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**INDIA METEOROLOGICAL DEPARTMENT**

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**WINDS, WEATHER AND CURRENTS**

ON

**THE COASTS OF INDIA**

AND

**THE LAWS OF STORMS**

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**1931**

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## PREFACE.

After the amendment in 1928 by the Government of India of the rules for examination of candidates for certificate of competency as Masters and Mates of Steamships, the need was felt of a text-book to enable Indian seamen to study the Laws of Storms and the prevailing winds, weather and currents in Indian Waters. To meet this need the preparation of this pamphlet on "Winds, weather and currents on the coasts of India and the Laws of Storms" was undertaken by the India Meteorological Department. The pamphlet has been compiled by Mr. S. Basu in the Marine Section of the Poona Meteorological Office from sources of information available in the department.

The India Meteorological Department will welcome suggestions for increasing the usefulness of this compilation in future editions.

C. W. B. NORMAND,

*Director-General of Observatories.*

POONA,  
*April, 1931.*



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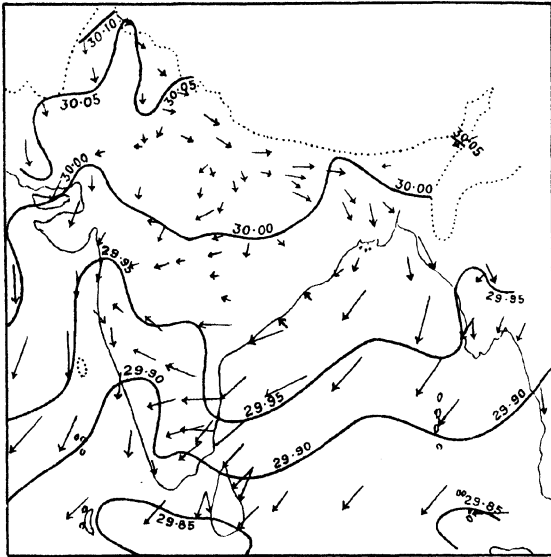
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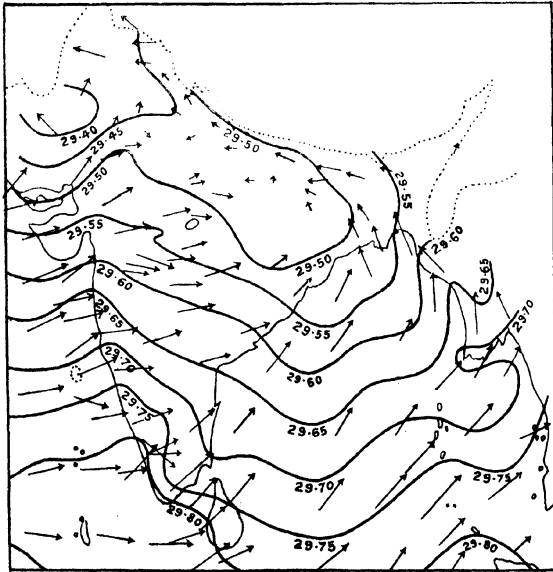
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AVERAGE BAROMETRIC AND WIND CHART FOR JANUARY.



AVERAGE BAROMETRIC AND WIND CHART FOR JULY.

## CHAPTER I.

### PREVAILING WINDS IN THE INDIAN SEAS.—THE MONSOONS. SEA AND LAND BREEZES.

**Monsoons.**—The outstanding feature of the wind system in the Indian Seas is the seasonal reversal known as the “ monsoons ”. During the winter third of the year the general flow of the lower air layers is from India and Burma over the Arabian Sea and Bay of Bengal towards the equator as a *northeast monsoon*. January is the month in which this air movement is best exemplified. In the summer third of the year the flow is almost completely reversed and the winds blow from the southwest over the sea towards India and Burma in the great current known as the *southwest monsoon*. July is a month representative of the weather conditions of the southwest monsoon season. In illustration of the two monsoons, charts of winds and pressure for January and July are reproduced in *Plate I*. In the January chart the seat of high pressure is in northern India and the pressure decreases steadily southwards to the areas at the bottom of the chart where pressure is lowest. In the July chart the regions of highest and lowest barometer are reversed. The high pressure is now at the bottom of the chart over the equatorial sea and the low pressure is over northwest India. In the interval between January and July this change is brought about by changes of temperature. In both charts the region of lowest pressure is also the region of greatest heat and that of highest pressure is the region where the atmosphere is coolest. Air tends to flow from a region of high pressure to one of low pressure ; hence, looking at the January chart, we would expect winds to blow, roughly, from north to south, and on the July chart from south to north. No atmospheric motion, however, is as simple as this. There are other controls. For example, the rotation of the earth causes a current in the northern hemisphere always to curve towards the right hand side. A current trying to move from north to south, being deflected towards the right, becomes a northeast current, as in the northeast monsoon. A current moving from south to north is also deflected towards the right and thus

becomes a southwest current as in the southwest monsoon. There are other controlling and disturbing influences, such as mountain ranges, which may deflect air currents, and coast lines, which give rise to land and sea breezes. The result is that the wind is not everywhere southwest in the southwest monsoon, nor is it everywhere northeast in the northeast monsoon. The terms "southwest" and "northeast" are indeed truly descriptive only in the Bay of Bengal and the western half of the Arabian Sea.

Between the two main monsoon seasons are two transition periods, making in all four seasons, into which the year may be divided for the purpose of describing the prevailing winds in the Indian area. The four seasons are :—

- (1) The Northeast Monsoon Season—(December to March)—when northeast winds of land origin prevail over the greater part of the Indian Seas ;
- (2) The Hot Weather—(April and May)—the transitional period of preparation for the southwest monsoon ;
- (3) The Southwest Monsoon Season—(June to September)—when southwest winds of oceanic origin blow steadily ; and
- (4) The Transition Monsoon period—(October and November)—when southwest winds of oceanic origin retreat southwards and are replaced by northerly winds of land origin.

**Northeast Monsoon.**—This is a season of winds of land origin and thus of generally dry weather, of clear, or lightly clouded skies and of little rain. Over the land this is the season of lightest winds. Air movement in northern and central India is from the west down the Gangetic plain. It curves through northwest to north across Bengal and to northeast in the Bay of Bengal. Across the Indian Peninsula the air moves from the east and passes out into the Arabian Sea, where winds are light northerly near the Indian coast but become stronger and steadier further west, blowing from north-northeast or northeast. A feature of this period is the succession of cold weather storms, or winter depressions, which pass from the west through Persia to northern India and cause considerable

snowfall on the Himalayas. These depressions sometimes give rise to squally weather in the north Arabian Sea and off the Bengal coast.

**Hot Weather.**—During this period temperature rises in northern India, more especially over the land area, the rise of temperature being accompanied by a fairly continuous fall of pressure. Winds become light in the centre and south of the Arabian Sea. Off the west coast and Gujarat, the winds strengthen and back to northwest. In the Bay of Bengal southwest winds spring up, though unsteadily, being sometimes interrupted by calms. It is a season in which severe tropical storms may develop in either of these seas (see later chapters) and in which some coastal districts are liable to be visited by thunderstorms or severe local storms, especially the Bengal coast, where the local storms known as “nor’westers ” are experienced.

**Southwest Monsoon.**—The summer monsoon is a season of winds of oceanic origin, of high humidity and of frequent and heavy rain over nearly the whole area. It sets in on the Travancore coast at the end of May or early in June and on the south Burma coast sometime in May. Within two or three weeks, it takes possession of the Bay of Bengal and the Arabian Sea up to their northern coasts. It invades India from these seas in two main currents. The Bombay current from the Arabian Sea blows on the west coast from directions between west and southwest and prevails exclusively over the Peninsula, Central Provinces and Gujarat. The Bay current sweeps from southwest over the Bay towards Burma. The southern portion is either forced across the Tennesserim hills or passes up the Irrawadi valley ; the remaining portion advances up the Bay and is deflected by the Arakan hills and the Himalayas, first towards the north across the Bengal coast, then towards the northwest up the Gangetic plain. A number of cyclonic storms form in this period at the head of the Bay of Bengal and, after crossing the Bengal or Orissa coasts, move in a northwesterly direction over the Indian land regions. These are times of strong monsoon in both seas. At other times both branches of the monsoon may relax their strength for a spell and fair weather with moderate wind may prevail for days or even for weeks. In

September, conditions rapidly change and the rain-bearing winds cease to penetrate to northwestern India.

**The Retreating Monsoon.**—The transition from the wet to the dry monsoon begins in the latter part of September and is usually not completed until the middle of December. It is thus a transitional period of considerable length and differs in this respect from the transitional period at the beginning of the southwest monsoon, which is usually established rapidly over the whole Indian area and extends over the greater part of India in the course of a fortnight or so. The advancing monsoon current is a vigorous movement ; but the retreat or withdrawal is a much more gradual and intermittent action. Before the end of October, the southwest winds weaken and then disappear in the Arabian Sea off the west coast and in the centre of the Bay of Bengal. The southwest winds persist for some time in the extreme south of the Bay, while the northerly winds are developing in the north of the Bay and are extending as a northeast current towards the south Madras coast. The inter-play between these two currents gives rise to alternate periods of fine dry weather and of boisterous wet weather. Each period of wet weather is, as a rule, associated with the development and progress of a cyclonic storm. This indeed is the most favourable season of the year for the formation of severe cyclones in the Bay of Bengal.

**Sea and Land Breezes.**—Besides the seasonal variation in the winds described above, there are local and seasonal variations in the winds along the coasts. The most important of these local variations is the daily variation due to the sea and land breezes. By day, the air over the land near any coast becomes, as a rule, warmer and therefore lighter than the air over the sea with its more equable temperature ; the heavier air from the sea flows in as a cool “ *sea breeze* ” displacing the warm lighter air over the land. At night, on the other hand, the land cools by radiation faster than the sea, and so the air over the land becomes cooler and heavier than the air over the sea ; hence the heavier land air slides out over the sea as a “ *land breeze* ” and displaces the warm lighter air that rests over it. When these breezes are regular, the land breeze begins to weaken after about 9 hrs. in the morning and decreases

to a calm about midday. Soon afterwards, the sea breeze sets in, increasing in strength as the evening advances. Generally at about sunset, the sea breeze is followed by a calm which continues till the land breeze commences between 20 hrs. and 22 hrs. At first the land breeze comes as a fluctuating gentle wind ; it soon becomes steady and continues so till 9 hrs. or 10 hrs. next morning.

Sea and land breezes are very pronounced along the Indian coasts during the bright sunny weather of the northeast monsoon season. They are least pronounced, in fact practically non-existent, during the southwest monsoon when cloudy weather prevents the land from heating up by day or cooling by night, and when, in any case, the regular strong winds of the season overcome the daily land and sea reversal.

Sea and land breezes deserve attention for sailing vessels if they are to benefit by them to the full extent. In the morning and before noon, it is advisable to edge more out to get an offing of 15 or 20 miles and be ready for the sea breeze. In the evening it is desirable to be near the shore before the land breeze comes on ; if close in prior to the commencement of the land breeze, short tacks are made near the shore until the breeze comes off. With the land breeze during the night it is prudent to keep well inshore, if the wind admit it without tacking, for it is stronger and steadier there than farther out.

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## CHAPTER II.

### LOCAL WINDS AND WEATHER ON THE COASTS OF INDIA.

**Mekran Coast.**—From October to February land and sea breezes prevail. They begin to weaken in March and vanish by April, the predominating winds during these two months being light to moderate west to southwesterly winds. May is the most windy month on the eastern half of this coast where moderate to strong west to southwesterly winds are met with, while in the western half winds are light and variable. The weather is generally fine and the sea smooth throughout these months except when affected by cyclonic storms in the Arabian Sea or the winter storms, also known as the western disturbances. Towards the beginning and end of this period, *i.e.*, in October and November and in May, cyclonic storms in the Arabian Sea moving northwestwards may at rare intervals affect this coast and cause cloudy and thundery weather with gales, rainsqualls and rough seas. During the winter months, December, January and February, gales or squalls with rough sea and heavy swell are sometimes experienced in association with the eastward passage of winter depressions over Baluchistan. The squalls behind these winter depressions may raise clouds of dust and produce a duststorm or thick dust haze; they are often the precursors of strong cold northwesterly wind known as "*Shamals*". Dust haze may sometimes last a few days, even after the subsidence of the strong winds associated with duststorms.

A period of threatening weather, which may sometimes be associated with the northwestward movement of a cyclonic storm in the Arabian Sea in early June, is usually followed later in the month by a moderate monsoon gale from westsouthwest which lasts from a few days to a fortnight and is preceded or accompanied by a heavy swell and rough sea. A westsouthwest monsoon breeze and swell (southerly to easterly winds over the western half of the coast) continues throughout July. The wind and swell diminish in August, when small craft go out to sea again, and by the beginning of September the monsoon is generally at an end. Between mid-July and September, depressions move westwards

over northern India and occasionally reach the north Arabian Sea when they may cause rain squalls and thunderstorms on the Mekran coast with moderate to rough seas.

*Visibility.*—The early part of mornings, from an hour before to an hour after sunrise, the atmosphere remains foggy or misty in March, and towards the latter half of the month dust begins to be blown about during the day causing loss of visibility. In April, the air sometimes remains hazy following duststorms. Visibility is decidedly poorest along this coast in May on account of dust haze everywhere and, in addition, occasional morning fog in the eastern parts of the coast. The poor visibility due to dust in the atmosphere continues during June. In July the atmosphere begins to clear, though along the coast misty and hazy conditions may prevail in the early morning. The visibility remains generally good thereafter, except for occasional morning fog in October and November.

**Sind and Kathiawar Coasts.**—Weather is generally fine and seas smooth in the cold weather months, when however local gales and squalls sometimes occur in association with the eastward passage of western depressions from Persia to northwest India. The characteristic cold weather months are December and January, when moderate morning land breezes generally alternate with weak afternoon sea breezes; the land breeze is the predominating feature and at times blows continuously for two days or more on end. After calm nights in the cold weather banks of fog may be seen on this coast at early dawn, which drift out to sea with the land breezes. Mirages are of frequent occurrence. From February onwards the westerly and southwesterly sea breezes become gradually more pronounced and from April onwards they blow by night as well as by day, being strongest in the afternoons. The southwest monsoon sets in in June, attended with overcast skies, occasional showers and strong winds at times rising to a fresh gale. It remains vigorous throughout July and August and weakens rapidly in September. The rainy spells on this coast during the monsoon are generally associated with depressions which advance westwards from the Central Provinces or the Gangetic plain; winds on the

coast are then variable in direction and the rain may be accompanied by thunderstorms. A heavy swell begins in the middle of May (when coasting steam vessels and small craft cease to put to sea) and continues with varying intensity until the end of the monsoon.

**The Konkan Coast.**—Throughout the cold weather the wind blows on the average from some northerly direction, in October from northwest, in November, December and January from north and in February from northnorthwest. The daily land and sea breezes are well marked, blowing from the northeast in the mornings and from the northwest in the afternoons and evenings. From March to May the average wind direction backs from northwest to westnorthwest and the land breezes become very uncertain, seldom coming off till morning; they continue for so short a time that they are of little advantage to sailing vessels. It is therefore necessary to keep an offing to be ready for the sea breeze, which in this season sets in at about noon. A feeble land breeze sometimes follows; but more frequently light airs from northward or calms may be expected from nearly midnight to about noon on the following day when the northwest sea wind again sets in. Sometimes these northwest winds are particularly strong, producing a short choppy sea and a drain of lee current; so that when it falls to a calm, it is necessary to anchor at times with a light anchor to avoid being driven southward.

The northwesterly winds continue, but are often variable and uncertain in May. The weather is cloudy with showers and lightning, which come at times from the southeast. In this month a gale from southwest may occur; and it is prudent therefore to keep well out from the land and be prepared for bad weather, in order to avoid being driven on a lee shore if a storm should set in from westward.

During the period of change before the southwest monsoon has set in, the small coasting vessels run in the afternoon into the nearest river or place of shelter south of Bombay; but large vessels should have sea-room.

At evening in May and in early June heavy clouds sometimes collect and hard squalls occur with rain at night. The southwest monsoon normally sets in at the end of the first week of June and up to the middle of August weather is generally very unsettled with hard squalls, much rain, dark cloudy weather and a heavy southwesterly swell. The monsoon begins to weaken in August and finishes in September. A period of light variable winds and frequent calms with cloudy weather and occasional showers intervenes. Late in October or early in November there is frequent thunder and lightning associated at times with a storm from southwards. After this period the northerly winds of the winter months are established.

*Visibility.*—During the season of northwest winds (February to May) the atmosphere is generally hazy southward of Bombay along the Konkan and Kanara coasts ; this is particularly marked in March and April. Owing to the haze the land and trees along the coast appear to be at a much smaller distance than they really are.

During the period from April to October the Western Ghats are usually enveloped in a dense mist or haze, which hides the mountains from view. These mists however occasionally disperse for short intervals after heavy falls of rain. In October early morning fogs occur obscuring from the view the low-lands and projecting headlands up to about sunrise or a little later.

**Malabar Coast.**—The daily variation of morning land breeze and evening sea breeze is a marked feature of the winds on the Malabar coast during the northeast monsoon season. In October the wind is generally weak and mostly off the sea, the land breezes as yet being only occasional, light and uncertain. The land breezes are strongest and most regular in December and January but are also fairly well marked in November and February ; even in these months the afternoon sea breeze remains a regular feature, despite the opposing influence of the northeast monsoon winds in the upper air. From March onwards, the land breezes decrease in strength and duration and are not always regular. Thus the navigator may calculate on sea breezes for nearly all the year, but on regular land winds for only about four months.

Opposite gaps in the mountain chain, as at Palghat on the south of the Nilgiri hills, the land winds in December and January, being helped by the northeast monsoon, sometimes continue to blow for more than a day without any intervening sea breeze. This also occurs, but in a lesser degree, off Karwar where the valley of the Sadasivgad river assumes a straight funnel shape eastward towards the interior of the Peninsula.

South of the Palghat gap the southwest monsoon sets in late in May. It frequently commences with a gale from southeast veering to south and southwest where it ultimately remains; at other times it commences with squalls from southwest, and a heavy long swell rolling in upon the shore. In June the wind keeps mostly between southwest and west by south, with much rain, high sea and severe squalls at times. In July the weather becomes a little more settled and the squalls veer sometimes to the west and westnorthwest. The sky is mostly obscured by heavy clouds during the southwest monsoon season, but considerable intervals of fine weather are occasionally experienced. In August the squalls have veered pronouncedly to the west and westnorthwest and winds become northwesterly or westnorthwesterly.

In September the weather moderates. West and westnorthwest winds are the most prevalent while calms are experienced off Cape Comorin. Severe squalls are rare although the weather is often cloudy and threatening with heavy showers. A swell often rolls in from westsouthwest in this month, particularly during unsettled, squally weather. After some weeks of mostly fine weather, but frequent showers, the Malabar Coast is usually visited, in the end of September or the beginning of October, by strong easterly squalls, rain and thunder which finally closes the southwest monsoon season.

The navigation southwards along the west coast of India, for sailing vessels, during October and a great part of November, is usually tedious and uncertain; for there is no dependence on the winds till late in November. But the light winds are not unfavourable for sailing down the coast as the drain of the current is still generally to the southwards.

**Gulf of Manar.**—On the west coast of Ceylon land and sea breezes occur from December to March (*i.e.*, the northeast monsoon season) and the weather is generally fine, but the winds along the Indian shore of the gulf do not assume the character of land and sea breezes until February. The sea breezes gradually become of longer duration after February and increase in force till about the middle of May.

Towards the end of April, at night the wind becomes light and variable and squalls and showers of rain may occur while a swell is experienced from the westward. The sky becomes overcast in May, banks of clouds rising over the ocean; and winds begin to blow continuously from the southwest. The southwest monsoon gains strength in June, and the fishermen seldom go out to sea in this month. Showers become less frequent in July, but the weather is cloudy and hazy with generally a fresh breeze; the wind moderates near the head of the gulf in the mornings and blows strong again in the afternoons. Fresh southwesterly to westsouthwesterly winds continue in August and September but the weather is generally fine; in the afternoon the breezes are strengthened and are accompanied with occasional squall and rain. The atmosphere often remains hazy in September.

October has more unsettled weather and at times there are heavy squalls with rain towards the end of the month. During November the winds are light and variable between northeast and westnorthwest; weather is very unsettled with frequent heavy squalls and rain. About the middle of the month the northeast monsoon is ushered in by lightning, thunder and heavy rain. The northeast monsoon lasts till the end of January and blows steadily from northnortheast along the Indian coast; but in the northwest part of Ceylon it is modified into land and sea breezes and is attended with generally fine weather except for occasional showers and hazy atmosphere.

**The East Ceylon Coast.**—Weather is almost invariably fine from February to April with occasional light squalls accompanied by thunder and lightning, at the end of this period. In May winds become southwesterly with cloudy skies and the southwest monsoon sets in towards the end of the month. The island of Ceylon shields

the east coast from the full force of the southwest monsoon, but at some distance off the coast, as well as on the south coast, isolated rain squalls are of frequent occurrence. The monsoon weakens generally in September and October but the force of the south-westerly winds in these months is very variable; the winds are feeble when fine weather prevails but invariably strengthen when squally or stormy weather prevails in the centre of the Bay of Bengal. After a period of light variable and unsteady winds the northeast monsoon sets in during November, and continues in strength until January; November and December are the two rainiest months of the year on this coast.

**Coromandel Coast.**—Weather is generally calm during the first half of October, but later, northerly to easterly winds set in and prevail till about the middle of February. Land and sea breezes remain only very weak throughout this period, being at their minimum in November. Rain is general over the southern part of the coast in November which is the rainiest month and also the month when the coast is most liable to be affected by severe cyclonic storms travelling west or northwestwards from the south of the Bay of Bengal and causing spells of strong winds, severe rain squalls and rough seas. The weather improves in December and is generally fine in January with much clearer sky and very little rain. Winds are less steady or strong in February when the normal direction at Madras is easterly. Hereafter land and sea breezes strengthen; they increase rapidly in March and April and are most strongly in evidence during the period May to September except on those days on which the southwest monsoon is strong. The land wind blows in the morning hours after sunrise, the sea breeze commencing in the early afternoon hours. In March and April southeasterly winds predominate and become very strong during the day. They veer towards south as the season advances, sometimes blowing as “longshore winds” directly or nearly directly from the south. The average wind direction in Madras is southwesterly in May, but it undergoes greater variations in direction and strength during the twentyfour hours each day in this month than at any other period of the year; occasionally indeed, a westerly wind prevails in this month throughout the day so that the sea breeze which usually sets in about midday does

not appear at all. Weather is generally fine during March to May interrupted occasionally by thunderstorms. Depressions sometimes form in the centre or south of the Bay and during the first half of May they may move in a westerly direction towards the Madras Coast, and for a time establish weather similar to those of November. In June southwesterly winds prevail, but only occasional showers and rain squalls occur in this month. On days when the southwest monsoon is strong, the sea breeze either does not set in on the Madras Coast at all or lasts for a very short time. During July, August and September, the southwesterly wind becomes weaker and rain squalls become more and more frequent, and showers increase on the Madras Coast. Sometimes very heavy and sudden showers of 2 to 4 inches are received in September, calms being frequent towards the end of the month.

**The Circars Coast.**—The dry season sets in by the end of November and lasts till early May. The mean winds are generally northeasterly during November and December, veer round to east during January, and become eastsoutheast to southsoutheasterly in February and first half of March. Land and sea breezes are well marked during the cold weather months, December to February. There is a pronounced shift of the predominating winds by the end of March when they are southerly to southwesterly, the weather remaining fine throughout. In May and June cyclonic storms originating in the Bay of Bengal approach this coast and affect the weather; in May the storms generally curve northeastwards towards the head of the Bay but in June they mostly pass inland through the Orissa Ganjam coast. Steady southwesterly winds predominate during July to end of August which is the rainiest period on this coast. During the withdrawal of the southwest monsoon, in September, October and November, this coast continues to get rain and squally weather in association with cyclonic storms of severe intensity. These storms generally form in the central Bay of Bengal about Lat. 16°N. in September and further south in October and November, and may move towards the coast causing much damage to life and property. In October the winds shift to a northerly direction and gradually the northeasterly winds of the cold season appear and hold steadily. By the end of October or

early November the rain slackens and feeble land and sea breezes set in and gradually gain strength thereafter.

**Orissa and Bengal Coast.**—In the middle of October the southwest monsoon winds are replaced by light unsteady northerly winds usually with more or less easting, calms being met with on the Chittagong Coast. As the season advances these northerly winds increase in steadiness and velocity, and in November and December blow as dry land winds from the northnorthwest to northwest, with the variation that they may be northeasterly winds in the mornings on the Chittagong Coast. From the beginning of October to the middle of December, cyclonic storms occur at irregular intervals in the Bay and occasionally advance northwards, curving sometimes northeastwards towards the Chittagong Coast. They are sometimes of excessive violence and a great majority of them affect the winds and weather on the Orissa-Bengal Coast. Dry northerly land winds with fine weather prevail as a rule in January and the greater part of February except during the brief periods when cold weather depressions cross northeast India. Winds during these disturbances shift round to southerly directions, and the weather becomes cloudy with occasional squalls. On the Chittagong Coast marked land and sea breezes prevail from the end of October to the middle of March.

There is a feeble indraught of local sea winds across the Bengal coast by early March. These southerly winds gradually strengthen, are vigorous and steady in April and May and continue unchanged in general character until the first or second week of June being sometimes of exceptional strength. These sea winds advance chiefly into eastern and northern Bengal and into Assam across the Assam hills and give rise to frequent afternoon and evening thunderstorms and much rain in those areas. Similar storms of considerable intensity occur in west Bengal, but not so frequently as in east Bengal. They usually advance from the northwest, and hence they are known as “*nor’westers*”. They occasionally pass seawards across the Bengal or Orissa coasts, during April, May and June and may be felt up to distances of 70—80 miles from land. The following is a brief description of a typical *nor’wester* storm :—

“The first sign of these storms is a low bank of dark clouds in the northwest, the upper outline of which has the appearance of an

arch. It approaches at first slowly, and then more and more rapidly and arrives with a strong gust or squall. There is frequently thunder and lightning followed by downpours of rain, and sometimes hail, which is driven by the strong wind. On some occasions the wind blows with almost hurricane force. The greatest velocity of the wind recorded in one of these storms (if the record can be relied upon) was 115 miles per hour. These storms commence generally in the afternoon, rarely last more than three or four hours and are usually followed by cool and clear weather during the remainder of the night."

Throughout the southwest monsoon period the predominating winds are southwesterly on the Orissa coast and southerly to southeasterly on the Bengal coast. July and August are the rainiest months. The transformation from the local southerly winds to the winds of the southwest monsoon proper usually occurs in the second or third week of June and is generally ushered in by the advance of a cyclonic storm of moderate intensity in the rear of which the monsoon currents are carried. These storms may occasionally reach excessive violence. From the commencement of the southwest monsoon in June to the end of September or middle of October there is a rapid succession of cyclonic storms or depressions which form at the head of the Bay. Advancing westwards these depressions cross the coast generally between False Point and Barisal. Hence the weather in this period alternates between periods of stormy conditions with showers and rain squalls during the inception and early stages of the advance landwards of these storms, and periods of light unsteady winds after their passage inland. The southwest monsoon usually withdraws in the first half of October.

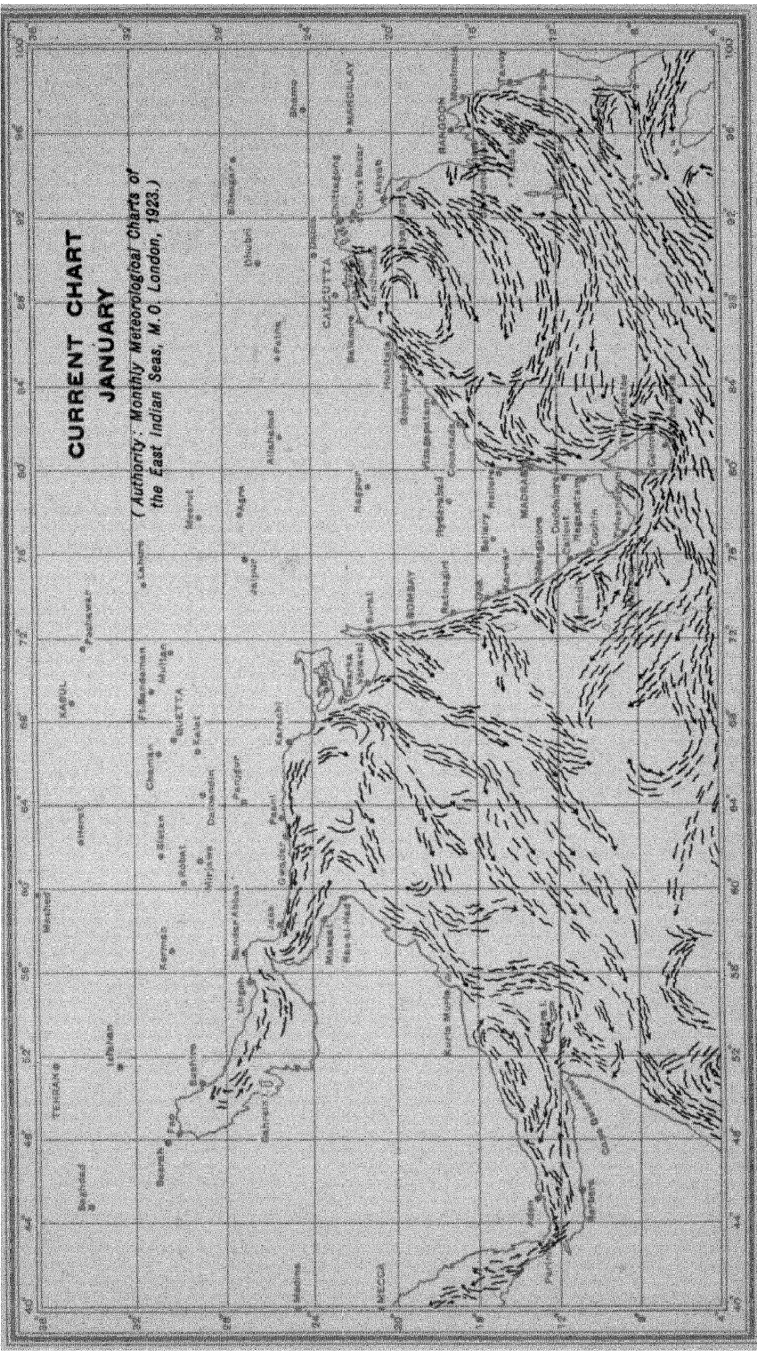
**Arakan Coast.**—The dry season lasts from the end of November to April. Light northerly winds with generally a slight westing prevail till the end of February. During the hot season, March to May marked land and sea breezes are experienced. In the months October-December and also April and May cyclonic storms sometimes form in the Bay of Bengal near and to the west or north-west of the Andamans and pass by a curved path to the Arakan Coast giving rise to rain and squally weather. During the rainy

season, June to September, strong southerly to southeasterly winds predominate. General showers of heavy rain are frequent, and are attended at times with squalls and occasional thunderstorms. July is the rainiest month on this coast. Isolated rain squalls occur throughout August and become more frequent in September. The rainfall diminishes rapidly in October and usually ceases after a few thundershowers in the first week of November.

**Lower Burma Coast.**—During the cold weather period, November to January the winds on the coast of Lower Burma of which Rangoon is representative, are steadily from the northeast, with a slight to moderate easting, increasing in amounts southwards. February is a transitional month during which the winds shift round to southerly directions in Lower Burma. On the Rangoon coast a feeble local southerly wind sets in early in February and gradually increases in force, marked land and sea breezes being met with. During the next three months the winds change from northwest to west and finally to southwest, with appreciable land and sea breezes near Moulmein. Showers are of occasional occurrence in March and April while general rain is of frequent occurrence in May, accompanied, near the Mergui Archipelago, with squalls, thunder and lightning. Occasionally, during April and May cyclonic storms form in the Andaman sea and travelling generally north to northeastwards affect the coast between Diamond Island and Moulmein with stormy weather. During the rainy season, June to September, the winds are generally southwesterly but steadier than in the preceding months, being from westsouthwest at Diamond Island, south to southsoutheast at Moulmein and southwest to westsouthwest at Mergui in July, which is the rainiest month on the Tenasserim coast. These winds change little in direction, or strength until September when they begin to show signs of weakening and also shift towards east. They decrease steadily in strength throughout September and October. The southwest monsoon winds usually withdraw from Lower Burma Coast by the end of October, and are replaced by light variable or northeasterly winds which gradually strengthen in November into the dry winds of the cold weather season.

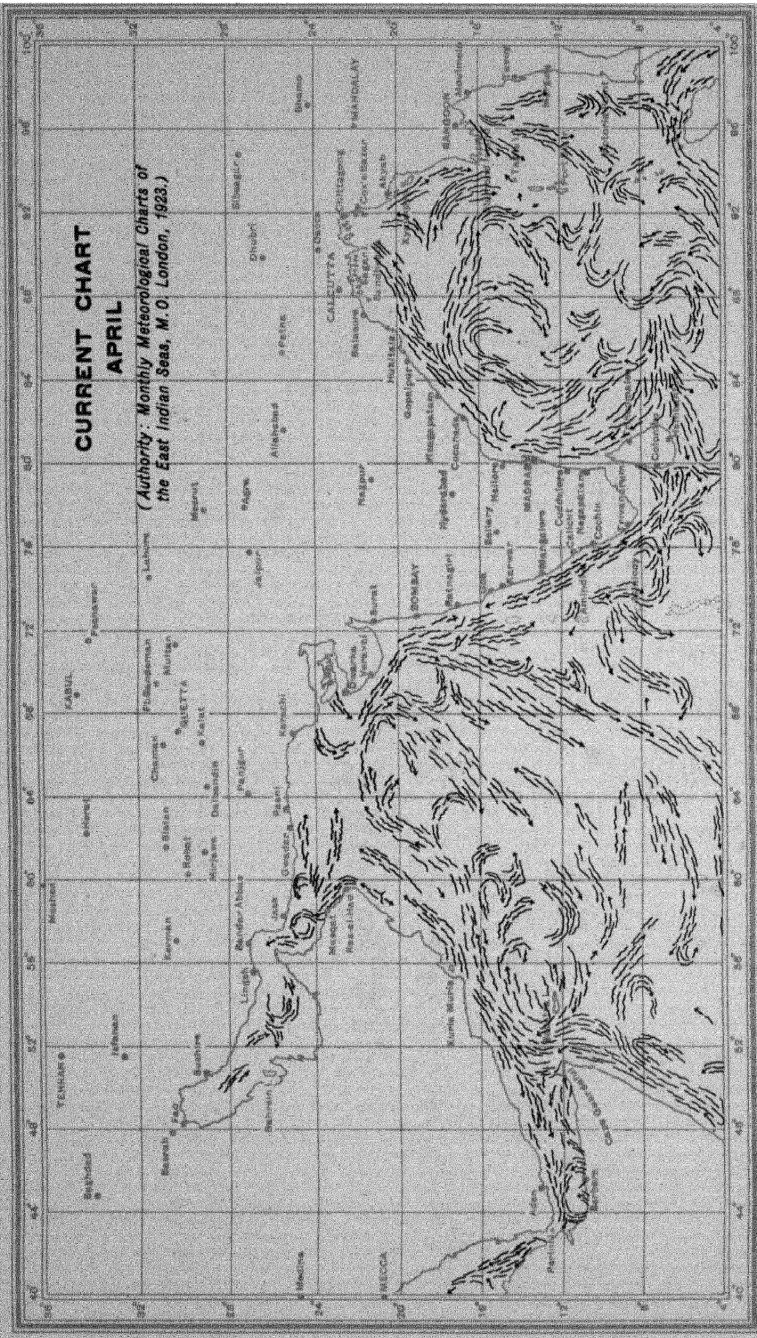
# CURRENT CHART JANUARY

(Authority: Monthly Meteorological Charts of  
the East Indian Seas, M. O. London, 1923.)



# CURRENT CHART APRIL

(Authority: Monthly Meteorological Charts of  
the East Indian Seas, M. O. London, 1923.)





# CURRENT CHART OCTOBER

(Authority: Monthly Meteorological Charts of  
the East Indian Seas, M. O. London, 1923.)

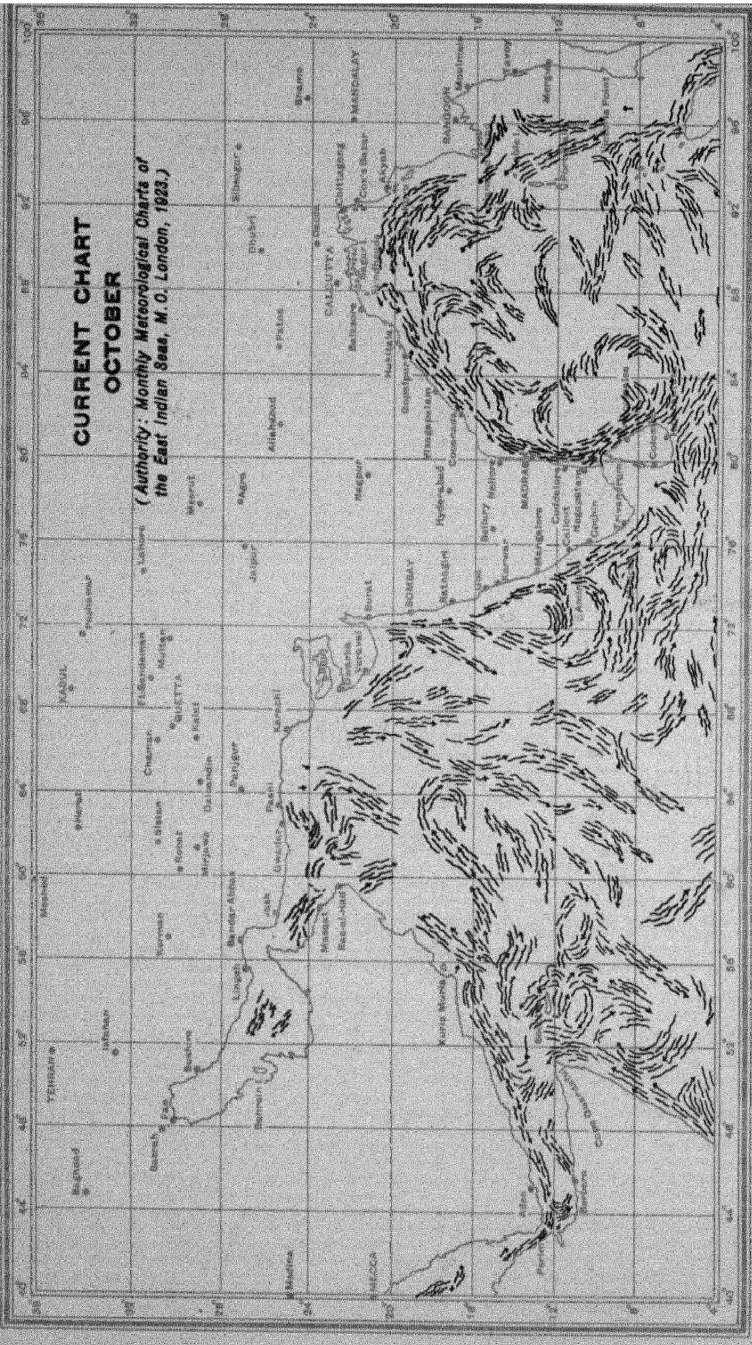


Plate 5.

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## CHAPTER III.

## CURRENTS AND TIDES.

*Currents.*

The currents in the Indian Seas follow to a great extent the direction of the winds of the prevailing monsoons. The general set is southwestwards during the northeast monsoon, northeastwards during the southwest monsoon and more or less variable during the transition periods. The attached charts (*plates 2—5*) compiled from the comparatively few current observations available, roughly show the general set of the currents in the different seasons.

**Arabian Sea.**—Near the shores, the currents are generally irregular during January to April; they become more regular northeastwards current in May. There is a general increase in strength and uniformity of the currents on the coasts in June and July; but they weaken and become less regular in August and September and are variable in October and December.

**Mekran Coast.**—The current along this coast in January is generally westward from 10 to 25 miles a day, but is variable thereafter till September. There is a feeble set to south in October and to southwest in November.

**West Coast of the Peninsula.**—From January to September the current remains 10 to 35 miles a day southsoutheastwards on this coast except south of latitude  $14^{\circ}\text{N}$ . where it may be as much as 30 miles a day northnorthwestwards; the velocity of the southsoutheastwards current sometimes increases to 10—65 miles in August. In October the current changes direction and a west-northwestward current flows till December.

**Coast of Ceylon.**—The island of Ceylon divides the oceanic current systems of the Arabian Sea and the Bay of Bengal.

When within 12 to 15 miles from the coast, *i.e.*, when inside the line of 100 fathoms, the currents are very variable. On both the eastern and western sides currents may be met with running parallel to the coast, but in diametrically opposite directions at the same time and within a few miles of one another. It would appear that the north coast currents generally circulate round the island in the direction of the hands of a watch during the northeast and in a contrary direction during the southwest monsoon being variable at the changes. From November to March, a strong westward current from the Bay of Bengal sweeps round the southern point of Ceylon; this current divides off Cape Comorin in January: one point runs northward and the other westsouthwestward to the equator. The current changes to eastward in May and continues in that direction till September; in August its velocity reaches from 10—65 miles a day. The set, though weak, is maintained in October.

**Bay of Bengal.**—During February to April, the circulation of the current in the Bay of Bengal is in the direction of the hands of a watch, eastwards or southeastwards across the head of the Bay and southwards or southwestwards on the Burma coast line. In October the circulation is in a contrary direction to that described above, *i.e.*, opposite to the direction of the hands of a watch. During the remaining months of the year the currents are generally variable, depending upon local conditions.

**Madras Coast.**—In January the set is 10 to 60 miles per day southward. It changes to northward in February and continues so till September, extending up the coast as far as lat. 16°N. only in July. The set finally changes to southward in October and remains so more or less till January.

**Orissa and South Bengal Coast.**—During February to June, the general trend of the current is northeastwards along Orissa and eastwards along the Bengal coast. In July near about latitude 16°N. a southeastward current is met with. A southwestward current sets in along this coast in August and continues till December.

**The Burma Coast.**—The current is southward to southwestwards from February to April. In October the set is generally northward. At the entrance of the Malacca Straits there is a fairly permanent current setting in a westerly direction at a rate ranging from 20 to 50 miles per day.

### TIDES.

Twice each day (more strictly between two moon rises) the attraction of the moon and the sun form tidal waves in the sea; the passage of these tidal waves causes the surface of the sea-water to rise and fall. The rising tide is called the “flood or flow” tide and the falling tide the “ebb” tide.

The tide varies from time to time: thus at new and full moon the range of the tide is greater than during the quarters. Tides with high range are known as “spring” tides and those with low range as “neap” tides.

Out in the sea and on the open coasts, the tide is merely a rise and fall in the water level; but along irregular coasts this change in level starts currents which often move with great velocity. These currents aid or impede vessels on their course and sometimes place them in dangerous positions.

**Arabian Sea Coasts.**—The stream during the flood tide sets eastward along the coasts of Sind and Kutch, northward along the Okhamandal coast, and southeast along the Kathiawar coast up to Diu head; here the tidal current runs 1 to 1½ miles an hour to the eastward. Off Diu head the westward stream during the ebb in the Gulf of Cambay frequently causes eddies. During spring tides bores are caused in the Gulf of Cambay, in the Mahi and Sabar-mati rivers.

On the Konkan and Canara coasts where there are no indentations the tidal wave strikes the coast from the westward at right angles to the mean direction of the coast line; there is thus very little difference in the times of high water on the west coast. Along the north Konkan coast the stream during the flood sets northward, increasing in strength as we go up north as far as the Gulf

of Cambay. From about Jaigarh (one hundred miles south of Bombay) to Mangalore and Mount Dilli no tidal stream is observed along the coast, except just off the mouth of the rivers; at these places the stream at the flood sets on the mouth of the rivers and that at the ebb seems to run out to sea. Southward of Mount Dilli the stream during the flood is just felt as coming from the northwest which becomes plainly marked at Cochin. At Cochin and Tuticorin a feature of the tides is their susceptibility to the influence of the wind; sudden changes of the level of the water, as much as one foot in an hour due to wind, have been recorded.

**Ceylon.**—At Colombo four floods and four ebbs have been observed in the course of 25 hours, but the tidal range or difference between the high and low water is only six inches. The Maldivé islands divide the tidal wave and give rise to two northward currents: the one inclines eastward towards the Gulf of Manar and causes high water at Colombo and Cape Comorin at the same time.

**The Bay of Bengal Coasts.**—The tidal wave appears to propagate in a northerly direction into the Bay of Bengal. The spring tides are highest in the day during summer and in the night during winter.

Near the coast at the head of the Bay the flood tide sets in to the north and in the Gulf of Martaban to a northeasterly direction.

Between the Nicobar Islands and the Malacca Straits there are occasionally lines of heavy breakers which occur in deep water. In the Straits of Malacca the flood tide sets to the east, the ebb stream being the stronger.

On entering some river mouths the tidal current takes the form of a single tidal wave of great volume, known as the “*bore*,” which travels rapidly up-stream.

Bores mainly occur at the spring tides during the southwest monsoon. The best known of these bores are those at the entrance of the Hughli and the Meghna rivers of Bengal, and of the Sittang

and the Pegu rivers of Burma. Generally speaking the height of a bore in the navigable channels is not such as to affect a ship ; but small craft should move out of its way or move off from the shallow into deep river.



During the premonsoon period storms occur less frequently in the Bay of Bengal than during the southwest monsoon period, *i.e.*, June to September when there is a rapid succession of storms. These are formed at the head of the Bay ; they cause strong westerly and southwesterly winds over the centre and north of the Bay which remain even after the storm centre has passed inland. These storms are generally of moderate extent and intensity, and rarely have the inner belt of hurricane winds or calm centre. In the majority of cases strong winds are only experienced in their south and southeast quadrants.

Cyclones of the post-monsoon period, *i.e.*, October to December are generally of great intensity, and may have a well marked inner area of stormy winds and a calm centre. The drift in the inner storm area of severe storms may be as much as 6 to 8 knots ; but near the head of the Bay of Bengal the current may be found to be stronger than this. For example, the S.S. "Zayani" bound from Aden to Bombay was caught up in a cyclone in the Arabian Sea from the noon on November 5th, 1919, until the afternoon of November 7th, and was carried during that time about 200 miles northwest of her dead reckoning. She was in the calm centre for about half an hour from 3 A.M. on November 6th. During another cyclone in the north Bay of Bengal from 4th—6th May 1923, the Captain of the S.S. "Angora" who was running up the Bay behind the storm found that he had been twentyfive miles east-southeast of his reckoning.

Amongst the October and November cyclones of past years are to be found many examples of the most intense tropical storms. They are usually of small extent, occasionally not exceeding two hundred miles in diameter. Hence, the shifts of wind accompanying them are usually very rapid and dangerous to vessels. The winds are exceptionally violent and of hurricane intensity in the inner storm area. The rain is usually described by sailors as falling in torrents. Another important feature of these cyclones is the piling up of a mass of water in the inner storm area. This advances with the storms and strikes the coast as a "storm-wave". The effect of this in flooding the coast districts depends largely upon the phase of the ordinary tidal wave at the time when the storm wave

strikes the coast. If the storm wave strikes the coast about or shortly after high water, it may produce the most disastrous results flooding low coastal districts in a few minutes to the depths of 10, 20 or even 30 feet above tidal high water level. Such inundations have occurred at intervals during the past century on the Madras coast, up the Hooghly and up the river Megna with disastrous suddenness, overwhelming practically the whole population in the inundated districts.

The frequencies, places of origin and tracks of storms in the Indian Seas in the different months are illustrated in the accompanying charts of Storm Tracks, *Plates 6—15*. Severe storms are represented by thick lines and other storms by thin lines.

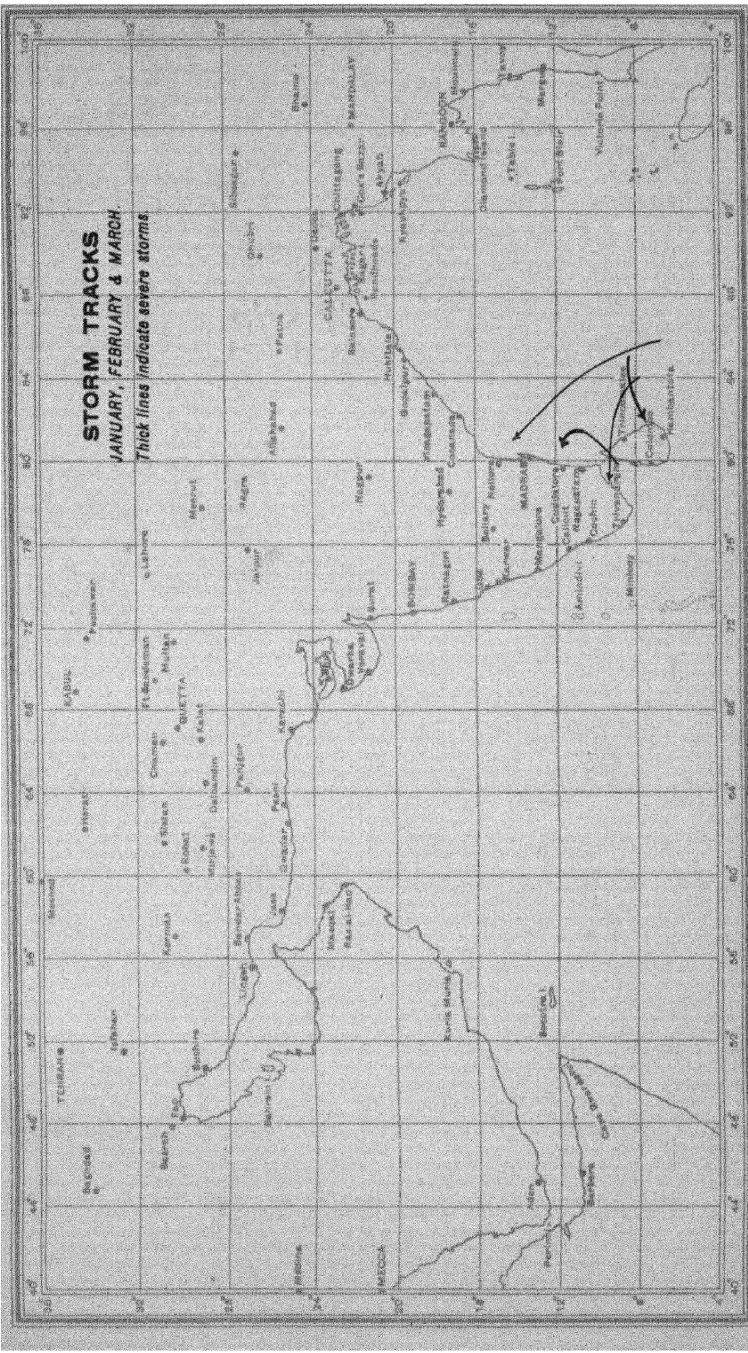
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## JANUARY, FEBRUARY AND MARCH.

**Arabian Sea.**—The Arabian Sea is practically free from cyclonic storms during these months, but local gales and squalls due to storms travelling eastward through Persia and Baluchistan may be experienced along the Mekran and Sind coasts. Even these become less severe in February and are of rare occurrence in March.

**Bay of Bengal.**—The Bay of Bengal is also practically free from cyclonic storms during these months; the few recorded instances formed off Ceylon west of long.  $86^{\circ}\text{E}$ . They may be of from moderate to severe intensity and move in any direction between SSW and NNW.

**STORM TRACKS**  
**JANUARY, FEBRUARY & MARCH**  
*Thick lines indicate severe storms.*



To face p. 26.

Plate 6.



## APRIL.

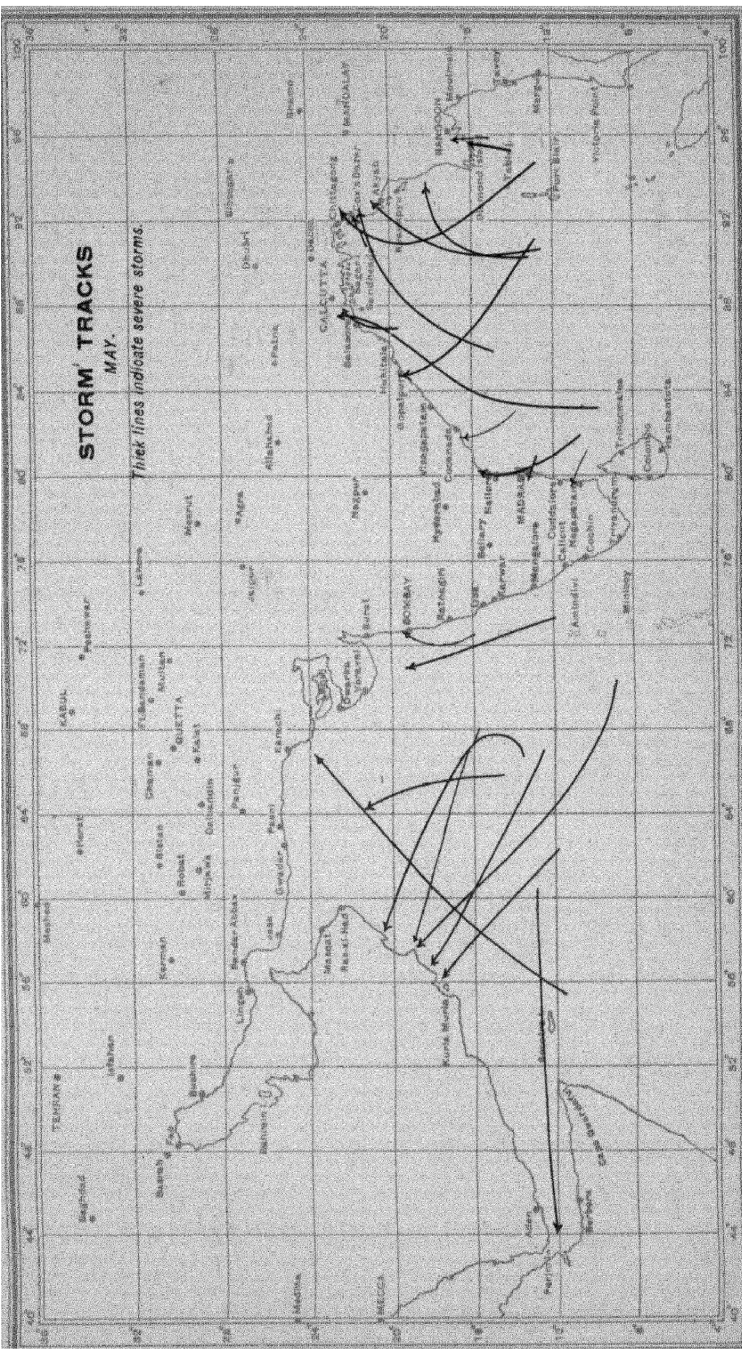
**Arabian Sea.**—Storms may occur, though not frequently during the latter half of the month. They are often severe and apparently any part of the Arabian Sea except the southwest may be visited by them. Their usual course is northnorthwestward at some distance from the west coast of the Peninsula, and then across the head of the Arabian Sea recurving to the NW or NE.

**Bay of Bengal.**— The storms of this month, some of which are severe, form in the south Bay of Bengal and less frequently in the Andaman Sea. They generally move in a north or NE direction towards the Burma and Pegu coasts.

## MAY.

**Arabian Sea.**—There is noteworthy increase in the number of storms recorded in this month most of them being severe. They form in any part of the Sea south of latitude  $14^{\circ}\text{N}$ , and travel in a direction generally between west and northnorthwest. Some of the storms which begin by travelling NNE recurve to the northwestwards.

**Bay of Bengal.**—Storms, which are mostly severe, are of comparatively frequent occurrence during May. They generally form in the centre of the Bay or in the Andaman Sea, and may travel in a NNW direction, frequently curving to the NE.



To face p. 28.

Plate 8.



## JUNE.

**Arabian Sea.**—Storms are frequent in this month and are mostly of a severe nature. Practically all form during the first fortnight of the month and eastward of longitude  $67^{\circ}\text{E}$ . between the latitudes  $12^{\circ}\text{N}$  and  $20^{\circ}\text{N}$ . At first moving in a NNW direction most of them recurve to the west and cross the northern part of the sea ; but a few recurve in a NE'ly direction and move to the Sind or Kathiawar coast.

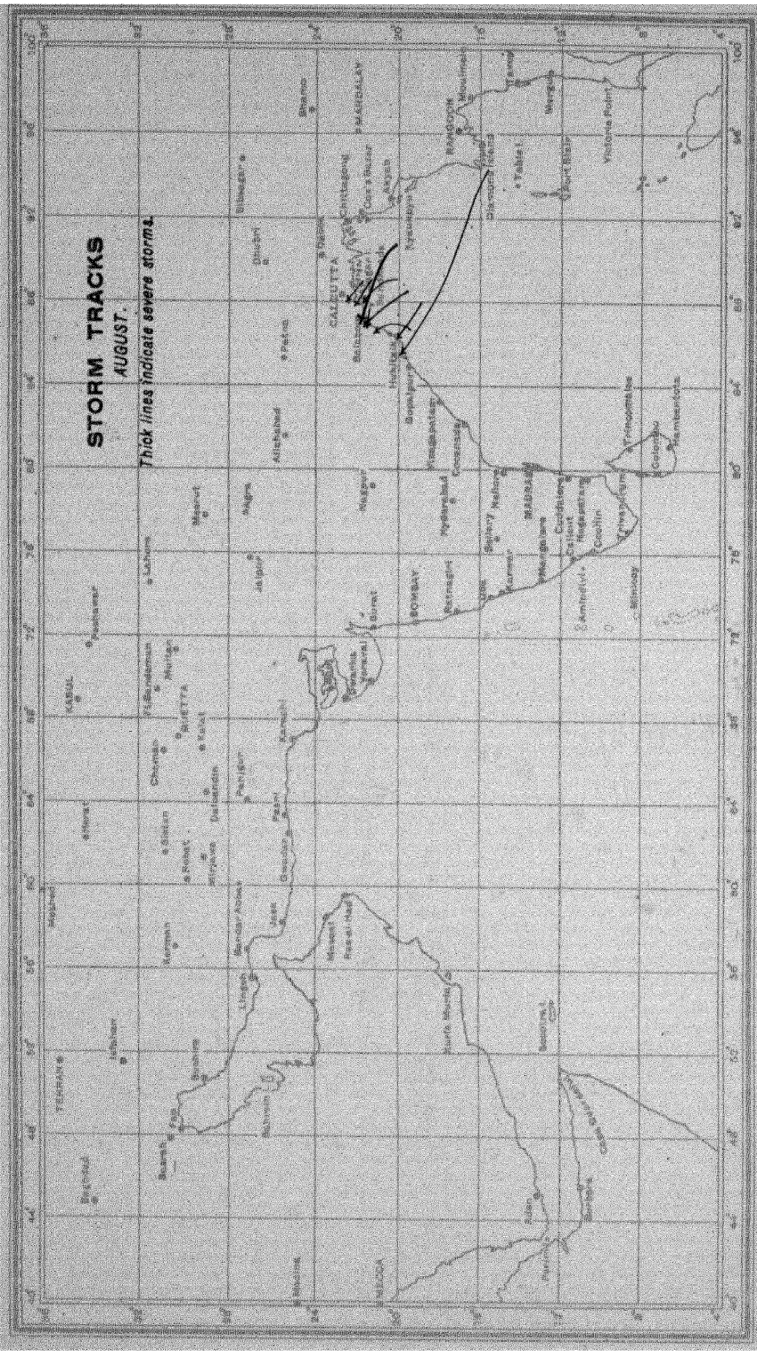
**Bay of Bengal.**—Storms are frequent and are mostly of moderate intensity and form north of the 16th parallel of latitude. They usually travel in westerly to NW'ly direction to the Orissa and Bengal coasts.

## JULY.

**Arabian Sea.**—The number of storms markedly decreases in July, those that form being only of moderate intensity and confined to the NE of the sea. Their direction of movement is between W and NNW.

**Bay of Bengal.**—Same as in June.





## AUGUST.

**Arabian Sea.**—The Arabian Sea is entirely free from cyclonic storms during August. The strong southwest monsoon winds that prevail may, however, at times reach gale force or even force 10 on the Beaufort Scale.

**Bay of Bengal.**—Same as in June.

## SEPTEMBER.

**Arabian Sea.**—The cyclonic storms are of infrequent occurrence during this month in the Arabian Sea.

**Bay of Bengal.**—The frequent storms of this month form to the north of  $14^{\circ}$ N. Lat. They may be of moderate or violent force and move in any direction between west and NNE.



# STORM TRACKS OCTOBER.

Thick lines indicate severe storms.

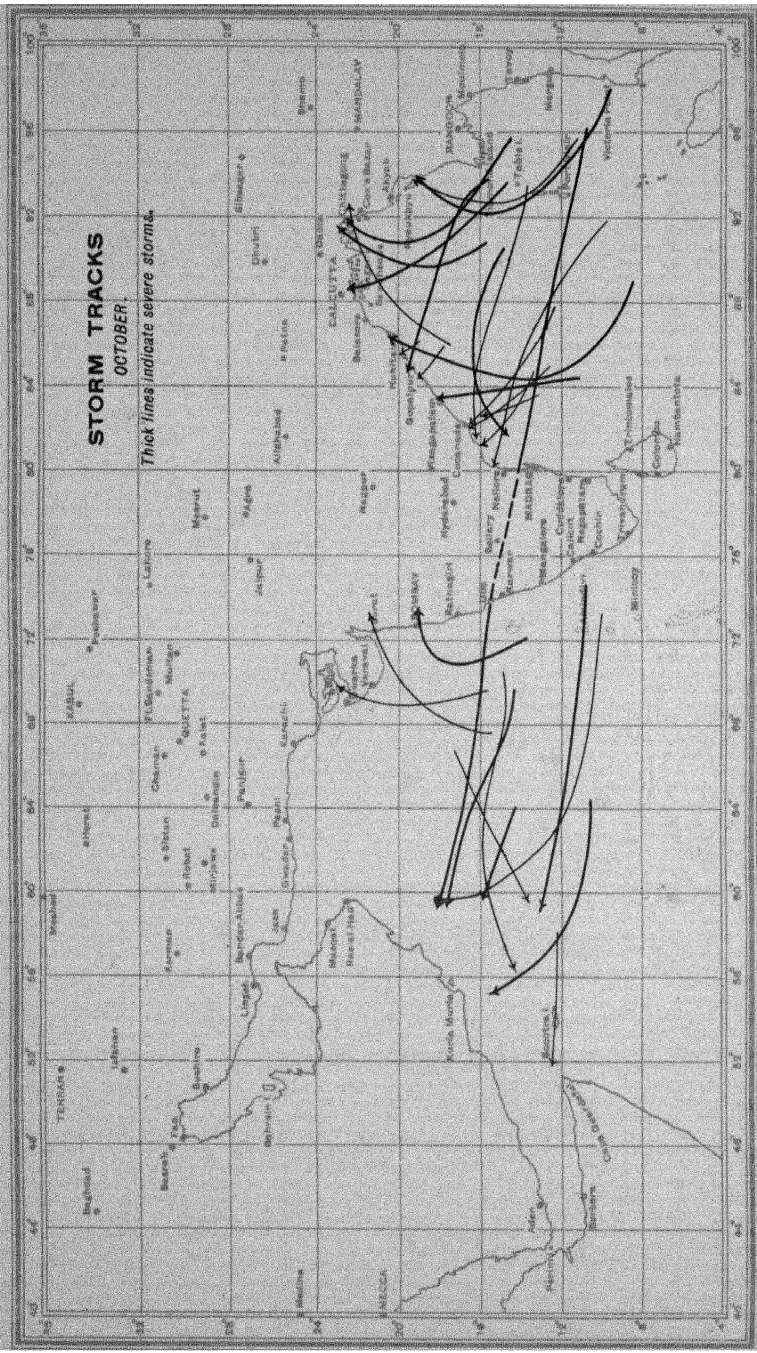


Plate 13.

To face p. 33.

## OCTOBER.

**Arabian Sea.**—Storms are of frequent occurrence in October and are generally of severe intensity. Those which enter the sea from the Bay of Bengal through the Indian Peninsula progress in a W by N direction to about the 58th meridian : while those which form in the eastern side of the Arabian sea itself travel at first in a NNW direction and then recurve to the NE. Storms which keep below latitude 18°N move in a west to NW'ly direction.

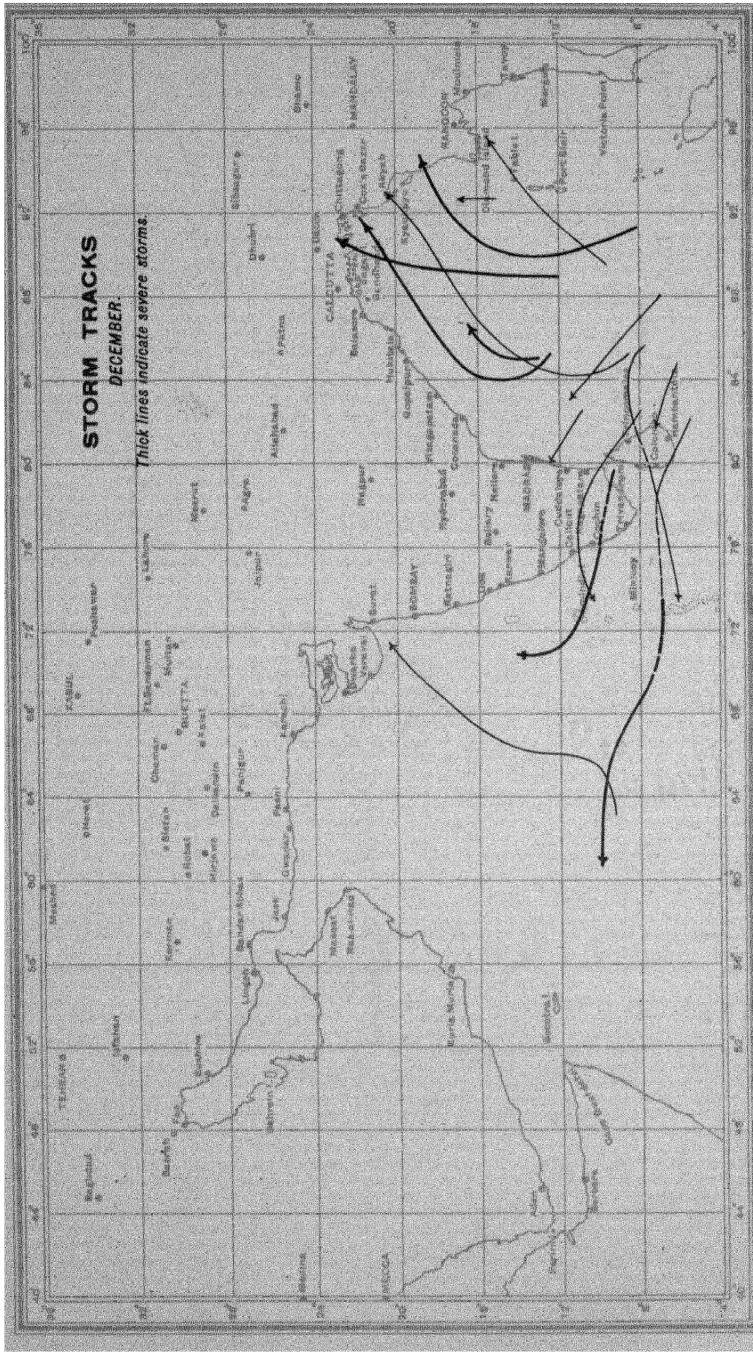
**Bay of Bengal.**—Storms are most frequent in this month, and may form in any part of the Bay. They are generally severe and move in any direction between W and N, with a tendency for recurring to the NE at their later stages.

## NOVEMBER.

**Arabian Sea.**—This is the month of maximum frequency for occurrence of storms which are of great intensity. They form between the 8th and 16th parallel of latitude eastward of 68th meridian or come through the Peninsula from the Bay of Bengal, and first travel north-westwards later recurving to the NE towards the Konkan and Kathiawar coasts. Cases are also known of storms having formed in the central Arabian Sea which travelled in a W to WNW'ly direction.

**Bay of Bengal.**—In this month storms are a little less frequent than in October and form in any part of the Bay south of the 16th parallel of latitude. They are generally very severe in intensity. The majority of storms forming between the 12th and 16th parallels at first move in a NW to N direction and then recurving to the NE advance towards the head of the Bay of Bengal. Storms forming south of the 12th parallel generally move in a west to NW direction towards the Madras coast.





## DECEMBER.

**Aratian Sea.**—The frequency of storms decreases in December. Most of them enter the sea from the Bay of Bengal, are severe and move generally towards W or WNW.

**Bay of Bengal.**—Storms which are much less frequent in this month than in the preceding two months form south of latitude  $16^{\circ}$ N. in the centre or SW portion of the Bay of Bengal. The former which are mostly severe move N'wards and then recurve to the NE and move to the head of the Bay or strike the Burma or Pegu coasts ; while the latter move in a WNW direction towards the Madras coast.

## CHAPTER V.

## THE LAWS OF STORMS AND RULES FOR HANDLING SHIPS.

## Nomenclature.

*Track* : the track along which the centre has travelled.

*Path* : the path along which the centre of the storm will probably travel.

*Right Semicircle* : looking along the path, that half of the storm which lies to the right.

*Left Semicircle* : looking along the path, that half of the storm which lies to the left.

*Trough* : the line of lowest barometer athwart the path. At places in the front half of the trough the barometer is falling and in the rear half it is rising. Near the trough the wind may shift suddenly and there may be much rain.

*Dangerous quadrant\** : the advance quadrant of that semi-circle which lies on the side of the path nearest to the normal direction of recurvature ; it is so named because a ship caught in the dangerous quadrant may be blown towards the path over which the ring of hurricane winds and the centre will pass, or the storm may recurve and pass over her. It should be noted that the strongest winds are usually found in rear of the trough, hence it often blows hardest with the first rise of the barometer.

*Navigable Semicircle\** : that semi-circle which lies on the side of the path furthest from the normal direction of recurvature.

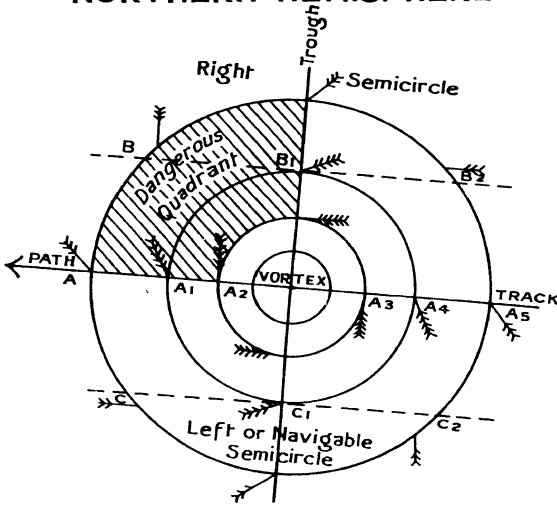
*Centre* : at the centre of the storm the barometer is always lowest and there is comparative calm ; here the sea is extremely dangerous, being the meeting place of heavy swells from all directions.

When the centre approaches a ship she experiences increasing wind with violent squalls, later perhaps hurricane force with mountainous seas ; as the centre passes over her the wind drops ; when

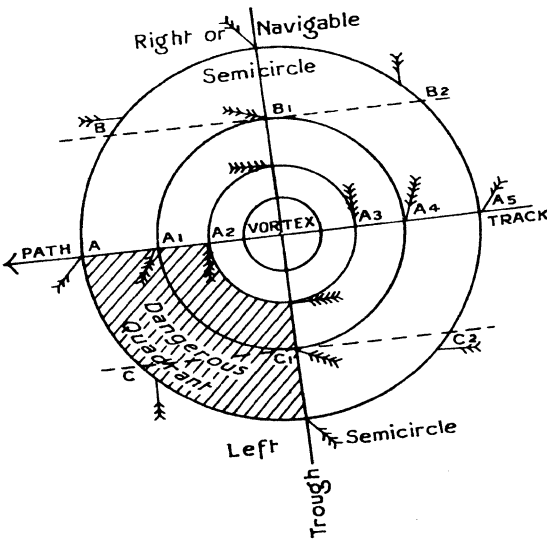
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\*In the southern Hemisphere the *left-hand* semicircle is the dangerous semicircle and *right-hand* semicircle is the navigable semicircle.

# NORTHERN HEMISPHERE



# SOUTHERN HEMISPHERE





it has passed the wind comes from the opposite point of the compass with renewed and increased violence ; as the storm moves away from the position of the ship the wind moderates ; this is illustrated by A, A<sub>1</sub>, A<sub>2</sub>, etc., shown in *Plate 16*. Much rain, thunder and lightning may be experienced. There is often a patch of blue sky over the centre, known as the " Eye ".

*Vertex* : the most westerly point reached by the centre when recurvature takes place. Also known as the Cod of the Track.

*Angle of Indraft* : the angle which the direction of the wind makes with an isobar or line of equal pressures.

The terms explained above are illustrated in the figure.

### Precursory signs.

The indications of the approach of or entrance into tropical revolving storms are :—

- (1) Swell. In the Right Hand rear quadrant of a storm (in the Left Hand rear quadrant in the Southern Hemisphere) the action of the violent winds blowing mainly in the direction of advance of the storm develop large waves which pass onward as swell. This swell travels to great distances and at a greater speed than the storm so that a long heavy swell coming approximately from the direction of the storm frequently forewarns an observer of the existence of a storm, occasionally by as much as two days before the other local indications of wind and cloud are sufficiently definite.
- (2) The fall of the barometer, more or less below its normal heights. If the atmospheric pressure is 1/10 of an inch below the normal value for the time of the day, the mariner may apprehend that a storm has formed or is forming in the vicinity and should be on the alert for other signs.

The barometer falls continuously in passing from the outskirts to the storm area ; the fall is slight in the outskirts, but it is more and more rapid as the inner storm area is approached. Sometimes at the centre of a cyclone the

barometer stands fully 2 inches lower than outside the storm field.

- (3) The occurrence of a succession of squalls (sometimes rain-squalls) which increase in frequency and intensity while the wind rises. The squalls usually come from the right of the wind direction, but sometimes accompany shift of wind.
- (4) A threatening appearance of the weather. The appearance of a peculiarly dense heavy bank of clouds on the horizon, its position being shown at night by the almost continuous lightning from distant clouds.
- (5) Sometimes a peculiar dark red or copper colour of the sky at sunset forebodes a storm.

### Laws of Storms.

When sailing in the region and in the season of revolving storms, the mariner should be on the watch for the precursory signs and carefully observe and record the wind and the barometer. When the wind, the barometer, the appearances of the sky and sea indicate the approach of a cyclonic storm, it is important to ascertain—

- (1) *the probable bearing of the storm centre, and, when in the storm field,*
- (2) *in which part of the storm area the ship is situated.*

In order to ascertain these two points it is necessary that the observer should be stationary. Therefore, the first thing to do is to stop head to wind or heave to. There should be no hesitation in doing so because the sooner a clear knowledge of the position of a ship in the storm field is ascertained the sooner will it be possible to take any action that may be necessary to avert danger. In heaving to, it should be assumed that the ship is in the dangerous quadrant and hence, in the northern hemisphere, heave to on the star-board tack (on the port tack in the southern hemisphere).

(1) *Buy's Ballots Law.*—In the northern hemisphere if you face the wind, the barometer will be lower (higher in the southern hemisphere) on your right hand than on your left. This law, known

as *Buy's Ballots Law*, should be clearly borne in mind, as by its application the probable bearing of the storm centre can approximately be ascertained. Thus having hove to on the star-board tack, face the wind and the bearing of the storm centre will be from 12 to 8 points of the compass to the right hand (left hand in the southern hemisphere). Allow 12 points at the beginning of a storm, 10 points when the barometer has fallen  $\frac{3}{10}$  of an inch (10 milibars) and 8 points when the barometer has fallen  $\frac{6}{10}$  of an inch (20 milibars) or more.

The direction of the ocean swell affords another indication of the bearing of the centre, for the swell comes approximately from the direction of the storm centre.

(2) Having ascertained the bearing of the centre, the semicircle in which the vessel is situated may be found by observing in which direction the wind shifts when hove to.

Thus (i) if the wind veers\*, *i.e.*, the ship is in the right-hand semicircle (see positions B, B<sub>1</sub>, B<sub>2</sub>, etc., in *Plate 16*), (ii) if the wind backs\* or shifts to the left the ship is in the left-hand semicircle (see positions C, C<sub>1</sub>, and C<sub>2</sub> in diagram), and (iii) if the wind remains steady in direction and increases in force with falling barometer the vessel is near or in the direct path of the storm centre.

This law holds good for both the northern and southern hemispheres.

### Rules for handling ships.

**A.**—In the northern† hemisphere :

- (i) If your ship is in the right semicircle and she is a sailing vessel, remain hove to on the star-board tack, so as to

\*Veering.—West to North to East to South.

Backing.—West to South to East to North.

†The rules for the southern hemisphere are :—

- (i) If the ship is in the right semicircle, whether she be a sailing vessel or a steamship, run with the wind on her port quarter until the barometer commences to rise.
- (ii) If in the left semicircle, and if she, a sailing vessel, remain hove to on the port tack ; if a steamship, heave to with the wind ahead if possible and if not, with the wind on the port bow.
- (iii) If in the path of the storm, run the ship, whether a sailing vessel or a steamship, with the wind on the port quarter ; this will take the ship to the right or navigable semicircle.

come up to wind and sea as the former continues to draw aft ; if a steamship, heave to with the wind ahead if possible, and if not, with the wind on the star-board bow.

(ii) If your ship is in the left semicircle, whether she be a sailing vessel or a steamship, run with the wind on her port quarter, until the barometer commences to rise.

(iii) If a seaman has reason to think that he is in the direct path of the storm centre he should run his ship, whether sailing vessel or a steamship, with the wind on the star-board quarter until the barometer ceases to fall, this will take the ship into the left or navigable semicircle.

**B.**—Should a vessel not have sufficient sea-room to run when in the navigable semicircle, she should heave to on the port tack.

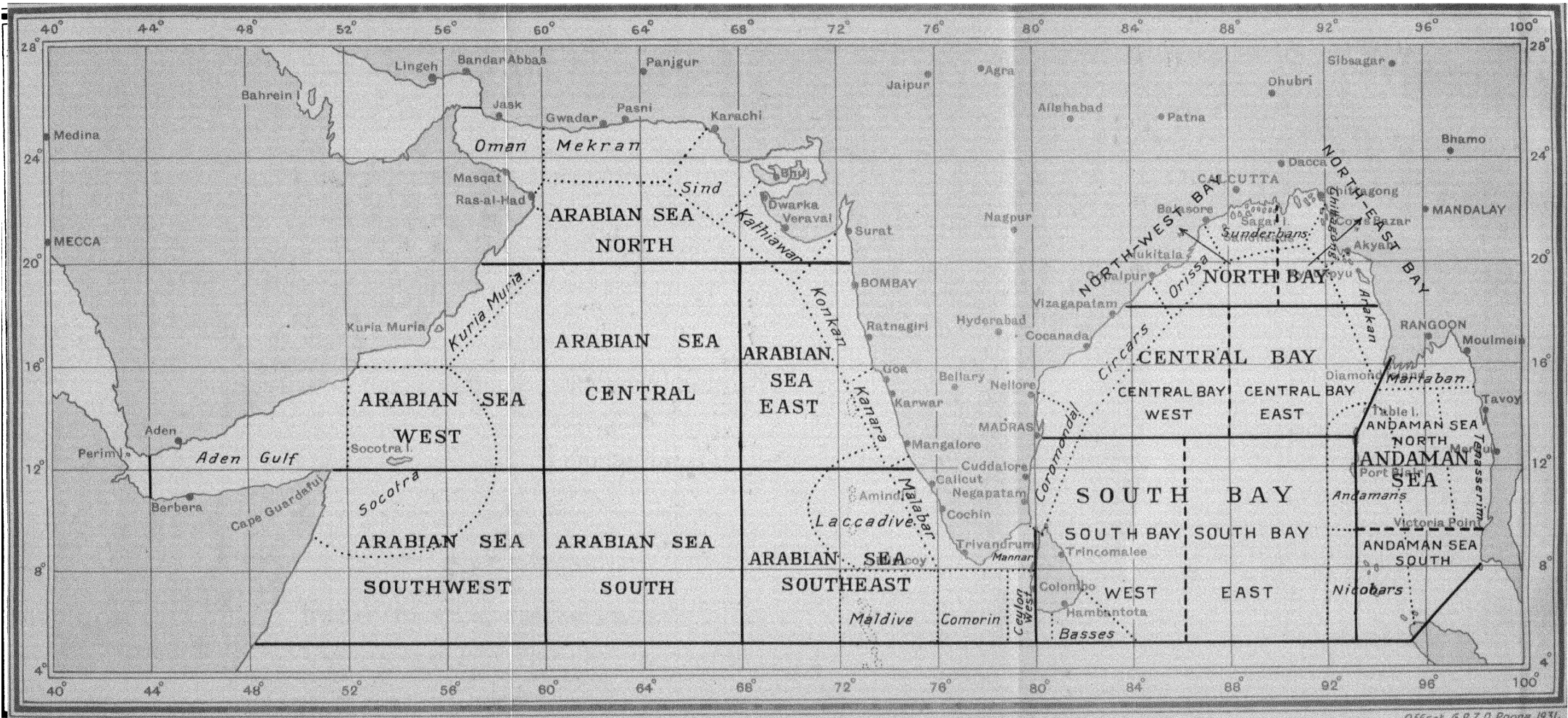
**C.**—If in a harbour or at anchor, the seaman should be just as careful in ascertaining the bearing of the centre and watching the shift of the wind as by so doing he will be able to tell on which side of the path of the storm he is situated and be able to act according to circumstances.

With wireless telegraph equipment it is possible for the navigator to obtain information about the position, intensity and movement of storms by collecting weather reports from other ships in the sea or from land, and combined with such information the rules given above may enable him to avert danger to a great extent.

### **Weather information by wireless telegraphy.**

*Bulletins issued by the India Meteorological Department* are broadcast each day from coastal radio stations in India, Ceylon and Arabia to ships in the Arabian Sea and the Bay of Bengal free of charge ; these weather bulletins briefly describe the position, development in intensity, probable movement and recurve of storms. The issues which are ordinarily twice daily, are increased in disturbed or stormy weather to three or six times a day. When necessary, further messages are broadcast at intervening times also. During disturbed weather these broadcasts contain definite





Office, P. I. D. Paone, 1931.

PLATE 17.

REGIONAL NAMES USED IN WEATHER BULLETINS  
BROADCASTED FROM INDIA



information about particular areas and in order to do this conveniently and concisely the Bay of Bengal and the Arabian Sea have been divided into different specific areas, to which names have been assigned as shown in *Plate 17*.

It must always be remembered that the warnings by wireless telegraphy issued by the India Meteorological Department can only be effective if reliable information from the vicinity of the storm is available along with the land observations at the Weather Office at Poona for the Arabian Sea disturbances, and at Alipore, Calcutta, for the Bay of Bengal disturbances; hence the urgent need for weather reports by wireless from ships to the shore stations.

The arrangements for broadcasting meteorological bulletins to ships at sea and for ships to transmit by wireless their weather messages to the coastal radio stations are fully explained in the publication named "Indian Ships' Code" issued by the India Meteorological Department.

### Conclusion.

Once a ship enters the wind circulation of a storm, her commander will be best guided by—

- (a) his own observations,
  - (b) reports from other ships in the vicinity, and
  - (c) weather bulletins and warnings issued through the coastal wireless stations from the Weather Offices at Poona and Alipore, Calcutta.
-

## CHAPTER VI.

### VISUAL STORM WARNING SIGNALS IN USE AT INDIAN PORTS.

Whenever a storm or a disturbance exists in the Indian Seas, suitable visual warning signals are hoisted at such ports on the coasts as are likely to be affected by the disturbance. The meaning of any given signal is the same throughout the Indian coast.

The Meteorological Department keeps Port Officers informed of the latest information with respect to all disturbances, and ships officers should apply to them for information to supplement the storm signals.

The present system of storm warning signals may be shortly described as follows :—

- (a) A general system consisting of eleven signals.
- (b) A brief system consisting of four only of the above signals. This system is used at smaller ports frequented mainly by small boats engaged in local traffic.
- (c) The general system combined with additional signals to indicate the position of the disturbance. The system is in daily operation at certain stations in the Bay of Bengal.

#### (a) General System.

1. *Distant Signals*.—To indicate Danger to Ships after they have left the Harbour.

Day.

Night.



*I.—Cautionary*.—There is a region of squally weather in which storm may be forming.

*Note*.—This signal will be hoisted at ports so situated with reference to the disturbed weather that a ship leaving the port might run into danger during its voyage. It will also be hoisted at Arabian sea ports when a disturbance is crossing the peninsula which may develop into a cyclone after entering the Arabian Sea.



**II.—Warning.—A storm has formed.**

*Note.*—This signal will be hoisted when there is no immediate danger of the port itself being affected, but ships leaving the port might run into the storm.

*Note.*—In the night signals  represents a white light and  a red light.

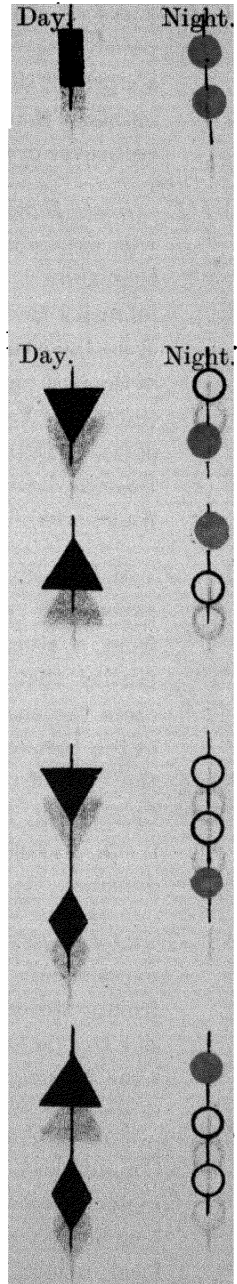
**2. Local Signals.**—To indicate that the port and ships in it are threatened.

**III.—Cautionary.**—The port is threatened by squally weather.

**IV.—Warning.**—The port is threatened by a storm, but it does not appear that the danger is as yet sufficiently great to justify extreme measures of precaution.

**V.—Danger.**—The port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast to the south of the port (or to the east in the case of Veraval, the Hugli ports, Diamond Islands, Bassein, Rangoon and the Andamans).

**VI.—Danger.**—The port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast to the north of the port (or to the west in the case of the Hugli ports, Chittagong, Rangoon, Moulmein, Karachi and the Andamans).



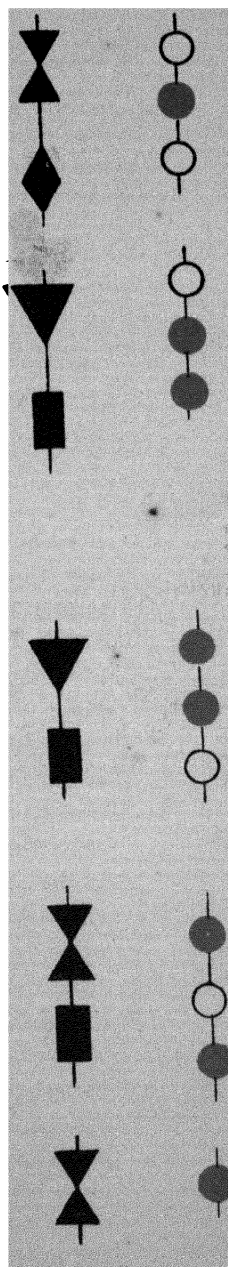
**VII.—Danger.**—The port will experience severe weather from a storm of slight or moderate intensity that is expected to cross over or near to the port.

**VIII.—Great Danger.**—The port will experience severe weather from a storm of great intensity that is expected to cross the coast to the south of the port (or to the east in the case of Veraval, the Hugli ports, Diamond Islands, Bassein, Rangoon and the Andamans).

**IX.—Great Danger.**—The port will experience severe weather from a storm of great intensity that is expected to cross the coast to the north of the port (or to the west in the case of the Hugli ports, Chittagong, Rangoon, Moulmein, Karachi and the Andamans).

**X.—Great Danger.**—The port will experience severe weather from a storm of great intensity that is expected to cross over or near the port.

**XI.—Failure of Communications.**—Communication with the meteorological headquarters has broken down and the local officer considers that there is danger of bad weather.







## (b) Brief System.

In the brief system only the four following signals will be hoisted, but the port officers will be kept informed of the progress of bad weather for the general information of shipping :—

Signal No. III.— <i>Cautionary.</i>	}	Meaning day and night signals as in the general system.
Signal No. IV.— <i>Warning.</i>		
Signal No. VII.— <i>Danger.</i>		
Signal No. X.— <i>Great Danger.</i>		


## (c) Additional Daily Signals for the Bay of Bengal.

In the Bay of Bengal it is possible to locate the area of bad weather with some degree of certainty even when it is far from the coast. Therefore in order to give information regarding weather in the Bay the following arrangements have been made :—

- (1) if the port itself is threatened the appropriate local signal of the “ general system ” will be hoisted ;
  
- (2) if there be an area of squally weather or a storm that does not threaten the port the “ distant cautionary ” or “ distant warning ” of the “ general system ” will be hoisted ; and additional signs will be hoisted under these to indicate the position of the disturbance in the Bay. For this purpose the Bay has been divided into six sections as shown on the accompanying map, see *Plate 18*, and the following signs have been allotted to each of the sections :—

Division	I	II	III	IV	V	VI
Signal						

Thus if there is squally weather in section V of the Bay the

signal  would be hoisted at the various ports ; and

if a storm has formed in section II the signal  would

be hoisted at all ports which were not directly threatened ; as already stated the ports threatened would hoist one or other of the local signals.

The Meteorological Department will endeavour to keep the number of locality signals on each hoist as few as possible and generally only the number of the section in which the centre of the storm is situated will be given. If, however, the centre of the storm is near the boundary of a section two locality signals will be given, the first indicating the section in which the centre is supposed to be and the second the neighbouring section near to which it is. In the event of a storm centre being near to the angles where three sections meet, three locality signals will be hoisted. The first will give the section in which the storm is supposed to be, the second the nearest adjoining section and the third the remaining section.

#### *Examples.*

Storm centre.	Locality signals.
Lat. 16°N. Long. 86°E. . . . .	. II.
Lat. 16°N. Long. 88°E. . . . .	. II and III.
Lat. 16°N. Long. 89°E. . . . .	. III and II.
Lat. 18°N. Long. 87½°E. . . . .	. II, I and III.
Lat. 19°N. Long. 89½°E. . . . .	. I, III and II.

The following notes may facilitate the identification of the signals :—

#### **Day Signals.**

(a) All distant signals, and only distant signals, have a bar either horizontal or vertical as their upper member.

(b) All local signals, and only local signals, have a triangle or a double triangle as their upper member.

(c) Cautionary and Warning signals (distant and local) consist of only one shape, except at certain ports in the Bay of Bengal where additional shapes are used to indicate the locality of the disturbances.

(d) Danger signals consist of two shapes the lower of which indicates the severity of the storm and the upper where the storm is expected to cross the coast.

(e) A diamond as the lower member of a danger signal indicates danger and a vertical bar great danger.

(f) The point of the triangle of a danger signal indicates where the storm is expected to cross the coast—the point down indicates the south, the point up north, and the double triangle, with its points in the middle indicates at or near to the port itself.

### **Night Signals.**

(g) Failure of communication signal consists of one lamp.

(h) Cautionary and Warning signals consist of two lamps.

(i) Danger signals consist of three lamps.

(j) The intensity of the danger is indicated by the number of red lamps ; in the danger signals there is only one red lamp and in the great danger two red lamps.

(k) The position of the red lamps in a danger signal indicates where the storm is likely to cross the coast. If there are more red lamps above the middle than below, the storm is expected to pass to the north. If there are more red lamps below the middle than above, the storm is expected to pass to the south. If the red lamps are symmetrical about the middle the storm is expected to pass over the port itself.

## APPENDIX.

### A note on navigation in the Bay of Bengal.

When running up the Bay of Bengal with a strong southwest wind, occasional squalls and rain, and a slowly-falling barometer, bad weather prevails somewhere to the northward.

Between the beginning of June and the middle of September the storm centres are generally northward of lat.  $16^{\circ}\text{N}$ , and in July or August still further northward, and a sailing vessel or low powered steamship should steer eastward and take advantage of the southerly and southwesterly winds on the eastern side of the storm as it moves northwestward. But should the weather get rapidly bad, and the barometer continue to fall, then heave-to, and determine the position with regard to the movement of the storm before proceeding.

In May, October, or November the storms travel in some direction from west, through north, to northeast and then the course of a storm should be definitely ascertained before any attempt is made to round its eastern side, because if it is moving northeastward such a procedure would be attended with danger.

When leaving the Hugli from June to September notice of the approach of a cyclonic storm or of the existence of a storm in the northern part of the Bay, is given by easterly winds and a falling barometer, or by the storm signals at the telegraph stations. In July or August the storm will probably be of moderate force, although not invariably so, but in June and September some most violent cyclones have visited the coasts of Bengal and Orissa. As a vessel sailing southward would not likely run into the storm, the river should not be left until the weather has moderated.

In May, October, or November a squally easterly or northeasterly wind driving low, long-drawn masses of cloud before it, or a strong westerly set in the sea at the head of the Bay of Bengal, indicate that a cyclonic storm is in the northern part of the bay, and a vessel should not proceed southward until finer weather

prevails. But in these months a cyclonic storm may be far down the bay, and at the Hugli river, or other port at the head of the bay, there may be every appearance of fine weather. With these conditions, on the first indications of the coming storm the changes of the wind and barometer should be carefully watched, and the course of the storm, if possible, be determined. If in the right-hand semicircle the vessel should be hove-to on the star-board tack until the storm has passed; and if undoubtedly in the left-hand semicircle should heave-to on the port tack if the wind is eastward of North, or run southward, keeping the wind on the star-board quarter, when the wind is North, or westward of North.

Vessels lying in the roadsteads of the Coromandel coast on the approach of a cyclonic storm usually run southward round the southwestern quadrant; this is probably the only course open to sailing vessels; but full-powered steamers leaving while the centre is still more than 100 miles distant, and the wind between north and north-north-west, might if necessary proceed northeastward, if it has been ascertained that the storm is not moving north-westward or northward of that.

Vessels leaving Rangoon or Moulmein, and encountering strong north-easterly winds, with a falling barometer, denoting the existence of a cyclonic storm eastward of the Andaman Islands, should delay their departure until the storm has passed, which is indicated by a rising barometer, and the wind shifting to East or southward of East.

The following instructions have been approved by the Port Officer, Calcutta, for the security of shipping in the approaches to the port of Calcutta :

*Danger Signal V* indicates that a storm of slight or moderate severity will probably cross the coast to the east of Saugor Island and west of Chittagong. Vessels may proceed to sea if the height of the barometer and state of the sea and weather are such as to lead masters and pilots to infer that there is no danger. The wind at the mouth of the Hooghly will probably haul from north-east through north to north-west or west.

*Danger Signal VI* indicates that a storm of slight or moderate severity will probably cross the coast to the west of Saugor Island and north of False Point. The wind at the mouth of the Hooghly will probably veer from northeast through east to south-east or south. As these easterly winds will raise a heavy swell and produce a strong westerly set in the channel at the Sandheads, it is advisable that none but fast steamers in light trim should put to sea, and those only if the weather appearances and state of the sea are not too unfavourable.

*Danger Signal VII* indicates the approach towards Saugor roads of a storm of slight or moderate intensity. It is advisable that no vessels except fast steamers in light trim should put to sea until the wind direction and force, the state of weather and sea and the rise of the barometer indicate that the storm has either broken up or passed inland. It should be remembered that cyclonic storms of small extent in the Bay of Bengal sometimes blow with hurricane force and raise a high sea near their centres.

*Great Danger Signal VIII* indicates that a storm of a great intensity will cross the coast to the east of Saugor Island and west of Chittagong. It is advisable that sailing vessels, with or without steam, and deep-laden or slow-steaming steam-vessels, should not proceed to sea, but remain in the river till the storm has reached the coast and passed inland. The wind at the mouth of the Hooghly will probably haul from north-east through north to north-west or west.

*Great Danger Signal IX* indicates that a storm of great intensity will cross the coast to the west of Saugor Island and north of False Point. No vessels should go to sea, and masters and pilots of vessels outward-bound should be guided by the appearance of the weather and height of the barometer in deciding whether it is advisable to proceed below Diamond Harbour or Mud Point. The wind at the mouth of the Hooghly will probably veer from north-east through east to south-east or south.

*Great Danger Signal X* indicates the approach of a storm of great intensity towards the mouth of the Hooghly and Calcutta. Masters and pilots in charge of vessels are cautioned not to put to sea from Saugor Island, not to proceed down from Diamond Harbour, and

they should make their vessels as snug and secure as possible. The masters of vessels in the port should take the special precautions for safety laid down in the port rules.

There will probably be a storm-wave, and it should be carefully remembered that its height and destructive effect will depend quite as much upon the state and character of the tide when the cyclonic centre reaches the coast, as upon the depression at the centre, or the intensity and extent of the storm.









