr. Rosario in 1958. Under his leadership the activities of the department increased rapidly eventually leading, in 1973, to a reorganization of the Bureau and a change of title to the Philippines Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) with Dr. Kintanar as the first Administrator. A Typhoon Moderation Programme, with a component Typhoon Research Project, was established by Republic Act 6613 in 1972. One of the aims of this national programme is to apply modification techniques (sect 18.3) to typhoons to reduce the damage and loss of life usually associated with these storms.

2.2.3 China

THE ZIKAWEI OBSERVATORY, SHANGHAI

In 1872 French Jesuits returned to China to resume the scientific work which they had carriedout in Peking in the 16th and 17th centuries. They built an observatory at Zikawei about 6 km southwest of Shanghai and began meteorological observations there in 1873. A regular meteorological and magnetic bulletin was published from 1874. Half of the running expenses for the Observatory was put up by the Chinese Customs, shipping companies, the municipalities of Shanghai and the Telegraph Companies.

The first director, Father Marc Dechevrens published a paper on the typhoon of July 1874 and followed this in 1880 with "The Typhoons of the China Seas", and in 1894 Father F.S. Chevalier published "The typhoons of the year 1893". In 1919 Dechevrens was succeeded as director by Father Louis Froc whose "Tracks of 620 Typhoons 1893 - 1926" became very well known. He in turn, was followed as director in 1930, by Father Ernesto Gherzi who had been working at Zikawei since 1920. He produced a report on the typhoons of 1926 and issued an annual typhoon report from 1928 until 1940. These reports were addressed to the members of the Shanghai General Chamber of Commerce and most of them contain interesting essays on some scientific aspect of typhoons (Bell 1974).

The Zikawei Observatory became famous not only for its publications and scientific work, but also for the storm warning service which it provided for shipping in the China Seas. In 1886 Father Dechevrens issued his first typhoon warning to the Port of Shanghai; three years later a signal tower was set up in the French settlement on which symbols were hoisted to warn seamen of the existence of typhoons in the China Seas. The municipal semaphore was operated by a Jesuit Father, and his staff, who were in telegraphic communication with the Observatory.

In May, 1949 Father Gherzi attended a meeting of international meteorologists, in Manila, to co-ordinate warning procedures for tropical cyclones in the Southwest Pacific area and to agree on a suitable terminology. In the same month the revolution in China overtook life at the Zikawei Observatory and Gherzi was refused permission to return there. The Observatory was taken over by the Meteorological Service of the Chinese People's Republic and Father Gherzi remained in Hong Kong where he worked for a few months in the Royal Observatory. He then moved to Macau to work for a few years in the Observatory there before going to St. Louis University U.S.A. in 1954. Whilst in Macau

he published two volumes on the 'Meteorology of China' (Gherzi 1951) which contain sections on typhoons. Although these sections suffer, in places, from being out of date and lacking in accuracy - Fr. Gherzi's notes remained in China - the books are a good record of the experiences of himself and others in typhoons.

It was during the few years that Father Gherzi spent in Hong Kong and Macau that I was fortunate enough to get to know him quite well (Bell 1974). A tall, majestic figure with a grandee's beard and long flowing cassock he was a popular character with mariners and airmen who worked on the China Coast. He enjoyed getting down to the 'nuts and bolts' of meteorology and used to surprise many meteorologists by putting on radio headphones to receive meteorological broadcasts whilst simultaneously decoding the morse and plotting the weather observations, in two colours, on meteorological maps. If necessary he would repair the radio first. He did much to keep up the standards of meteorological telecommunications in the region by sending terse letters to stations which did not keep to schedule or had sub-standard morse operating techniques. I admired both his organ playing - Bach was a favourite - and his highly developed cocktail party tactics; at more than one party did he persuade very senior naval officers - R.N. and U.S.N. - to give him a radar set. He would then use influential contacts in London and Washington to see that the arrangements were 'regularised' and that the equipment was promptly delivered and installed - in the name of science.

The Central Meteorological Service of the Chinese People's Republic is now very large and ranks amongst the most highly developed services in the world having 30 times more weather stations now than in 1949. This great activitity in meteorology is due, in the main, to its importance for national agriculture,defence and fishing. The proper application of meteorology to agriculture can achieve huge gains in productivity which are vital to China where some 800 million people have to be fed and where the weather is notoriously fickle.

Weather observations are made regularly eight times each day at over five hundred surface stations. In addition, radio-sonde balloons are released twice each day from over one hundred and ten stations. This large volume of valuable information was regularly and freely broadcast, in morse code, from the 1st June 1956 and was thus available to the world in time for the beginning of the International Geophysical Year in 1957. The Service operates computers, satellite receiving stations and a network of weather radars. Tropical cyclone warnings are prepared on a regional basis and are disseminated over marine and domestic broadcast channels. Details on most of these broadcasts and stations are given in the handbooks of the World Meteorological Organization which China joined in 1972 after resuming her seat in the UN. Meteorological observations have been passed from Peking to Hong Kong by cable since December 1975 and to Tokyo via satellite from 1977.

Many scientific papers on tropical cyclones have been written by Chinese scientists since the war and a Typhoon Joint Study Group has been established at Shanghai.

2.2.4 Hong Kong

The Royal Observatory

Typhoons figure prominently in the history of the Colony of Hong Kong from its very first year. Preliminaries to a formal treaty ceding Hong Kong Island to the British Crown were agreed on 20th January 1841 and a survey party landed on the barren island a few days later. Land sales took place in the following June and building began immediately thereafter. On the 21st July the island was swept by a severe typhoon which removed the roof of every building and damaged shipping. The settlers immediately began reconstruction and had made good headway when, four days later, a less severe typhoon again caused destruction. During the second typhoon, the chief administrator of the Island, the Queen's Chief Superintendent of China Trade, Captain Charles Elliot R.N. was caught between Hong Kong and Macau in the cutter "LOUISA". He assumed command of the vessel and "showed great seamanship in beaching it on an island, where it was completely wrecked"!(Endacott 1958). The island was one of the group known as the Ladrones. Elliot survived the wreck and returned to discover that he had been relieved of his post for - amongst other things - having negotiated the cession of Hong Kong, a scarcely populated, barren, granite rock.

In 1852 sets of meteorological instruments were supplied to the Royal Engineers at overseas stations together with a book of instructions on how to make observations. These early British meteorological observations dating from 1853, constitute a valuable legacy to many countries. Apart from their use in purely scientific investigations they also enabled the frequency of floods and droughts to be estimated so that safe and efficient dams could be designed and constructed to improve the well-being of millions of people. Hong Kong was not an exception in this programme. The Royal Engineers made meteorological observations in the city of Victoria from 1853 and were later joined by the Staff of the Government Civil Hospital. In 1865 the Army Medical Department took over the task from the Royal Engineers and maintained the observations so that, when an observatory was established in 1883, thirty years of weather records were already in existence. It was in 1879 that the Royal Society of England first recommended the establishment of an observatory in Hong Kong (Starbuck 1951). It was pointed out in a memorial to the Secretary of State for the Colonies that Hong Kong was "favourably situated for the study of meteorology in general and typhoons in particular." Sir John Pope Hennessy, Governor of Hong Kong supported the proposal on "local and imperial grounds". After an examination by Colonel H.S. Palmer R.E. the scheme was abandoned as too costly. However, in May 1882 the Surveyor-General (Mr. John Macniel Price) submitted a less elaborate scheme which was accepted. The proposal was that the Observatory should make first class meteorological and magnetic observations and operate a time service. The Observatory was the sixteenth department to be formed in the Hong Kong Government and Dr. William Doberck, a German, was appointed to be the first Director. He arrived in the summer of 1883 along with his First Assistant Mr. F.G. Figg. There were no other directors in the Hong Kong Civil Service at that time, the title was new, but Doberck preferred the title Government Astronomer as astronomy was his main interest and, indeed, he used the title for sometime until corrected by his superiors.

Doberck soon appreciated that there was a need for local weather forecasts and tropical cyclone warnings but it was first necessary to obtain weather reports from many places. Therefore, in the second half of 1883 he visited the Treaty Ports to obtain their co-operation in exchanging meteorological reports by telegraph. He also recruited voluntary observers whenever he could and after obtaining the services of an Englishman in the Philippines, he wrote:-

> " The Superintendent of the station in Bolinao in the course of October commenced to forward observations also at other hours, whenever he apprehended atmospheric disturbances in the vicinity of Luzon. He then also observed the direction, whence the clouds were coming. The importance of similar telegraphic information from a gentleman of scientific training during the coming typhoon season cannot be overestimated."

The Hong Kong typhoon warning service became established in May 1884 when Doberck published a statement to the effect that he would notify the Harbour Office, Telegraph companies and the newspapers whenever there were indications of strong winds. A system of visual warnings based on a drum, ball and cone was installed in August that year to warn masters of vessels of the whereabouts of typhoons. Additionally, a gun at the foot of the signal mast at Tsim Sha Tsui Police Station was fired once when a gale was expected at Hong Kong, twice when winds of hurricane force were expected and three times when the wind was 'likely to suddenly shift around'. The same gun was also fired to announce the arrival of mail and, as can be imagined, this led to some confusion.

Official typhoon warning services were thus established in both Manila and Hong Kong in the year 1884 and in Shanghai in 1886. A warning service was started in Japan in 1883.

Doberck adopted Admiral Fitzroy's international signals in February 1892 but they were not popular. Residents had grown accustomed to the original system in use from 1884 to 1896 and they were adverse to change so the old system was re-introduced at the request of the Committee of the Chamber of Commerce who wrote:-

> " Those signals, having been in use for 13 years, were becoming gradually more understood and rightly interpreted by the boat and

> seafaring people as the time went on, as is always the case, the Committee believe, when a system of signalling is introduced."

The typhoon gun was replaced by bombs in 1907; the bombs were discharged when the wind was expected to reach gale force. Canton adopted the Hong Kong signalling system in the same year.

In 1886 Doberck published a pamphlet entitled "The Law of Storms in the Eastern Seas" which contained a famous chapter on "How to manage your ship in a typhoon". The pamphlet was immediately popular and came into widespread use along the China coast. However, he was moved by plagiarism to write in 1888 that it:-

> "..... has been repeatedly reprinted and translated into foreign languages.... Writers very rarely make use of such reports without due reference to the Observatory from which they emanated, but in a paper in the Annalen der Hydrographie (Berlin,1887,XV page 333) the substance of my pamphlet has been republished and even paths of typhoons, which were constructed at the expense of the Colonial Government, have been reproduced without any reference to this Observatory."

With the addition of two new chapters the pamphlet was issued as a book in 1898 (Doberck 1898) and went through several editions in subsequent years.

Doberck's sister, Miss Annie Doberck, obtained a degree in mathematics at Copenhagen University and after some negotiation was ultimately successful in obtaining appointment as a meteorological assistant to visit ships to obtain logs and assist masters in meteorological matters. She soon earned the sobriquets "Typhoon Annie" and "Sampan Annie"; sampan being the local name for the type of small Chinese boat used by her to visit ships in the harbour.

On the 15th October 1889 a typhoon hit Hong Kong without warning. The Governor of the day, Sir William Des Voeux, lived near the top of the Peak (552 m above m.s.l.) on Hong Kong Island and he experienced a "blow" there some hours before Doberck issued warnings. Doberck lived at the Observatory which, being in Kowloon on the mainland some 4 km to the north of the island, was relatively sheltered. The Governor was moved to appoint Commissioners to determine - amongst other things - whether there were practical advantages to the community in having an observatory. The Commissioners were also

required to determine why no adequate warning was given of the October typhoon. Doberck complained of inadequate facilities for both local and international communication because, for financial reasons, he had been denied a direct cable to Hong Kong island. Some idea of the problems this caused can be obtained from the following reply which he gave to a question from the Commissioners on the method of communication between the Observatory and the Police Station at which the cross harbour cable terminated:-

> " I send down a coolie to the Police Station. Sometimes we attempt to telegraph but that often leads to delay. I have now made arrangements to telegraph and send down a coolie as well."

There were occasions when gales made it impossible for the coolie to deliver weather reports or warnings.

Doberck benefited considerably from the Report of the Commissioners who recommended the provision of extra staff, a direct telegraph cable and an observing station on the Peak. The latter was to enable Doberck to get earlier notice of increasing winds and, incidentally, to know to what winds the Governor was exposed.

Dr. Doberck, both from reputation and from his writings, appears to have been an excessively pompous and egocentric individual. He was, apparently, a difficult man with whom to have dealings. The Jesuits at Manila Observatory whilst being far from pompous were very proud of their achievements in the warning of typhoons. With the paucity of data available on most typhoons in those days there was even more judgement involved in the preparation of warnings than is the case to-day. It will be readily appreciated, therefore, that the two directors had differences of opinion from time to time on the location or movement of individual typhoons and these differences were exacerbated by the personalities involved. Although it is written that "a prophet is not without honour save in his own country" it is nevertheless true that a well managed publicity programme can do wonders for a meteorologist's image. The Jesuits were good at selling themselves and their work, indeed, this was necessary if they were to attract adequate financial support; Doberck however, shunned publicity whenever he could, and if drawn into some public controversy he was frequently his own worst enemy. Telegrams would come to him from Manila intimating that a typhoon had crossed Luzon and was heading in a certain direction or was likely to do so, these cables were, of course, made public.

Doberck was grateful for the telegrams containing factual observations but the appended opinions on the course of the typhoons often made things difficult for him in Hong Kong. He preferred to be without the observations rather than to accept both the observations and opinions. After the United States Administration took over the Manila Observatory in 1899 Doberck wrote to the Weather Bureau in the U.S.A. to have them stop Manila sending their unsolicited judgements. He was successful, but his success was short lived for the infuriated Jesuits brought all their guns to bear; they handled the press,diplomats and other authorities with skill, got the decision reversed and, through the Hong Kong Chamber of Commerce, caused the Hong Kong Government to write to the American Governor in the Philippines to state that Doberck's request was unauthorized and that they - the Chamber of Commerce - would like to receive the Manila warnings. Subsequently, no opportunity was lost by the Jesuits to hit back at "this German person in the British Observatory". They belittled him for telling ships' masters how to handle their ships in a storm and footnotes began to appear in their technical writings whenever there was an opportunity to score a point against Doberck.

On 17th September 1906 residents of Hong Kong and the masters of the many ships in the port retired to bed in fine weather with no indication or warning of any approaching typhoon. At 8 a.m. the next morning the drum was hoisted to indicate that a typhoon was to the east of the Colony within 300 miles. At 8:30 the wind began to rise and at 8:40 the typhoon gun was fired. By 11 a.m.the fury of the storm had passed and it left the Colony and its shipping devastated. Of the 47 ocean going ships in harbour at the time 6 were sunk, 21 grounded and the remainder were severely damaged. The Harbour Master and the Protestant Bishop of Hong Kong were among the approximately 5000 souls lost in this typhoon. The mean hourly speed of the wind attained only 56 knots but there were some "squalls of great severity" these, coupled with a flood tide, were the main cause of the damage to shipping. There was, of course, criticism of Doberck in the press but he made no attempt to defend himself. The Governor of Hong Kong, Sir Matthew Nathan, appointed a Commission to "Enquire whether earlier warning of the typhoon of September 18th 1906 could have been given to shipping."

— see Fig 2.1 —

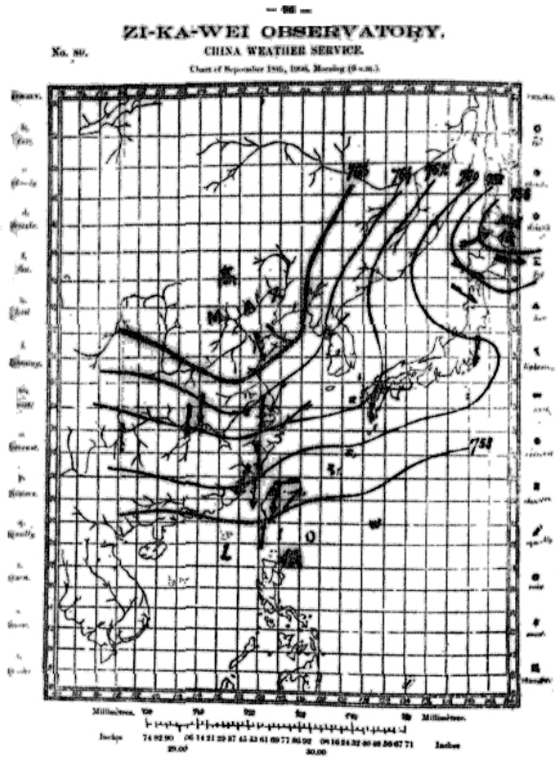
In his evidence to the Commission Doberck pointed out that the typhoon had been very small "one eighth of the usual diameter of a typhoon" and that its centre - moving westwards - passed six miles north of the Observatory. Doberck presented no special case for his defence but relied on his answers to questions put to him by the Commission.

It so happened that a French mail steamer the "Polynesien" and four French destroyers suffered damage in the typhoon with the loss of five French sailors. The French Consul requested permission to appear before the Commission. He was primed with information and opinions from the French Jesuits in Zikawei and the Spanish Jesuits in Manila. He maintained that on the night of the 17th it was obvious, to the experienced, that a typhoon was due. So much so, he maintained, that the Commanders of the destroyers and of the "Polynesien" had ordered that their ships get up steam to weather the storm.

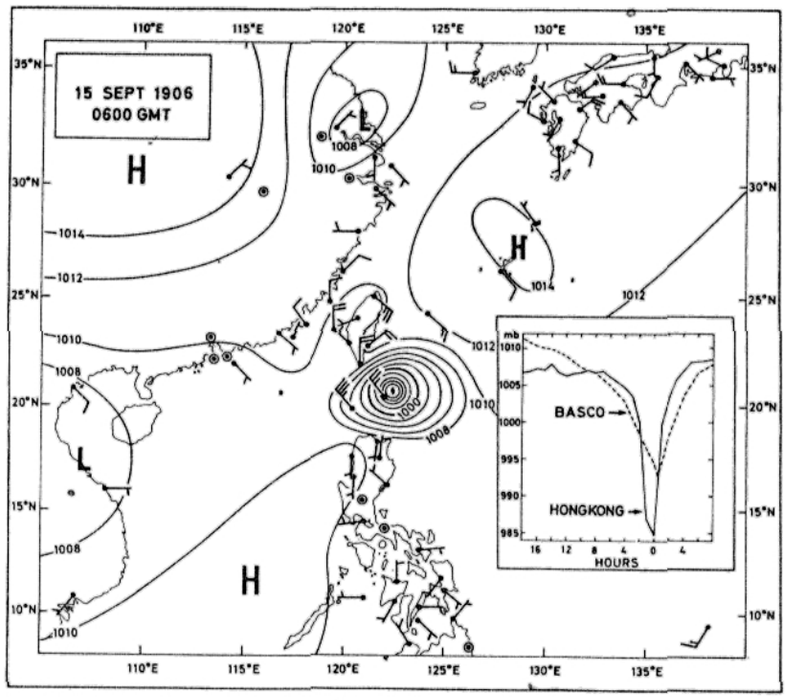
The Commission found that Doberck had warned the storm as soon as had been possible. They noted that there was no indication of a typhoon on the weather maps (Fig. 2.1) or in the forecasts and telegrams from other observatories and that there had been no other indication of the approach of a typhoon prior to the fall of barometric pressure at Hong Kong at 7.44 a.m. On the last part of the French Consul's evidence, the Commission observed that "..... the "Polynesien" was due to sail at noon on the 18th, and would in any case have had steam up at the hour mentioned. With respect to the destroyers it seems to the Committee inconceivable that they should have been "fully prepared" for the typhoon, and yet have remained at their buoys in close proximity to a dangerous lee shore,....."

The Governor referred the report of the Commission to the Astronomer Royal of England who concurred with the findings of the Committee.

In the course of the inquiry Doberck was asked if his relations with other observatories were cordial, his answer, as always, was in the affirmative. He was asked whether observatories put remarks after their telegraphed observations, he replied that this was done only by Manila, that it was



Weather Chart for 6 a.m. L.T. on 18th Sept 1906 being Number 80 from the Zikawei Observatory. The plotted observations were received by telegraph. The arrows show the direction of the wind and the number of fleches indicate the wind force. Isobar values are in millimetres of mercury. 753 mm and 766 mm are equivalent to 1004 mb and 1021 mb respectively.



Reconstructed weather map for 0600 GMT on 15th Sept 1906 prepared by the author from weather reports from ships logs and observatory annuals. There are so many observations from Taiwan and the Philippines that they could not all be shown. The typhoon crossed the island of Basco (Santo Domingo 20.9°N 122.0°E) and, later Hong Kong. The hourly pressure readings at these places during the passage of the typhoon are shown in the inset. The instantaneous lowest pressure recorded at Hong Kong was 979.4 mb at 9.40 a.m. H.K. St.T.

irregular, contravened the telegraphy regulations whereby meteorological observations were carried free of charge and that it caused harm. There were no remarks from Manila on the date in question. So ended the battle between the Manila Jesuits and Doberck. He retired the next year (1907) after 24 years of service in Hong Kong. Although his tactlessness in some dealings with the Manila Observatory lead to strained relations, his writings showed no animosity towards the Jesuits whom he cordially thanked, each year, in his reports. He also acknowledged Manila's information when he used it in papers he published in England, Germany and Hong Kong. He was not such a villain as he has been painted (Repeat 1982) and in the one dispute with Manila his case was not without merit.

Doberck's successor, Mr. F.G. Figg, early travelled to Manila soon after taking office. He was cordially received there by Father Algue' and good relations between the two observatories were permanently restored.

In 1908, arrangements were made for Her Majesty's ships to send in weather reports to the Observatory using the new technology of wireless telegraphy. In the following year the Observatory trained selected Chinese personnel before they were sent to Pratas Reef to make meteorological observations and to transmit them by wireless telegraphy. From that time onwards meteorological reports from Pratas have been of the greatest value in the preparation of warnings of tropical cyclones in the South China Sea. It was in 1909 that the daily weather maps were first distributed in the port.

In 1912 Mr. T.F. Claxton, formerly the Director of Royal Albert Observatory, Mauritius was appointed Director of the Hong Kong Observatory and in June, His Majesty, King George V, sanctioned the designation "Royal Observatory". On 15th July 1915 a radio station was established at Cape D'Aguilar for transmitting and receiving messages from those merchant ships which were equipped with radio. Approximately one weather report was received each day during the first month but this number soon increased. For any efficient forecast or typhoon warning it is essential that meteorological observations from ships and other stations should be received with the minimum of delay. It was with pleasure, therefore, that Mr. Claxton was able to report in his annual report of 1927 that:-

" Father Gherzi of the Zikawei Observatory, after patient

experiments and with the utmost goodwill, has recently inaugurated a short-wave broadcast service by which we obtain at 9 hr. 45 min. the 6 hr. observations from 7 stations from the Yangsi and North China. The thanks of all concerned are due to Father Gherzi for these valuable observations."

In April 1934 the directors of the Zikawei, Manila and Hong Kong observatories held a conference in Manila on Storm Warning Procedures. As a consequence a uniform code (containing four international symbols) was adopted in Hong Kong and the Philippines from 1st January 1935. Zikawei had already adopted a more extended code which included the Philippines/Hong Kong symbols. Subsequent changes in the warning signals will be discussed in Chapter 17.

At the end of his first year in Hong Kong,Dr.Doberck produced a summary of the typhoons in the Far East during 1884 and, apart from the war years 1940 - 1946, an annual typhoon summary has been printed each year ever since. Later directors e.g. Claxton, Jeffries and Heywood all made contributions to the literature on typhoons and additionally, Claxton, while he was at the Royal Albert Observatory in Mauritius wrote a well known book on cyclones of the Indian Ocean.

2.2.5 Japan

In Japan, Phenological records and the dates of freezing have been kept for many centuries but full meteorological records, as we know them to-day, were first made in the early 19th Century at Edo (Tokyo) Astromonical Observatory and, from 1872, at Hakodate. Fukuzawa Yuckichi (1834 - 1901) was a great educator and founder of the Keio University. He convinced the Japanese government that if they wished to modernise the country and catch up with the west in science and technology then the government should import western teachers and send promising students overseas for further training. This enlightened but revolutionary policy was applied in many fields, not the least in meteorology, and so the Tokyo Meteorological Observatory came to be founded in 1875 with Henry B. Joiner, an Englishman, as its chief technician. The first director of the Observatory was Ikunosuke Arai who had earlier been an Admiral and Fleet Commander.

The first weather charts in Japan were prepared on the 16th February 1883 by E. Knipping, a German member of the staff and a regular series of charts was issued in printed form from the 1st March 1883 onwards. From these charts Knipping was able to issue his first storm warning on 26th May 1883. This was the first official warning service in the West Pacific, being one year earlier than the Hong Kong and Manila services but four years after Father Faura issued his first unofficial warnings in 1879.

The Japanese Meteorological Service - named the Japan Meteorological Agency, in 1965 - is now among the largest and most advanced meteorological services in the world with an annual budget (1970) of US$33 million. Japan's susceptibility to damage from typhoons and earthquakes, her industrialisation and large merchant fleet are factors which made sophisticated meteorological and seismological services an economic necessity. Within the Japan Meteorological Agency there is a Meteorological Research Institute containing a Typhoon Research Laboratory. There is also a National Institute for Disaster Prevention and many University Institutes are engaged in meteorological research work. However, Japan's greatest contribution to meteorology in general and tropical cyclones in particular was its Geostationary Meteorological Satellite (GMS) successfully launched in July 1977.

Japan has a large number of internationally renowned scientists studying typhoons, far too many to list here but reference to their work is made later in the book. However, among the early pioneers should be mentioned. Dr. Yosihi Horiguti of the Imperial Marine Observatory, Kobe, who wrote "On the Typhoon of the Far East" (1926). This is a well known and extensive set of papers dealing with the structure of typhoons. K. Takahasi, S. Syono, T. Otani, S. Fujiwhara, T. Okada and H. Arakawa are other Japanese meteorologists who wrote notable papers on typhoons in the pre-war years.

2.2.6 *United States of America*

The Joint Typhoon Warning Centre at Guam

European settlers on the North American continent and in the Caribbean region were troubled by the hurricanes of the North Atlantic and Eastern Pacific Oceans. Later, in 1898, following the Spanish-American war the U.S. Government gained the Philippine Islands and Guam and so acquired an interest in typhoons. This interest was greatly intensified during World War II because typhoons then constituted a threat to the security of U.S. Forces in the Pacific. In order to minimise losses from this cause, meteorologists in the U.S. Air Force and the U.S. Navy began to reconnoitre typhoons and to issue warnings on them.

After the war, the continued U.S. military presence, the acquisition of the Trust Territories and the increased importance of the Dependencies in the Western Pacific all dictated that a warning service, for agencies of the U.S. Government, should be retained. And so it came about that, on 1st May 1959, the American typhoon warning effort was rationalised and centralised in a Joint Typhoon Warning Centre. Its terms of reference were to provide warnings on all tropical cyclones west of 180° longitude, to determine reconnaissance requirements, to publish annual typhoon summaries and to conduct research into the forecasting and detecting of tropical cyclones. The Centre was located in Navy premises at Guam and was staffed by both Navy and Air Force meteorologists.

During the early post-war years both the U.S. Navy and the U.S. Air Force independently published annual reports on typhoons but after the formation of the Joint Warning Centre a single "Annual Typhoon Report" was published, the first issue being for the years 1959. These reports contain not only the tracks of typhoons but also give details of aircraft reconnaissance observations and contain the results of research work completed at the Centre.

During the immediate post-war period, warnings issued by both U.S. Navy and U.S. Air Force meteorologists began to include twenty-four hour forecasts of the positions of tropical cyclones. At the time, this innovation caused considerable controversy among meteorologists, many of whom considered that knowledge in this field was not yet adequate to enable scientifically based forecasts to be prepared. However, in many activities, for example, in the routing of ships, decisions have to be based on estimated future positions of tropical cyclones. Meteorologists are the people best qualified to make these estimates and it is not surprising, therefore, that such forecasts should now be made routinely by several national meteorological services. As frequently happens in such cases, the necessity of producing forecasts stimulated the search for methods of improving them, and many techniques are now available. The Joint Centre at Guam currently issues forecast positions for twenty-four to forty-eight hours ahead using, amongst other aids, the results of computations made on large computers some situated at Guam and others on the U.S. mainland.

The U.S. Government provides two very costly facilities for the detection and tracking of typhoons. Firstly, they operate routine reconnaissance flights and secondly they provide meteorological satellites which enable countries to directly observe pictures of cloud conditions over the oceans. The results of both the aircraft and satellite surveys are made rapidly and freely available to the meteorological community and, without doubt, make a substantial contribution to the well being of the people inhabiting South East Asia and islands in the Western Pacific Ocean.

2.2.7 Other Fareast Observatories

In 1896 a meteorological service was organized in Taiwan under the authority of a Japanese Imperial Ordinance. In the same year observatories were established at Taihoku, Taichu, Tainan, Koshun on the main island and at Hokoto on the Pescadore islands. Weather reports were exchanged with other observatories in the region and weather charts and typhoon warnings for the island were prepared. These stations and others are currently operated by the Taiwan Provincial Weather Bureau.

On 11th September 1963 Typhoon Gloria struck the northern part of Taiwan and caused the loss of 239 persons, left 89 missing and caused estimated property damage of US$17,500,000. The Director of the Taiwan Provincial Weather Bureau Dr. Kenneth T.C. Cheng was indicted for dereliction of duty in that he allegedly informed the public that the typhoon would not strike Taiwan (Anon 1965a). If convicted he would have been liable to a maximum sentence of 10 years in jail. The American Meteorological Society wrote to the Taiwan Ambassador (Anon 1965b) deploring the indictment of a meteorologist for an incorrect forecast and pointing out that if forecasters were indicted each time they made a wrong forecast there would soon be a total lack of them! During the trial the prosecution accused Cheng of negligence and dereliction of duty and asked that he should be held responsible for some of the damage. Cheng told the court that the forecast he gave was the best that he could make using the information and limited facilities available to him. The trial was adjourned indefinitely but the District Court of Taipeh finally acquitted Cheng on the 7th December 1964.

In Macau, routine meteorological observations were begun as early as 1861 by Dr. Lucid Azevedo da Silva, Director of the Military Hospital. He maintained a continuous record of pressure and temperatures there from January 1862 to April 1866 and included rainfall data from 1863. Between 9th January 1874 and September 1875 the officers of the gunboat "Tejo" made regular observations whilst their ship was moored in the inner harbour. When storms were felt, hourly, and even half-hourly observations were made. In 1880 the Director of Zikawei Observatory requested the Macau Harbour Master to make and telegraph routine observations. This was done from 1881 onwards and the observations were published in the "Boletin Official". From 1881 to 1900, inclusive, the Harbour Master made the observations from his office on the left bank of the inner river but this location was surrounded by hills and in order to obtain a more representative exposure the observations were transferred - by a Royal Decree of December 1900 - to a small chapel on a nearby hill. Observations began there in January 1901 but in 1904 they were again transferred this time to a building in the grounds of what is now known as the old Observatory, some 370 m to the southwest of Guia hill.

The Observatory was established as a locally independent Meteorological Service in 1950 and its first director Dr. Manuel T. Ferreria Cabrita served in Macau from 1951 to 1955. The subsequent director Engenheiro-Geografo Periera Natario summarised the Macau observations for the period 1901 to 1955 (Natario 1957a) and listed 119 tropical cyclones which passed within 180 km of Macau during the 246 years between August 1708 and August 1954 (Natario 1957b). The most violent of the typhoons were those of 22nd September 1874, 31st May 1875, 18th August 1923 and 3rd September 1937. There was no early activity in plotting weather maps or issuing typhoon warnings. To-day the Observatory continues to make meteorological and geophysical observations and issues forecasts and typhoon warnings for the residents of the Territory but, it was moved on the 28th April 1966 to the Monte fortress some 700 m west of the old location and 57 m above sea level.

In December 1902 the French Government established a Central Meteorological and Magnetic Observatory at Phu-Lien about 9 km southwest of Haiphong. This

observatory was soon connected to meteorological stations at Da Nang and Cape St. Jacques. Reports from these three stations are plotted on the 1906 weather chart shown in Fig. 2.1 . Because of the economic importance of agriculture to the economy of Indo China an excellent network of rainfall and climatological stations was established and in 1917 the then Director M. La Codit wrote a remarkable paper on the rainfall of Indo China. E. Bruzon (Director) and P. Carton wrote a large and well known work "Le Climat de l'Indochine et les Typhoons de la Mer de Chine". Typhoon tracks during the years 1911 to 1929 were summarized. Typhoon warnings were issued by the Observatory and visual warning signals were displayed after the manner of those in use in Hong Kong and Zikawei.

The invention of the rain-gauge is generally attributed to the Korean King Syo in 1441. A network of his instruments was established in Korea by 1450 and was of great assistance to the early development of agriculture in that country. Korea suffers from the visitations of typhoons and has a modern well equipped Weather Bureau which issues typhoon warnings but there is no record of any particularly early activity in this field.

2.3 Origin of the Word Typhoon

The term "hurricane" has come to us from the Caribbean Indians via the Spaniards. In June 1494 during the course of Columbus' second expedition to the New World he left some man at an old City called Isabella which was near the present town of Montecristi, Santo Domingo. Whilst there, they were struck by a hurricáne and heard the now extinct tribe of Tainos Indians refer to it as a "furacán" which, in their language, means evil spirit. According to Millas (1968) it was at this moment that the word entered the Spanish language but, following the unification of the kingdoms of Aragon and Castile, some changes in the Spanish language itself took place and amongst them, the Aragon "f" gave way to the Castilian "h"; "furacán", with plural "hurricanes". In Portuguese, the initial "f" is still maintained. In all other European languages the words for a hurricane are derived from the Spanish "huracán". Unfortunately, the etymology of the term "typhoon" is not so certain, not because of the lack of clues, but rather because of their number and the diverse derivations indicated by them. Apart from several possible derivations from Chinese origins, etymons from the Greek and Arabic languages have also been proposed.

The Greek word "typhon" (a monster) has been suggested as a possible etymon because of its similarity to "typhoon" and also because Aristotle in his "Meteroological" use the word "Τμφων" to mean a wind-containing cloud. Aulus Gellius also used the word with this meaning in A.D. 160 (Hobson-Jobson 1903). These early references were probably to waterspouts or whirlwinds but the word was used subsequently for cyclones and violent storms of wind. Eden wrote in 1555 "These tempestes of the ayer (which the Grecians caule Tiphones that is whyrle wyndes) they caule, Furacanes," (O.E.D.)

The Arabic word "tufān" is used for a violent storm of wind and rain, tempest or hurricane and appears with this sense several times in the Koran (Hobson-Jobson 1903). The origin of the word is obscure; derivations from Arabic roots have been offered but many etymologists consider that it came to the Arabs from the Greek, either through maritime intercourse or from translations of Aristotle. The Portuguese name for a typhoon is "tufão" and this comes directly from the Arabic and was used by Vasco da Gamma and others long before they got to China (Boxer 1969). Hobson-Jobson considers that "tufão" was made into "touffon" and then "typhoon" by English sailors as they got "moncao" directly from Arab pilots and made it into "monsoon". In contrast, some writers have pointed out that the

Arabs were in maritime contact with the Chinese from about the seventh century and that they may have got the word from them. The Arabic "tufān" has long been used in India for a tropical cyclone and Koteswaram (1963) writing on the practice there states that:-

> " The local word used in India for the tropical storm is "Toofan" which was obviously derived from the Chinese "Thai-fong" which is also the source for the word "typhoon".

This brings us to the question of Chinese origins. In Cantonese the word for "big" is "Tai" 大 and that for "wind" is "fung" 風 and the combination "Tai-fung" means big wind and, as can be imagined, this Chinese term is frequently given as the origin of the word typhoon. Unfortunately, when Chinese literature and regional practices are examined the problem is seen to be more complicated. Piddington (1942) in his "Sailors' Horn Book" is very assured and writes:-

> " Tyfoon. This word is undoubtedly Chinese, and by no means derived from the Greek "Typhon", as has been supposed. Dr. Morrison, in his Notices concerning China and the Port of Canton says that -
>
> > " At Hainam and the Peninsula opposite (to the North of it), they have temples dedicated to the Tyfoon, the Goddess of which they call keu woo, "the tyfoon mother", in allusion to its producing a gale from every point of the compass, and this mother-gale with her numerous offspring or a union of gales from the four quarters of heaven makes conjointly a tae*fung* or *tyfoon*" .
>
> In a work called "Kw'an Tung Sin Yu" the tyfoon is called either Kow-fung or fung-how. A severe one is called tēe hwuy or tēo keu, an iron whirlwind. They have also separate names for whirlwinds, which I am informed are called "yung-hok-foong" and "Suing-Foong".

Hirth (1921) and others consider that typhoon is derived from "Thai-feng" 颱風 (wind from Taiwan); he found this word in a Chinese book on Taiwan published originally in 1694. Schlegel (1896) considered that there are several possible solutions to the etymology of "typhoon" but that the most probable origin is the Chinese "Ta-feng" 大風 (great wind) which is pronounced as Tai-fung in Cantonese and Japanese - in which language the same characters are used. The same derivation has been given by others including the author of "Histoire de

l'Eglise au Japon" 1634.

Father E. Gherzi wrote on the derivation of the word and gave it as his experience in Shanghai that the word "Ta-fêng" is used to indicate monsoon or winter cyclone winds whereas "Chü-fêng" (Cantonese Ku-fung) is used for typhoons; he states that Chinese mariners would ask whether the "Chü-fêng" (typhoon) which had been signalled would also bring "Ta-fêng" (big winds). This was also the practice in Hong Kong where the words are pronounced "Keu-fung" and "Tai-fung". In modern usage, the word "Tai-fung" 颱風 is used universally. Father Gherzi quotes the following account which was prepared for him, in Hong Kong, by Fr. R. Maglioni:-

" The Chinese name for typhoon is (Mandarin) "Chü-fêng" or (Cantonese) "Ku-fêng," character 颶風 . The character "Chü" (or Ku) is the proper character for typhoon; it is composed by "Chü" 具 or 俱 which means "all, whole, altogether" and the radical "fêng" 風 i.e. wind; meaning "all wind, wind from all quarters". Really the Khangshi Dictionary explains the character as "strong wind at sea; a strong wind from the four quarters as it occurs along the Southern Provinces, especially during summer and autumn" .

The weather signs, as the formation of clouds, the conditions of the sea, from which people forecast typhoons are called "Chü-mou" 颶母 i.e." mother of the typhoon" .

In Hoklao dialect, spoken at Swatow, Amoy and Taiwan, a typhoon is called "Hong-thai". "Hong" being 風 "wind" and "thai" being a vernacular word with the same sound and the same tone as "Thai" 胎 "the womb". The latter character is ordinarily used also in the case of "Hong-thai" meaning "the womb of the wind". The idea seems to correspond quite well with the "mother of the typhoon" "Chü-mou" the name given to weather conditions which generate a typhoon.

For this Hoklao dialect word "Thai," a new character has been formed which is not found in old dictionaries, "Thai" 颱 in which the radical "flesh" 月 of the character for "womb" has been changed into the radical "wind". This new character is now commonly used for the word "Thai-feng" 颱風 i.e. typhoon (Cantonese Thai-fung). Another name, pronounced "Ta-feng" 大風 is applied according to its meaning to strong winds generally, i.e. cyclonic or anticyclonic. "

In the first century, writers in Japan (chap. 2.1.1) used the expression "Tai Fung" 大風 but it is not clear whether this was used as a synonym for typhoon or just for a big wind generally. The ancient Japanese word for typhoon is known to have been "Nowaki" 野分 (Nemoto 1969) which, etymologically speaking, means an autumn wind swaying or dividing the grass, other etymologists think it is a corrupted word from the dialect "Waida" meaning a strong wind from the Southern Sea. When Piddington's book on tropical cyclones was translated into Japanese in 1857 the term "Cufu Shinwa" 颶風 was used for typhoon. However, since 1910 the term "Taifu" 台風 has been in general use. Nemoto notes that the word "Tai" 颱 came into usage in the 17th Century and is not found in Chinese dictionaries before that time whereas the word "typhon" was in use in France as early as 1504; he therefore believes the Arabic "tufan" to be the true origin of the word "typhoon".

From the foregoing it will be seen that four derivations of the word typhoon from Chinese origins have been proposed, they are: "Tai-fêng" 大風 (great wind), "Tai-fêng" 臺風 (wind from Taiwan) and two possible derivations from the ancient Chinese word for a typhoon "Chu-fêng" 颶風. There are also two other possible derivations one from the Arabic "tufan" and one from the Greek "typhon". Although "Ta-feng" 大風 (strong wind) was not used in China strictly for a typhoon as such, the word would have been used incidentally in connection with typhoons, and could have been picked up by early Arabic as well as later European travellers. However, at present, the true derivation (or derivations) of the word "typhoon" remains unresolved.

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