HURRICANE FORECASTING
(A SOLILOQUY)

by

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INTRODUCTION

When an effort is made to tell others how to forecast weather, the task becomes more impossible the more we think about it. This is the case whether it be day to day weather, cold wave, storm, or hurricane. There have been many attempts to put on paper some of the rules by which modern forecasting is done, all the way from the empirical rules of the past generation to the analyses of air masses by the thermodynamics of the present day. Many books and papers have been written about it, but in many cases the writers could not translate their own methods into forecasts that were up to standards of excellence, to say nothing of assisting others by their writings. I have failed so far to find where a fledgling forecasters has materially benefited beyond the broadest outlines and generalities. When it comes to making specific forecasts for a given locality or area, or the issuing of special forecasts or warnings for a particular phenomenon, each man has been compelled to dig for himself. I confess to some attempts myself to set down rules or precepts that might help some beginner over the rough spots, but candor forces me to admit that it is doubtful if much benefit resulted.

But, nothing daunted, I set myself the task of trying to tell on the written page some of the things that have been helpful to me in hurricane work, but this time I will talk to myself. This may prevent harm to others, and it might crystallize my own thinking to the point of giving myself a better conception of what I have been trying to do. This should be a guide, or a base, for future progress and action. At any rate, my audacity, which often causes me to rush in where angels fear to tread, and say foolish things, will be consumed on myself, and will not encourage others to foolish deeds. Most of the hurricane writings have emphasized, or over-emphasized, some particular concept; others have been historical and descriptive with no attempt at forecasting. Volumes have been devoted to theoretical and dynamic aspects, but even in these fields there is still a wide divergence of opinion, and the order of the day is disagreement. Perhaps that is the way we advance our knowledge - by thesis, antithesis, and synthesis; by concept, disputation, other concepts, and finally agreement. At present the situation regarding hurricanes is very much in the state of the blind men who went down to the circus to see the elephant.

Cline wrote a book to tell the whole story of "Tropical Cyclones". Tannehill wrote another, but he confined himself to the historical and descriptive, with some very cautiously inserted observations and theories; and called it "Hurricanes". In later years a host of meteorologists, such as Palmer, Bellamy, Reihle, Schaeffer, Simpson and other in the Weather Bureau, the Universities and the Armed Forces have had some connection with hurricanes in various parts of the world, and have written of their research in various phases of tropical meteorology. Many nicely framed theories of genesis and propagation have been expostulated and concepts of one phase or another advanced. In addition better observation, especially in the upper air, have led to a better knowledge of the make-up of the hurricane. The armed forces have flown many missions into, around, over and under these storms in various parts of the world. We have radiosonde observations in and around them. We certainly know more about the hurricane than we did 25 years ago, but none of the newer writers have come out with a substantial anchor to windward when the howling monster bares its teeth and roars down toward defenseless islands and cities: they still haven't told the forecasters the rules by which warnings must be issued to save the lives and property of these millions of people. Make no mistake, it is warnings properly placed, sufficiently far in advance, that saves lives and property, and it is failure in those that result in casualties, property damage and Congressional investigations.

Considering the array of brains that have attacked the hurricane in recent years with calculus and formulas and thermodynamics, I certainly am not going to stick out my neck in that direction. In the first place I would be over my depth and out of my sphere, for although it has been my official job to head up the hurricane warnings service of the Weather Bureau in the Southeast for more than a decade, I frankly confess to considerable ignorance concerning hurricane make-up. What I do not know about hurricanes would make by far a larger book, and if this paper were confined to what I actually know about them, it would qualify for "the soul of wit" . . . When the record of the years is examined, however, it will be found that warnings have always been up in the right place at the right time, and I have no Congressional investigations to my credit. We must conclude, then, that perhaps too much knowledge becomes a handicap when warnings have to be issued. I mean theoretical knowledge. So, let us frankly admit that the measure of success which as attended our efforts is not the result of any super-knowledge.

THE FORECASTER, his Temperament and Philosophy

If the statements in the preceding paragraph are true, then what is our idea of the necessary qualifications for hurricane forecasting? Perhaps it is trite, if not absurd, to say the first requirement is a forecaster. Our forecaster must have proven himself beyond any doubt that he can forecast. He should have had several years of seasoning under various degrees of pressure involving day to day weather forecasting, including issuing of cold wave, ordinary storm, and various other weather warnings. We believe all will agree that the

hurricane warning service is no place for the novice or the beginner; neither does it matter how much theoretical, dynamic, or synthetic meteorology he may have from the college class room. The young doctor, for example, has to spend a period of internship to gain actual experience, before he is turned loose to practice his Materia Medica on suffering humanity. He will kill enough people even then. Just so with our forecaster, he must prove himself before we turn him loose to grapple with hurricanes. Here is a place where an inadequate diagnosis and warning may kill thousands in a day. Surely then, this is a place for only the proven and tried. Academic degrees will not in themselves be assurance that he is qualified, for here is a very important job that requires maturity based on aptitude, interest, judgment, and experience. This is graduate work, and let no one deceive himself into thinking there are short cuts to the top. we have to miss only one hurricane warning and the mischief is done. There may be no time for a second chance, then certainly we cannot afford to entrust this work to any but the skilled, the true, and the tried. we must indeed apprentice new men but it must be done under supervision. The trainee should not be permitted or expected to assume the responsibility until he is ready for it. We do not place the fledgling officer from the Military Academy, with no combat experience, in charge of the army fighting on the most difficult front.

Then I think we should know something of our forecaster's temperament. This is no place for the cringing, the timorous or the vacillating. He must be able to stand the severest pressure. He should have in addition, qualities of perception, concentration, imagination, and confidence in himself. I have seen several very good men go into panic when the pressure was applied. Several questions should be satisfactorily answered. Can he make a decision and act on it? Does he have confidence in himself to deal with the situation, and at the same time does he remain humble and lacking in egoism? Does he have a mind that is firm, but not inflexible and stubborn? Can he be deliberate and careful in arriving at a conclusion, but finally make up his mind and not vacillate? can he forget the publicity his work entrails, and use himself only as a servant of the millions who are depending on him for their lives and property? Does he have interest enough to dig and dig and hang on and never let up until he has the answer? This is not place for the self-seeker, the egoist, and vacillating, the half-interested, or the half-hearted. he may be ever so well equipped from other important standpoints, but if he is lacking in these attributes, he will not make the best man for this work.

We should also know something of out forecaster's philosophy. Now, you say, we are getting on irrelevant ground and our position is likely to become untenable. Perhaps so, but I have come to believe a man's philosophy has a great deal to do with his success or failure at any vocation in life. Our modern philosophical thinking follows pretty much the pragmatism of William James. In this system of philosophy, we proceed with no preconceived ideas, but through trial and test we determine whether a thing is workable or unworkable, right or wrong. We believe this is the modern philosophy which dominates American thinking today, and that it is good as far as it does. It must be realized however, that such a philosophy limits us to the natural senses and the recepts and concepts provided by the stimuli of our environment, plus our ability to reason and make deductions therefrom. The transcendental philosophy of Kant, Fichte, Hegel, Emerson, Channing, and others, would have us believe that "the mind of man is a flash of the Infinite", and as such it can, and does at times, transcend the limits of the natural senses with their purely deductive and analytical powers, and receive from the Infinite, the Summun Eonum, or God is you will, inspired insight and knowledge. I believe that most men give some credence to these older philosophies, as witness the almost universal belief in a Supreme Being that in some way has a connection with the minds of men and their destinies.

Now our hurricane broadcaster should, in my opinion, have a good foundation in a philosophy which embraces a great deal of both the pragmatic and the transcendental. He must have all the training and experience possible, both in the classroom and laboratory, and in actual practice and test in the chosen field. But he should also have enough of the transcendental to permit of revelations that goes beyond his own powers. We might it intuition. Certainly if there is no other source of wisdom except academic training, then by all odds someone else should have this job. Then let us have men who have learned all they can, but who are also willing to seek wisdom and guidance from the source of All Wisdom. They will reach the limits of their own powers and still feel the need for help, when they stand alone between one of these monsters and the homes and lives of people.

REPORTS AND THEIR ANALYSIS

A forecaster may be the first requirement, but no forecaster, however well qualified, can pull storms out of his hat like the magician's rabbit. Neither can be do much with highly specialized qualifications unless he has laboratory data to analyze. The next requirement then is to give him something to work with in the way of report and observations. The hurricane region of the North Atlantic, Caribbean, and Gulf of Mexico offers a

network of land stations only in the chain of islands that string out from the Florida peninsula and Cuba around through the Lesser Antilles to Trinidad, coupled with the coastal stations of the mainland. But there are the wide stretches of the Atlantic north of this island chains with no possibilities for land observations, except at Bermuda; while the Gulf of Mexico is nearly 1000 miles one way by 500 to 700 the other with no island station possibilities at all. The Caribbean Sea has a few island locations but they are mostly confined to the northwestern portion - Jamaica, Swan Island and the Caymans. The islands constitute practically the only locations now available, outside of the mainland, for the use of the radio and radar methods and for pilot balloon observations. It is true that we have a few Weather Ships equipped to make such observations, but this methods may not be continued. Also it is true, unfortunately, that our island stations possibilities have not been exploited to the fullest, and although the difficulties are recognized, we should bend [?] every effort to keep these reporting stations in operation. Here we are trying to track hurricanes over areas larger than the continent with fewer reports than we consider necessary for the proper analysis of a small section of the country. In recent years the airplane has been brought into the picture to help fill the gap, and they have done a wonderful job during the war years, and since, in helping us follow storms. But with few exceptions we have had to locate the storm, or at least suspect its existence, from ships or land station reports, before we could bring the airplane into use. It is hoped that soon the merchant vessels of all nations will resume weather reporting, since this constitutes our best available source for a wide network of surface reports over the ocean areas.

Sufficient reports must be available for a reasonably good analysis, and great care is necessary on the part of the analyst to utilize to the ultimate every report available. There will be none too many at best, and a large percentage of these will be of doubtful accuracy in some aspect. No forecaster can do good work without an adequate field of good reports, and a very careful analysis of them. There is not greater need anywhere than in the hurricane zone for careful analysis, especially so since much of the material available is of questionable accuracy. Storms areas must be accurately located, and after formation they must be located at frequent intervals in order to have a reliable trajectory of past movement. Too much emphasis cannot be placed on the necessity for furnishing the forecaster with sufficient reports for an accurate analysis of the storm are and its surroundings, both at the surface and aloft. But you say this is self-evident and elemental, and so it is, but it is not always easy to obtain the necessary reports. The difficulties run the whole gamut from lack of sufficient appropriations to the untrained native observers on some Caribbean islands.

An accurate trajectory must be maintained, for it the center is poorly located, the calculated future positions will be correspondingly in error. We most know where the storms are and keep accurate track of them, not only as to location, but also intensity, speed and direction. In other words, past performance is a helpful key to the future. It is here that airplane reconnaissance has proven effective. Fast plane can go many hundreds of miles out over the oceans and accurately locate the center of a storm within the space of a few hours, and radio the findings back to the forecaster while out there. With this method, the storm is never lost except at night. It is possible that radar will soon enable airplanes to follow the storms at night as well as during the day, and overcome the problems of navigation, etc., that now hampers night operations. But with two or three good fixes during daylight hours, the problem of extrapolation through the night is ordinarily not too difficult.

Some of the instructors at Chicago University during the war attempted to show how a reasonably good forecast could be made from the observational material available at only one station. This is old stuff down this way! We have had to practice that kind of forecasting for years. I imagine we have had as much actual experience in utilizing the data from one stations, or at best a few stations, as any one in the game. A few years ago we attempted to follow the movement of a hurricane from far northeast of the Leeward Islands, around through the Atlantic west of Bermuda and to the east of Newfoundland, with the station at Bermuda as our principal source of observational material. We were surprised at the very creditable job we did of tracking and forecasting it over nearly 2000 miles of its track. But when it comes to the necessity of forecasting these monsters from inadequate observations, it is dangerous business, and it ages the forecaster prematurely. It may be necessary on some occasions to make the best of a few reports and do your utmost anyway. This was the case during the first few years of the late war, when reports were almost completely blacked out from ocean areas, but now that this necessity no longer exists, every effort should be made to increase the number, and the accuracy of reports in the hurricane zone. As a beginning some fully equipped weather ships should be stationed in the Atlantic between Bermuda and the Antilles, and at least one or two in the Gulf of Mexico. Rawinsonde data are very badly needed for these areas to supplement surface observations made by merchant ships, and reconnaissance reports by aircraft.

TYPES OF STORMS AND THEIR GENESIS

Five type classifications are recognized by the writer for hurricanes in our part of the world, after their forming areas or genetic factors. Our types are as follows: (1) Masterly wave type; (2) Inter-tropical Convergence (front) type; (3) Dynamic Shear type; (4) The Cape Verde type; and (5) the Miscellaneous types. These may be further condensed to three types: eastern waves; ITC; and old polar front discontinuities.

The easterly wave has received more attention in recent years than all other types combined, but while it is the predominant type in our part of the world, it is by no means the only one. in some years (1946 for example) very few easterly wave hurricanes were noted, but since Dunn first called these waves to our attention in the Bulletin of the American Meteorological Society (June 1940) they have received much attention from writers on tropical meteorology. This type storm usually comes from the east off the Atlantic, either as a wave, or a fully developed hurricane, into our field of observation. Those that come from the far eastern Atlantic are called the "Cape Verde Type" because they apparently have their genesis off the coast of Africa in the vicinity of the Cape Verde Islands as perturbations on the Inter-Tropical Convergence. The Cape Verde Storms are the really great storms of the middle hurricane season, and often cross the Atlantic, devastate a few islands in the Caribbean region, and strike some part of the coast of North America, by far the larger number recurve over the Atlantic to the east of our shores, fortunately, or our hurricane history would be even more tragic than it has been. The pure easterly wave type appears as a convergence wave moving westward with the trade winds. These waves are stable in character about 80 to 90 percent of the time, but the remainder are unstable, or become unstable some time in their journey, and form hurricanes. These formations may occur anywhere from several hundred miles east of the Lesser Antilles to the Gulf of Mexico.

The Inter-Tropical Convergence type from along this convergence zone where it curves far enough north of the equator to permit cyclonic circulation. The Cape Verde type mentioned above probably form on this convergence front where it bends far northward of the equator in closer to the region of Balear and the Cape Verdes. But aside from these, the Inter-Tropical Convergence Front (or zone) is the principal genetic agent for early- and late-season storms of the Western Caribbean-Central American area, and for the occasional storms that form off the northeast coast of South America. Convergent areas along the Inter-Tropical zone are rather frequent, and produce the heavy rainfall of the tropical wet season, but it is only when this convergence is a considerable distance north of this equator that hurricanes can generate. This occurs in the western Caribbean-Central American area at the beginning of the season (June-July) and the close (October-November).

The Dynamic Shear type is formed by high pressure areas from temperate latitudes moving out over the Atlantic and strengthening the semi-permanent Bermuda-Azores Atlantic high pressure cell. When this occurs it causes a line of wind shear (cold front discontinuity) or surge of increased velocity in the trade wind belt. These changes may be either at the surface or aloft, or both. When such a surge comes into contact with an easterly wave it may quickly be changed from a stable wave into a hurricane. On other occasions, it appears that the hurricane develops as a result of the difference in velocity along the boundary of the surge, possibly assisted by dynamic heating aloft which may be producing super-gradient winds.

Under the miscellaneous type comes a rather large number of storms of uncertain ot complicated origin. They might be called the "octoroons" of the hurricane family; of uncertain parentage and mixed blood. Some of the causes are convection, dynamic heating aloft, foehn heating in the South Atlantic States, wave formations on old extra-tropical frontal discontinuities, etc. Some are apparently like Topsy in Uncle Tom's Cabin, "They just growed".

FORECASTING THE VARIOUS TYPES

The map-type forecaster was buried with the so-called age of empiricism and his bonet left to rot amid the limbo of other old Victorian virtues. That is, until some modern intellectual dug him up and dressed him in the fancy new name of "analogues!" I guess in that case empiricism is not entirely dead, nor the map-type forecaster either. In our work, type forecasting has its points, but even clad in a new name it has to be taken in small doses like an opiate, for its usefulness is limited. In other words, regardless of the type of origin, or the dynamic forces that acted as genetic agents, they are all the same type of storm. They are "Hunrakan's Monsters" whether they are "To the Manor Born" or the half breeds of the meteorological world from across the tracks.

Average movements of storm originating in the several forming zones have some characteristics peculiar to each, but these have been published many times in track-charts. The forecaster should have reference to these, since they furnish background information similar to analogues, climatology, or map-types in regular forecasting. These track-charts will show marked variations in direction, speed, and intensity for the several types, and for the various months of the season. The early- and late-season storms, for example, tend to form mostly in the Western Caribbean - Central American area, with some forming near the northeast coast of South America. In June and early July the Western Caribbean formations may move in any direction from westward to northward. In October and November their movement is predominantly toward the north and northeast. Storms forming off the northeast coast of South America tend to move on a broad curving path to northwestward and northward. Mid-season storms mostly come from the east near the Cape Verde Islands, or develop on easterly waves in any location from the Lesser Antilles to the Gulf of Mexico. They build up to great heights and are very persistent and destructive. This led me to say in a weak moment of generalization that "August hurricanes never die". This is an overstatement for emphasis, but note the broad, smooth parabolic curves of the August and early September tracks, as they move at a faster than average speed. You will note that few freak movements are noted, such as loops, stalls, changes in course, or dissipation. In September the tracks become more erratic, but persistence and severity are still the keynote.

We could linger over the experience charts and study them in detail for the several months of the season, and from the several forming zones, but these are available in any number of publications and can be pondered at will. These are the experience tables of hurricane movement and action. Such helpful background information can be gained from a thorough study of them that will fix in the mind the general behavior to be expected. We should pause here for a note of warning, for it has been my experience that hurricanes do not abide by the rules very well; rather they are the "rugged individualists" of the meteorological world and quite capricious at times. This indicates that the forecaster should not encumber his mind with too many preconceived ideas, but with a good background in these experience charts, let vigilance and flexibility be his watchwords.

A few of the miscellaneous type may form in nearly any area. On two or three occasions they have formed in retrograde wave-bubbles from the foehn area of South Carolina and moved southwestward across the Gulf of Texas. Some form in the Bahama Island region, either from obscure easterly waves or convection, and quite a few have formed over the Atlantic east of the South Atlantic States out to Bermuda or beyond, from old extra-tropical cold-front discontinuities. These usually move with a northerly component, but much depend on the high pressure that moved over them to the northward. On at least one occasion a foehn bubble from the Carolinas moved eastward and northeastward and developed hurricane force. But let's pass on to other methods.

SURFACE PRESSURE CHANGES

The 24-hour change is still the only means available to eliminate the large diurnal changes in the tropics. Pressures have to be compared at the same hour of the day to be of any value, since corrections for the diurnal variations are not available. This has caused the general adoption of the 24-hour change chart, since in these the diurnal changes are eliminated, and we get a true picture of the magnitude of the actual change. There are times when very fast moving storms actually outrun the 24-hour changes, however, and the chart is of little value, but at any rate they are all we have except the isallobaric 3-hour changes which are sent from some stations. In evaluating the usefulness of the 24-hour changes, we have come to believe they are extremely valuable in anticipating hurricane formation. A concentrated 24-hour fall of more than three millibars is almost certain to indicate hurricane formation, but note the word concentrated. A widespread pressure fall of that amount or even more, that, for example, covers most of the Caribbean Area, may simply mean that a general collapse in pressure is taking place. Since all parts of the map are falling in about the

same order it is obvious that there is no single location where the air is being withdrawn faster than the others, but if the fall is concentrated and circular in form it is highly significant. This applies to storms of all sources or origin, or wherever located. It must be remembered that barometry is still not up to standard in most of the hurricane area. In a number of places aneroids of hoary age have not been calibrated in years. Their action, or lack of it, or uninterested observers, the results are trying. Great care and judgment are necessary on the part of the forecaster to weed out bad reports and properly evaluated the good ones. The erroneous must be discovered and discarded in our change charting, and only the dependable used. In many cases a single observer will make an error and his station will show a significant change. These can usually be spotted very readily, but if there is any doubt, it is best to have the readings checked or a new reading made. In other words, be sure your change is real, and for this, more than a single station report is usually necessary, unless the station is one that is known for consistency.

The isallobaric changes for three hours have some value in predicting future movement for the short term, and the rules are the same as for any moving pressure system. A word of caution is indeed here. Since hurricanes are generally slow moving storms, the diurnal changes may mislead you unless you have readings close to the storm are of more value in indicating development than in predicting movement.

PRESSURE PATTERNS AND CHANGES ALOFT

Much has been written about the value of upper level pressure charting. I believe we call them constant pressures, which differ slightly from the constant level charts formerly used. Different interpretations have been made by various meteorologists who have used them, but here again it seems to depend on where they got hold of the elephant as to what it looked like to them! Some have bound themselves in their thinking to the 10,000 ft., or 750 mb. level, as the answer to the whole problem. This has especially been true of some practitioners in middle latitudes. Experience has demonstrated that this is not to be depended on in the tropics. Later, various other levels have been used, or combinations of two or more emphasized. Still others would depend on the density difference between certain levels as expressed by the temperature. Recently R. H. Simpson has published a paper as the result of some research with these density difference between the 750 and the 500 mb levels. (Transactions, American Geophysical Union - Vol. 27 No. V, October 1946) He apparently found a very high correlation of movements in the direction of warm tongues as shown on these charts, but when we endeavored to use these findings in connection with the storms of the 1946 season, not a single one conformed, and the charts were of no value in forecasting. This should not be accepted as proof that they are of no value; quite the contrary. But it does warn us against a blind adherence to any constant level charting, or combination thereof. I think those charts are very valuable, but they have to used with care and discretion along with other analyses. It should be remembered that Rasonde stations are few and widely separated, and errors are common in the data. It should be kept in mind also that there storms build right up through the atmosphere to the tropopause at times, and they may even reach the stratosphere. Then surely we should blindly tie ourselves to a thin slice or two at some intermediate level. To do so merely fetters the mind, and blinds us to broader view of the picture in the entirety. We are likely to find that the storm won't stand hitched to our pet level(s). These storms are "rugged individualists" and have so far failed to comfort to straight jackets of whatever make. We must look at the entire picture insofar as it is possible, whether it be 10,000 feet or 60,000 feet. My advice, then, to hurricane forecasters is to keep free of hitching post for hurricanes. The storms probably won't understand that they are supposed to stay tied to the post, and you will be left behind!

Perhaps a longer period of experience and study will bring out more useful and usable methods of upper air analysis, and in the mean time I believe out constant pressure level charting should be continued and used for all it is worth. Out present method of taking four levels may be sufficient, but we must admit that the atmosphere consists of an infinite number of these levels or slices. Perhaps we are not slicing it thin enough and too much goes on between layers. This was, of course, Simpson's reasoning when he began to examine the differences in the thickness of the later between 750 and the 500 mbs (Opp. Cit.) I believe this is on the right track, but the difficulty here is that is does not represent all situations, as witness the total lack of conformity in 1946. He was looking at the density difference between only two layers, and they are quite a distance apart.

THE WINDS ALOFT

Robinson Crusoe was supposed to have soliloquized at length in his loneliness. Among other things he was supposed to have said "Home! what treasures untold abide in that heavenly word." This is not at all surprising for a man alone in his nostalgia. But if ever you hear the writer talking to himself about the third dimension of his hurricane forecasting, it will be a nostalgic longing for the winds aloft. Here is the upper air pressure in its entirety! (If winds are available.) Not just a few thin slices taken more or less arbitrarily 10,000 or more feet apart. In my opinion the winds aloft, taken to the height of 50,000 or 60,000 feet, comes closer than anything yet available to giving the forecaster the key to the situation. But before we dive off the deep end for winds aloft, perhaps it would be well to refresh ourselves on the preceding paragraphs about tying ourselves up too tightly to a single concept. But here there is a very important differences which I have already stated. We get a look at the movements of the entire atmosphere at internals of 1,000 to 2,000 feet up to 20,000, and at 5,000 feet levels thereabove. But we must have them all, and the only way to get them above the cloud decks is by means of the radar principle of the Rawinsonde. We must have them at least to the top of the vertical circulation of the storm we are dealing with, and storms vary greatly in the height to which they build up. A single storm in its progress may build up from 12,000 or 15,000 feet to 40,000 or 50,000 and later decline to lower levels. (This depends on depth to wind central pressure falls. See comments.) This requires constant vigilance, and limits the forecast use of the winds to not more than 24 hours in most cases. Some can be extended to 36 or even 48 hours with reasonable assurance, but at other times the forecast should be limited to 24 hours, because of possible changes in the height of the storm or in the strength and direction of the carrying currents.

But with full knowledge of its limitations, I believe I would trace practically all other forms of analyses for a complete Rawin chart. Give me the wind storm near the top of the vortex and a few thousand feet above, for in my opinion there is the steering current that is moving the storm along. Of course we use every other aid to analysis, orthodox or otherwise, but these upper winds furnish the answer the greatest number of times. No single level should be followed blindly, for the significant layer may be several thousand feet thick, and it may change with the depth of the storm circulation. If we will stop to think, the logic of this principle will strike us. Hurricanes are whirlpools in the stream, and their direction of movement must of necessity be governed by the broad flow of the main current in which they are embedded. Like all other forecasting aids it is necessary to use good judgment and common sense in using it; in fact, perspective, judgment, and imagination, are prerequisite to the complete understanding of any analytical process. The storm will move in the direction of the wind-stream prevailing from a few thousand feet below the top of the vertical circulation, to a few thousand feet above the top. Its speed of movement will be governed by the speed of this current, but due to the storm's velocity it will be less than the velocity of the freely flowing stream; roughly 60 to 80 per cent of it. It is better to use the winds far enough ahead of the storm to be sure to be outside the influence of the circulation itself, it these are available.

We should not forget the little matter of Coriolis force in our calculations. In the northern hemisphere, it deflects to the right things that are moving freely. Therefore, if a storm is moving in the easterly trade winds, for example, in latitude 20 degrees north, with the strength of the winds force 5 to 6 Beaufort (20 - 30 mph), coriolis force will cause the storm to move in the direction approximately 20 degree angle across the wind toward the north. If the wind force becomes lighter, the angle will be correspondingly greater, and if the wind is stronger the angle will be less. Easy, isn't it? But remember coriolis force varies directly with mass, speed and latitude. Just get your wind stream at the proper level, make a good rough estimate of what coriolis force, friction and centrifugal force will do, and shoot! (There is a tendency for air to be thrown out and piled up down stream and to right side of storms.) Well, perhaps it is not quite as simple as that, but that is the general idea back of my forecasting. It isn't always possible to have the necessary wind observation at the right height and covering the necessary areas, but neither are other data available in all cases in sufficient numbers. (Pressure data, observed or computed, can compliment winds because isobars and wind nearly same.) Wind observation in the immediate vicinity of the storm center are unlikely but if you did have them, you would not be sure that they were not in some way affected by the cyclonic circulation. It is better to sue points outside the immediate vicinity of the storm; 200 or more miles ahead are usually best. But more of this later.

CROSS SECTION ANALYSIS

During the recent war the armed forces established a number of radiosonde stations in the Caribbean area, which, with the aid of a few Weather Bureau stations, made it possible for the first time to prepare daily cross sections through the sub-tropics. By using the absolute altimeter correction as compared with a sub-tropical

standard atmosphere, aided by wind stream lines, R. H. Simpson in an unpublished paper, has shown some very interesting relationships of density patterns in easterly waves in the north Atlantic trade wind area. The cross sections have revealed patterns of density which were only suspected before, not only associated with the waves but with their transition unto hurricanes. These have been valuable for research purposes, and have added other concepts in our search for the physical and dynamic forces that make up hurricanes. They have also proven helpful in predicting hurricane genesis, but have not proven of great value otherwise as prognostic aids. By this type of analysis it was confirmed that most waves were of a stable pattern, with their axes sloping backward aloft. So long as the axis tilt of the wave was backward aloft, convergence and, of course, hydrometers associated therewith, were also to the rear of the surface position of the wave. When the axis assumed the vertical, and/or a forward tilt it was noted [that] the wave became unstable and the hydrometers extended ahead as well as to the rear, and hurricane genesis was a distinct possibility. We learned that we need not be much concerned with a wave so long as it tilted backward aloft, but when it assumed a forward tilt, it was the signal for intensive watch for hurricane formation. With the post war demobilization, a number of the Army and Navy stations furnishing data required for this type of analysis were closed, and while some remain, they are scarcely enough to continue the cross sections on a space basis. It is possible to make time cross sections for single stations which are of some value.

TIDES AND SWELLS

Cline in his book "Tropical Cyclones" was probably the first to show how tides and swells have value in hurricane forecasting. In later years others have written more extensively and scientifically about them. As time has given us other and better tools, the former emphasis on tides and swells as prognostic aids has become less. They are of considerable value, however, specially in lieu of better information. They have their greatest value in relatively closed bodies of water like the Gulf of Mexico and the Caribbean Sea, in connection with fairly large and well developed storms which produce a long fetch of the wind over water. Around Florida there are too many obstructions to a free movement to permit much benefit from the tides and swells. The Bahamas, Cuba and the Keys break up the swells to prevent a sufficiently long over-water fetch of the wind to produce them. The value of tides and swells lies, of course, in that the strongest winds of the hurricane creates long, heavy, swells which move faster than the hurricane system. They pass out of the storm area and far out ahead, indicating its approach when they reach a coast line. It will be seen that this requires open water and a long fetch of the wind free from obstructions. Not only the height of the swell is important, but the length. The hurricane produces long, heavy, swells; they will reach the shore at about the rate of four to seven per minute (in the Gulf of Mexico) depending on the intensity and closeness of the storm. If they are of shorter length not much importance should be attached to them.

Small storms, although they may be very violent, do not send out swells very far in advance. This is apparently because the area of agitated water is too small, and the winds do not have the long sweep necessary to create and send out the long heavy swells.

In Southeastern District, we have received only occasional assistance from tide and swell data. As stated above, the many islands and reefs upset them for most of Florida, while further north along the coast of Georgia and the Carolinas very few tide stations are available from which to obtain reports. Here the tide and swell data would probably be valuable, especially if the storm was moving toward the shore. In most cases, however, storms move up parallel to the coast in this area, and in that case, the strong-side wind and swells are off shore and of not much benefit. Generally speaking, therefore, we have come to depend on other means for storm information, and to that extent the tides and swells have been relegated to a secondary role.

CLOUDS

Carefully observed clouds can be used to supplement the winds aloft. The cirrus, alto cumulus which flow out ahead of the hurricane are particularly helpful since, in most cases, they will be carried along with the wind stream that is steering the storm. The difficulty arises from the wide variation in height of cloud formation in the tropics. The cirrus, for example, may be found at any level from around 17,000 feet to 70,000 feet, while the alto stratus may range from 7,000 to 20,000 feet or higher. We use the clouds to fill in the gaps in the wind aloft data where we think they are good. It must be kept in mind that cloud observations

are none too carefully made by our own trained observers, to say nothing of the untrained and careless with which we deal in much of the tropical area outside the States. The clouds are useful, then, as supplemental data, but should not be depended on too much. Furthermore, some storms do not send out cloud formations far in advance and we may find ourselves dealing with residual cirrus from ancient thunderstorms that are entirely too high and in a different air stream.

MICROSEISMS, LORAN (OR OTHER RADAR), SFERICS, ETC.

These, and perhaps others, are being experimented with in connection with hurricane detection and some have given promise of usefulness. Microseisms, for example, have been experimented with by the Navy for several years and promises helpful results in locating storms far out at sea with sufficient accuracy to aid in directing reconnaissance aircraft. None of these several methods have been sufficiently developed as hurricane finders or followers up to the time to warrant dependence on them without the aid of the more conventional forms of reports. Several uses are being made of the radar principle, such as assisting aircraft in locating storms within a range of 100 miles or so, and the rawinsonde method of obtaining winds and other data to great heights through clouds and otherwise. These are merely mentioned to indicate the never ending search for new tools and new methods. Out of these many come many other useful aids to the forecaster.

AIRPLANE RECONNAISSANCE

Although we have already mentioned the usefulness of aircraft in obtaining observations on storms, we feel that some additional mention should be made of the great assistance they have been to the hurricane forecaster since the beginning of their use during the war. The development of fast, sturdy planes for military purposes made it possible for the first time to venture into a hurricane with aircraft. The purpose here is merely to emphasize the continuing value of the airplane as an indispensable method of quickly securing a complete set of observations around storms. Their principal value so far lies in their ability to accurately locate the storm and indicate its intensity by the force and direction of the wind, or the control pressure, in daylight hours. No forecaster can do much at hurricane forecasting unless he knows where his hurricane is and how intense it is, and there is no quicker way to find out than with aircraft. This is a rather expensive way to obtain reports, but since the armed forces have the planes and the crews, and must keep them in training, part of it can be done in riding hard on hurricanes. In that way no additional expense in involved.

COMMENTS, DEDUCTIONS, & RULES

It will be noted that no new or radical interpretation or analysis has been mentioned in our dealings with hurricanes. The observations, their charting, and analysis, are the same as the conventional system used by all forecasters who have access to the data on the weather circuits. If anything, observational material at the hurricane forecaster's disposal is scantier and less reliable. He has vast stretches of ocean to analyze with, he hopes, the aid of a few ship reports. When most needed, the ships are usually conspicuously absent! The question then is, with the same data available to all, why can some individuals turn in a better performance than others? To answer is but to ask other questions. Is it not true that in every vocation or walk in life, some excel, while most remain in the realm of the mediocre, and still others fail? Do all graduates of art schools turn out Raphael or Hoffman masterpieces? Can all musicians using the same rudiments, notes, scales, time and tempo, compose operas like Wagner and Verdi or oratories like Handel and Mendelsohn? Do all doctors or medicine become equally skilled in the diagnosis and treatment of disease? The answer to these questions must obviously be in the negative. Despite the solemn preamble to our constitution, all men are <u>not</u> created equal, neither do they have the same aptitude, interest, energy, purpose or deductive powers. Some excel at one thing and some at another, even given equality of mental capacity and attainment. But the great multitude plot the broad road of the mediocre and never reach beyond the median line at anything. Weather forecasting is not exception. There simply is no such thing up to the present of divorcing the forecast from the man who made it, neither is there an objective short-cut to excellence. We have not, and probably never shall, make forecasts that are purely objective and systematic, regardless of the efforts and writing of some who would have us believe it desirable. It may be possible, although I do not think so, but if

there was such a thing as robot forecasting, there would still be the need for human intelligence back of it; the fact is, I see no reason to extract the subjective from our work, rather it seems both necessary and desirable. Forecasting is an ART based on a science, and that requires an artist as well as a slide-rule.

The questions I would want answered in the affirmation of our would-be hurricane forecasters are many. Is he so intensely interested that he would burn the midnight electricity digging at the job? Does he love the work so much that he willing to give it the devotion of his life? When the answer does not come easily by the ordinary analytical processes, will he hang on until the mind tunes itself to the infinite where it may receive an impression that transcends the natural senses? But you say this smacks of the mystics, the clairvoyant, the esoteric! No, rather I believe nine-tenths of it is intense interest and application. A lot of things will clear up if a man is willing to stay with them and apply the brains he is endowed with. Who was it who said that we all live far below our mental capacities? Try applying yourself with whole-hearted interest, for you may be sure that hurricanes are stern realities and not to be dealt with lightly. On one occasion a Great Teacher told his followers who had failed a hard task, "This kind cometh not out, except by fasting and prayer," and that is good advice for the fellow who is trying to figure out a hurricane. When you have used all powers you have, all the science you know, all the reasoning and deductive powers at your command, are you willing to say a little prayer for guidance and then make a decision and act on it? Do you hesitate to the point of vacillation and then become panicky? Again let me say this is no place for the timorous, the half-hearted, or the half-interested. We are putting our wits against the monsters of the meteorological world, and will need giant-killer stuff. The Hebrew scouts of Canaan reported back to Joshua, "The giants, the sons of Anak, dwell in that land and their cities are walled and very strong," and here also we have giant monsters of power to deal with. Are you willing to fall in the middle life, wounded in body and mind in the battles, with nerves unstrung by super-tension until the hands are palsied and the health undermined? Think these things over, you who aspire to hurricane forecasting. It may be the price you will have to pay if you expect to be a success. Do you think the small salary of a Government Civil Service Position will compensate you for all this, or do you look to other compensations? I know a man who stood before the pyre of hundreds of persons who died in a hurricane, while they poured gasoline over the bodies and set them on fire! They had been dragged from the muck of the Everglades in all stages of decomposition. Before this pyre, a man remarked, "If the Weather Bureau had warned us sufficiently, this need not have been!" This terrible indictment, even though not wholly true, was enough to give one man an incentive to strive to see that it didn't happen again in the future. The greatest satisfaction of my life comes when they tell me that since that day the casualty list has dropped to 3 per cent of what it was then! I hope to see the day when it will drop to zero. It can be done, but not unless some men determined in their hearts by the help of Almighty God that they are going to do something to make it so. And don't think the forecaster is the only man who has had a part in this. He is only one of many, but a very important and indispensable cog in the machinery, without which others could do little.

Now that several paragraphs have been used in an effort to scare prospective forecasters away from this field of endeavor, I can hear you say something about this purporting to tell how hurricane forecasting is done. Since I have had a measure of success, luck, or something, there are those who think I have the open sesame to the secret treasures. Sorry to be a disappointment, but you should have expected by this time that I do not have all the answers, even though I have avoided serious failures for more than a decade. Yes, the warnings have always been distributed to the right places at the right time through some stroke of luck or act of providence, but I know full well that those storms can out-maneuver me. Smarter men than I am have failed, so I remain a confirmed pessimist when dealing with them. The facts are, like all other forecasters worthy of the name, we use every scrap of information, and every known method, new or old, that we think might be helpful. We live with the storm and never for a moment relax out vigils. We try to see it as a whole, and analyze its several parts. We keep in mind the pressure pattern as a whole that forms the environmental field in which it lives and moves; the wind pattern at all levels, with the changes that are taking place or like to develop within the next day or two. Some will be found to be relatively simple systems moving straight away under a definite wind and pressure pattern that is not changing. These are very easy, but there are others so complicated, so buffeted by changing currents or opposing forces, that forecasting is very uncertain and trying.

As stated before I have uniformly had greater success with the winds aloft than all other information combined. I am prepared to say that the upper winds are my principal prognostic tool, and I know of no other that remotely approaches it. Like everything else it has to be used with judgment and common sense. Migrating disturbances in extra-tropical latitudes may cause changes, but these can usually be anticipated by several hours to a day at least. Not only the immediate hurricane vicinity is important, therefore, but the surrounding area sometime for hundreds, or even a thousand miles. Ordinarily the winds are not to be trusted for longer than 24 hours; on some occasions as long as 48 hours, but on numerous others you cannot be very certain for as much as a day. Furthermore, we cannot repeat too often that the best of rules are not to be used blindly. But, by the large, the winds aloft from a few thousand feet below, to several thousand feet above, the top of the hurricane circulation is the steering current. Then take into account coriolis force, and you have the best method I know to predict hurricane movement.

Come to think of it, this is so elementary that I learned it from Waldo's Elementary Meteorology in preparing for the Junior Observer Examination about 35 years ago! Waldo wrote in the 1890's that a hurricane trajectory was the resultant of two forces, viz, the wind stream in which it was embedded, and the rotational effect of the earth or angular momentum, which caused free-moving objects to turn to the right in the northern hemisphere. We call that rotational swerve to the right, Coriolis force, and after figuring for a while we come up with some rules about it. It was found to be directly proportional to the Mass, the Velocity, and the Sine of the Latitude. Now supposed we take a well-developed, average size hurricane moving in the trade-wind stream in about latitude 20 north (a cylindrical parcel of air) driven by a wind stream force of the order of 5 or 6 Beaufort from the east. A rough figuring of Coriolis force, acting across the wind toward the north, or right, will give a movement of the storm an angle of about 20 degrees across the wind. If the wind slows down, the Coriolis angle will increase proportionately, and if the wind speed is greater the angle to the right will be less. Then supposed the storm recurves into a southwesterly wind stream in higher latitudes. Here Coriolis force has had its full effect in diverting the wind stream itself, so that regardless of the higher latitude and the increased mass, we will probably find both storm and wind moving in about the same direction. This has been observed to happen in a number of cases, and should be taken into account after recurvature. In lower latitudes, Coriolis force is weak, and may be easily overcome by gradient and other factors.

With the increase in upper air observations of wind and pressure by the Rawinsonde method, we have gained more confidence in them as steering principles, because we have been able to see the complete picture. Our former theories and suppositions have been verified in a most gratifying manner, and we have been amazed at the way storms have been guided by currents as high as 30,000 to 50,000 feet. The first really large, fully developed hurricane for which Rawin data were available in sufficient numbers to provide a fairly complete view of the entire structure, was in October 1944, when we surprised ourselves by being able to predict the movement right through a surface high pressure area. This high extended to a height of about 15,000 to 20,000 feet right across the path of the storm. It was guided, however, by a stream that topped the high at 20,000 feet and above. With the aid of these higher winds we were able to predict the movement with great accuracy, to the astonishment of many of our associates who were watching it with us. We were very uneasy that our partially substantiated theories would not work out, but when it was over, it could be seen that the movement so completely conformed to the wind-stream near the top or the vortex that it was absolutely uncanny. The rule that we had used in a limited way with other storms, including extra-tropical cyclones, was so completely verified that I became a confirmed "wind jammer", if indeed I had not been all along.

In September 1945 another hurricane (the Turks Island-Florida storm) gave such a good account of itself in following the wind-coriolis rules that for the first time in my career I ordered full hurricane warnings on a definite and limited section of the Florida Coast when the storm was nearly 400 miles away, and fully 24-hours ahead of its arrival. The actual place where the centered reached the coast was only about 30 miles off the calculated position made 24 hours previously, and the warnings verified perfectly since we had included a slightly wider section of coast to allow for possible error. Since our experience with the high-level winds had been limits, we refrained from making a definite statement as to just where the center would strike, but actually it was about 30 miles north of our calculated position due to slight recurvature beginning a little sooner than expected. It we had provided for a little increase in coriolis effect due to lighter winds on approaching Florida, even this slight error might have been foreseen. This was a fast-moving, small, but very intense hurricane. It will be remembered as the one that caused the destruction of the Navy's Lighter Than Air Hangars at Richmond, Florida. (See Figure 1. Map Series)

The closing of a number of Rawin stations operated by the armed forces because of demobilization at the end of hostilities, left us with only a few Rawin Observing Stations for the 1946 season. But with the confidence gained in the two previous seasons, the storm of October 1946 (Cuba-Florida) was predicted on the basis of observations from but two Rawin Stations, Havana and Miami. With the air of a Rawin Map 6 hours previously which gave us a better coverage, plus a trajectory giving accurate locations of the center for three 6-hour intervals, - (a total of 18 hours history) - the prediction was made at seven o'clock in the morning that the center would move into Florida in the Tampa Bay area at midnight. This was only 17 hours in advance, but the result was a perfect bull's eye that left some of my associates gasping for breath! (See Figures 2 and 3, Map Series). Actually the calculations - all mental - consumed about 10 minutes. I checked with the observer who made the Miami rawinsonde and he told me he would guarantee the wind direction was accurate at all levels, but that the reported velocities were doubtful above 10,000 feet due to the smallness of the elevation angle. Too bad, now I could not do much on figuring acceleration, but the direction could be trusted. A brief study of the wind charts 6 hours previously showed a strong wind from the south at all levels above the hurricane with a slight veer to south-southwest at about 20,000 feet and above, the estimated height of the vortex. The movement for the 18 hours was straight away at an angle of about 10 to 15 degrees to the right, into the wind, which became less aloft - just about right for coriolis force. The

mass was increasing and there were indications of acceleration in velocity; the latitudinal increase in moving northward would be small and largely canceled by gradient. The conclusion - NO CHANGE IN DIRECTION. The trajectory was extended in a straight line to the Florida Coast at Bradenton at the south shore entrance to Tampa Bay. The forecast: - "The center will enter Florida west coast in the Tampa Bay area about midnight". The center missed Bradenton by about 10 miles, and in fact, it was in the edge of the calm center - at midnight!

Too good to be true you say, and I frankly admit it. That definite language "will" took a lot of nerve and left some of my fellow workers with popped eyes and short of breath, but in this business you have to de definite. There are several million people with their ears glued to the radio listening for what we have to say. Their lives and property are in danger and they are depending on us. Our language must carry the impression that we know what we are talking about, and out voice over the radio must be free from excitement or hysterical inflection. All forecasters know there is no such thing as 100% certainty in our work. There has always been a margin of error in predictions of whatever nature, and in weather we know this weeoe is around 15%, so the only thing to do is screw up enough nerve to make a definite statement, rather than equivocate. We certainly cannot always be correct in out forecast, and there are many occasions where it would be impossible to even approximate this accuracy, but I feel that the people in our district deserve the best we can give, and in language they understand. Indefinite phraseology or any tendency to vacillate, creates the impression that you are not certain of yourself, and people become confused and panicky when listening to you. We keep reminding ourselves that there is not one else who knows any more about it than we do, and we must be specific even if we miss. We must see to it that we do know as much as possible about these storms. I had rather "strike out" any time than fumble with the bat and finally be "called out".

I have never gotten to the place where I can relax or sleep after I have issued a hurricane warning until it is over. The nerves are taut as fiddle strings and relaxation is impossible, there is too much at stake. Every observation, every deduction and calculation, every statement issued, is burned indelibly into the mind. When I close my eyes they are turned over a thousand times in the mind. Did I figure this factor right? Was full importance given to this observation? Did we place the warnings over the right area and cover every known contingency? Did we say the right thing to produce just the right amount of action to save life and property, without creating hysteria or scaring people to death? I hope and pray that nobody gets killed because I failed to warn them sufficiently. There is no sleep or relaxation here! Well, I'm just plain scared that I may miss. The only consolation we have at a time like this is in a knowledge that we have done out very best, and if we have done less than that, an accusing conscious may add to our mental torture. If we fail, a confused and hysterical populace will have no mercy on us... Who was it who thought he saws only glamour and publicity and a soft job, and so wanted to become a hurricane forecaster?

DIFFICULT CASES

If we must concede that we are not completely certain of our forecast when the storm presents no unusual difficulties, what must we say of those that seem to be possessed of the Imp of the Perverse? There have been many of the difficult type in the past and we have every reason to expect them to plague us in the future. Perhaps the reason we have been successful to a considerable degree in recent years is because of the nice behavior and cooperation of the storms. What, for example, could we do with the loop hurricane that twice swept over the Havana-Key West sections in October 1910? Many others have been just as difficult. The hairspin storm of October 1935 which moved northeastward from just north of the Canal Zone to eastern Cuba, only to reverse itself and move southwestward into Honduras, and others we could mention. Frankly we do not know how our rule would apply to them. It is possible, if we had the full picture, we might be able to see the reasons freakish movements, but I do not want to jump to the conclusion that they were simple of solution. This would be very kind of fallacy I have been trying to guard against; over simplicity.

There was the case in 1920 when a hurricane moved up from the southeast and stopped in the vicinity of Nassau and lingered for about 72 hours before it finally turned slowly to southwest and passed through the Florida Straits and over the Keys. Imagine the state of mind of the people on the southeast Florida coast with a hurricane stalled on their very doorstep for three days! But worse, what condition do you thing the forecaster would in by that time? I feel sure that if he was in Miami he would be either dead or a fit subject for a padded cell! But these difficult storms are our lot along with easy ones that move straight away and pass on. Wonder how our wind formula would have served us in this case? Of course we cannot tell, since we did not have the complete wind picture at the time. Perhaps it would have worked if we had had sufficient reports to see the entire picture, but a storm becalmed within a few miles of a hurricane hotspot is a prospect I do not covet!

SOME IRREGULARITIES DUE TO TERRAIN

In the more or less landlocked Caribbean area, hurricanes come in contact with laud friction when passing over islands, which has marked mountains the wind circulation of the western semicircle us broken in the first few thousand feet by the mountain range, while the strong side winds sweep unobstructed over the flat country to the east. The result is an interference with the completion of circular rotation of the winds about the center, which stretches or distorts the vortex out of symmetry. It becomes elongated or otherwise distorted out of shape, and on some occasions it has seemed to be torn apart for a time. This will appear to cause a wabble, hesitation, or change in direction as the center emerges into the Florida Straits. If the storm is moving under a good live wind stream, the center will not be much changed in course, and the symmetry may soon be re-established but if the movement is slow the distortion and wabble may cause the center to make a loop to the left. This looping occurred in the October 1910 storm, and smaller loops in several others crossing at this point. Of course, we do not have the upper wind data to verify just what happened in 1910, but we believe this loop was aided by a sluggish upper wind movement, or perhaps a temporary change in direction. Since I am confirmed "wind jammer", I am persuaded that if you have all the wind streams that bring their forecasts to bear on a storm, the answer will be found in them.

In the past some have emphasized pressure systems, particularly high pressure areas, as the controlling factors in hurricane movement. In bringing this paper to a close, I call your attention to the fact that no conflict with this concept is here made ot intended. The wind is a product of pressure and temperature, so that pressure patterns and wind streams are interchancheable one with the other. In fact where we do not have upper winds to sufficient heights and can have the pressure, either by observation of computation, we use the isobars in lieu of wind streams. But remember the significant levels are those near the top of the circulation and just above, regardless of what the surface pressure-wind pattern may be... So, whatever has been said about hurricanes being steered by pressure-wind systems, (Bowie's concept) is just another way of saying they were steered by wind-streams produced by the pressure systems, and don't forget that the pressure-wind systems controlling the storm movement may be 25,000 feet aloft, or even 50,000 feet, and the lower levels may be without appreciable significance.

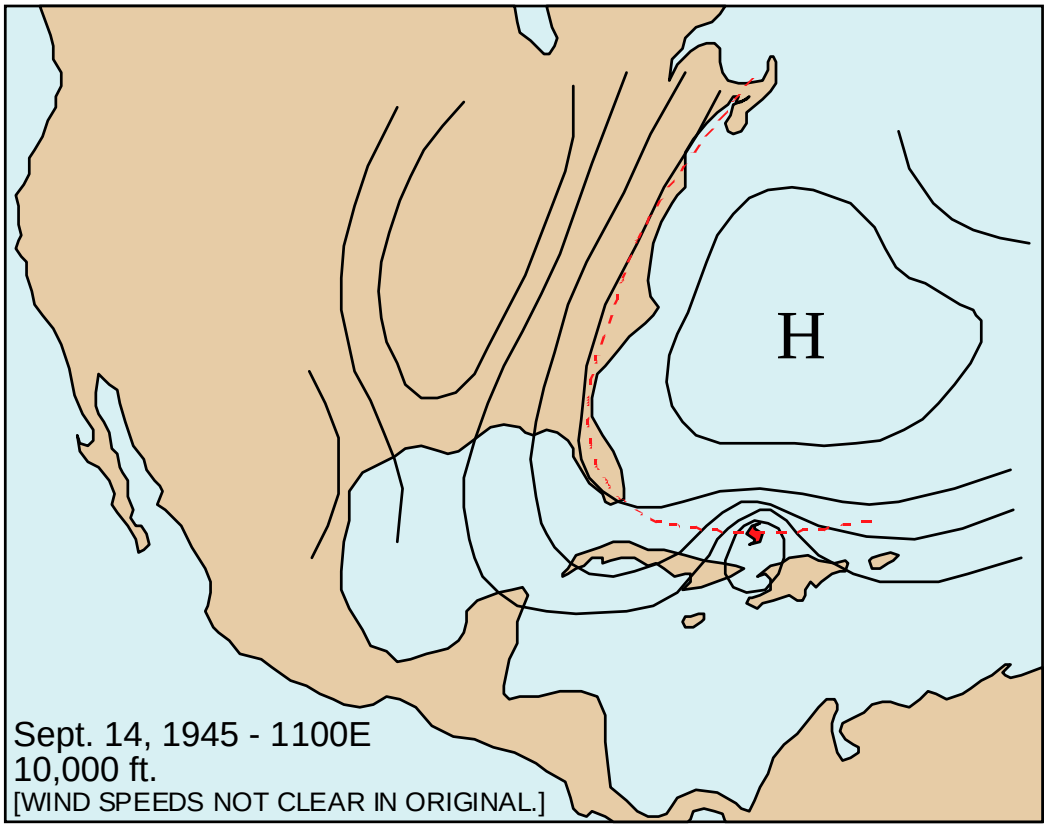
The following is quoted in part from the conclusions of Bowie: (Bo**wie,** E**. H.,** MWR**,** Vol. 50, April 1922). He asks:

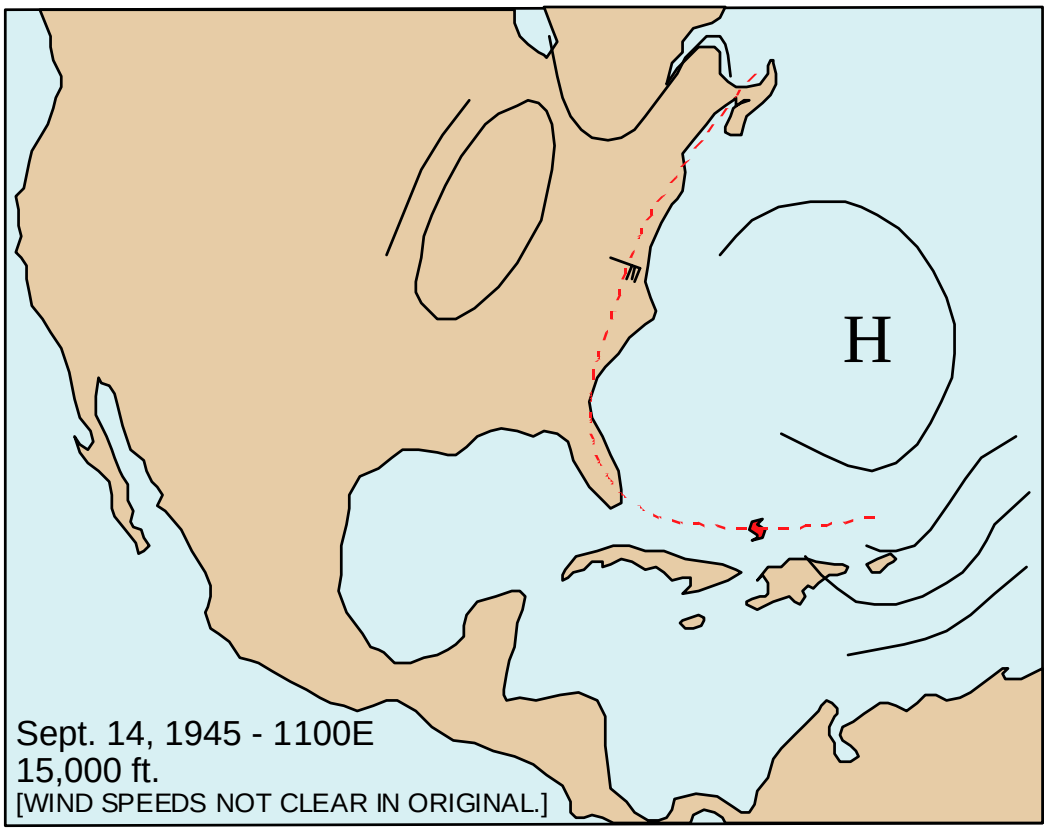
"Disregarding the internal mechanism of the hurricane, are we to assume that the 'general drift of the atmosphere' which carried the hurricane onward, prevailed over the area occupied by the hurricane? Or are we led to assume that the right semicircle of the hurricane was involved in a major wind system flowing along the isobaric system, of the adjacent area of high barometric pressure to the northward, and that it was this wind system that carried the hurricane along its course?"

He left his questions largely unanswered but both are right?

This attempt to say something about hurricane forecasting, certainly will not, and should not end the research for better understanding, analyses and forecasts. The next generation of forecasters should build on the work of those of us who have laid the foundation for a real hurricane service. We have set the pace, but those who come after us must go on to greater perfection. There must never again be a backward step, but let the Weather Bureau lend greater effort and more attention to seeing to it that never again will people have any reason to condemn us for lack of an adequate warning service. Our efforts may seem puny indeed a few decades hence, and that is as it should be. Men with better equipment and better training should build on the foundation we have laid in "blood, sweat, and tears," until the ultimate of perfection has been reached.

Figure 1. Charts for 10, 15, 20,25 and 30 thousand feet showing how hurricane moved with windstream. Little change with elevation in this case. Sept. 14, 1945, 1100 E..




H
Sept. 14, 1945 - 1100E
15,000 ft.
[WIND SPEEDS NOT CLEAR IN ORIGINAL.]

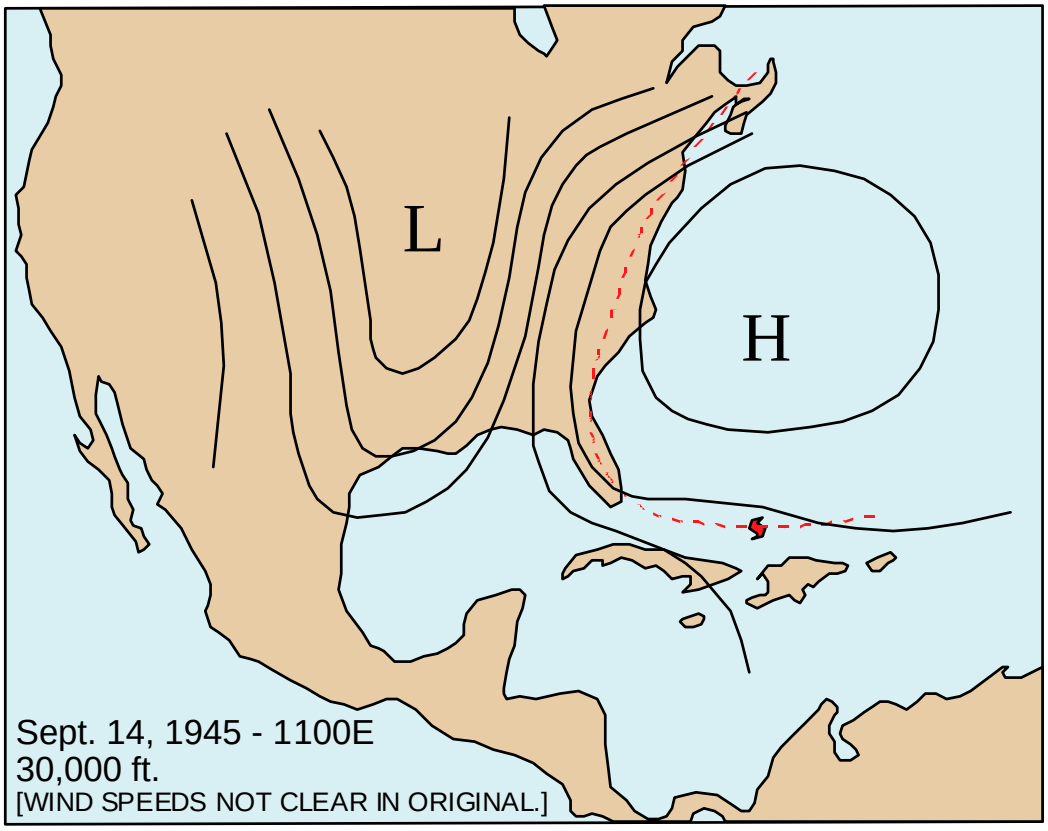
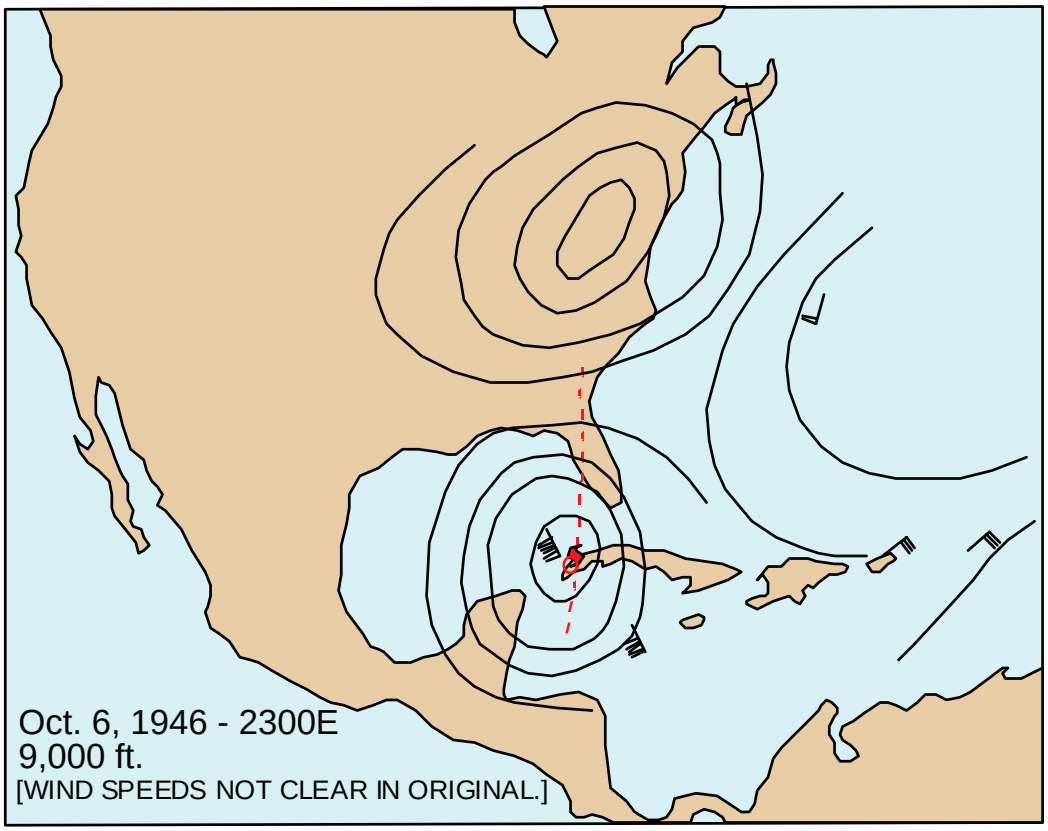
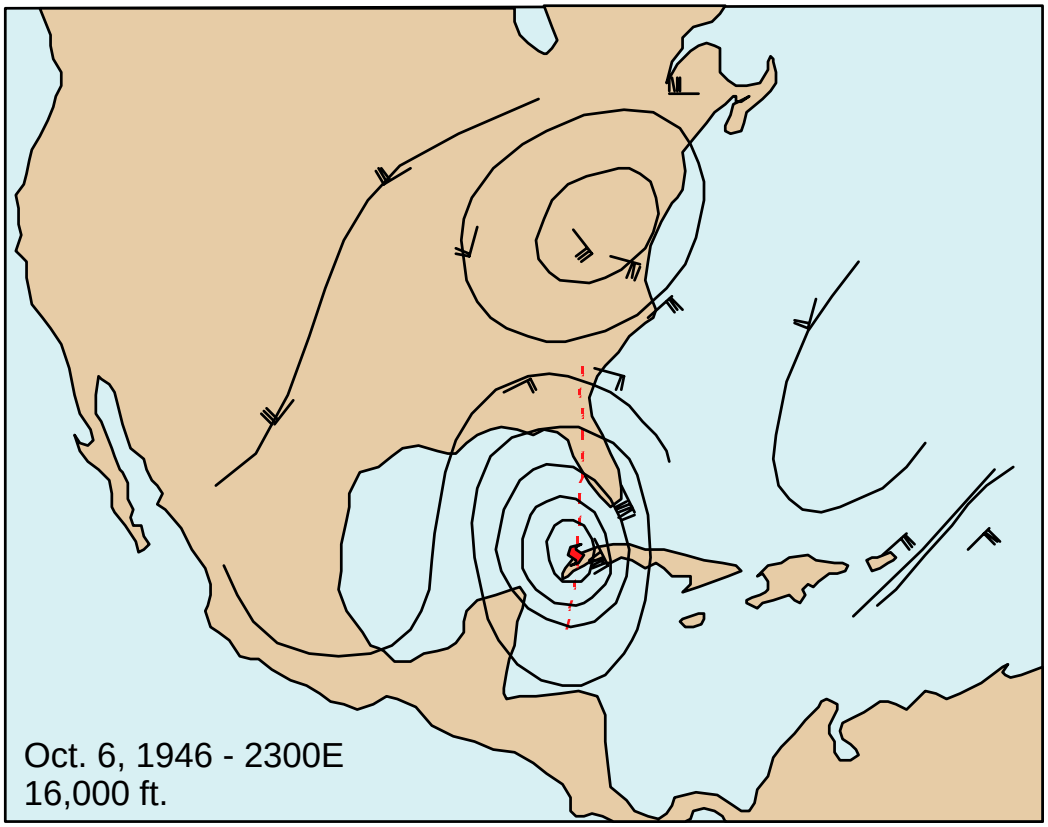
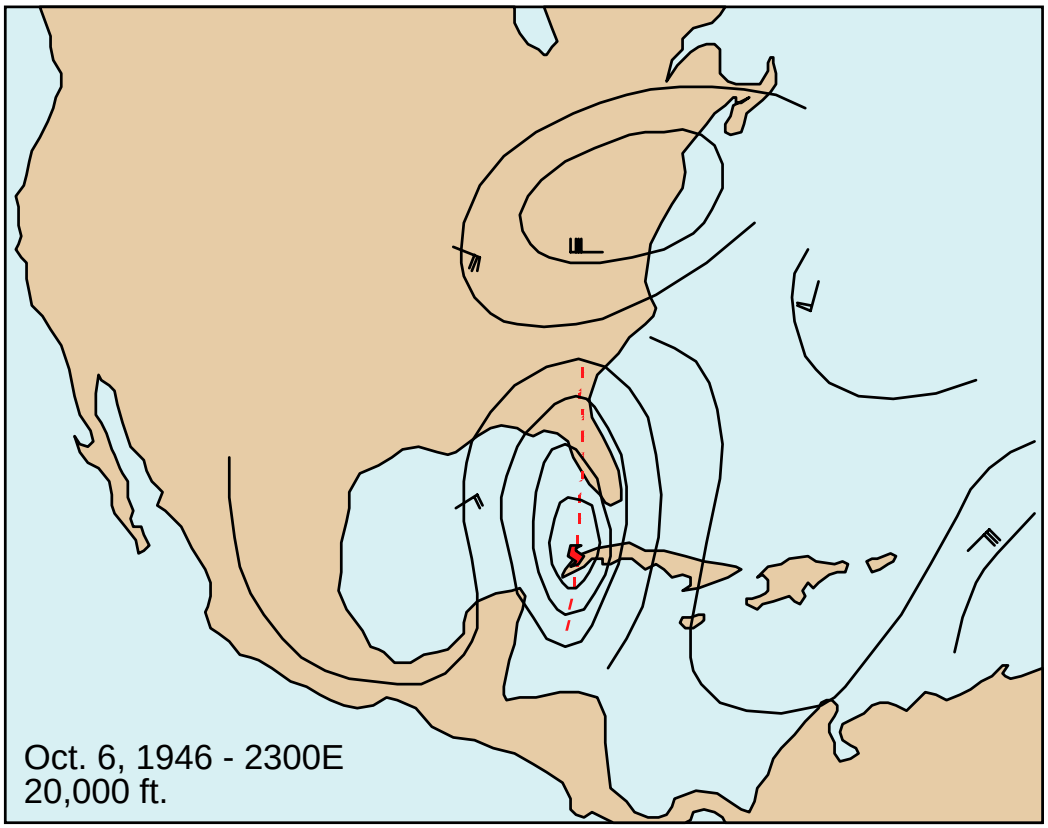

L
H
Sept. 14, 1945 - 1100E
30,000 ft.
[WIND SPEEDS NOT CLEAR IN ORIGINAL.]

Figure 2. Charts for 9, 16, 20, 25 and 30 thousand feet showing how hurricane moved with windstream at higher elevations. (Not much except for 20,000 feet and [NOT READABLE].) Oct. 6, 1946, 2300 E..




Oct. 6, 1946 - 2300E
16,000 ft.


Oct. 6, 1946 - 2300E
20,000 ft.


Oct. 6, 1946 - 2300E
23,000 ft.
[WIND SPEEDS NOT CLEAR IN ORIGINAL.]

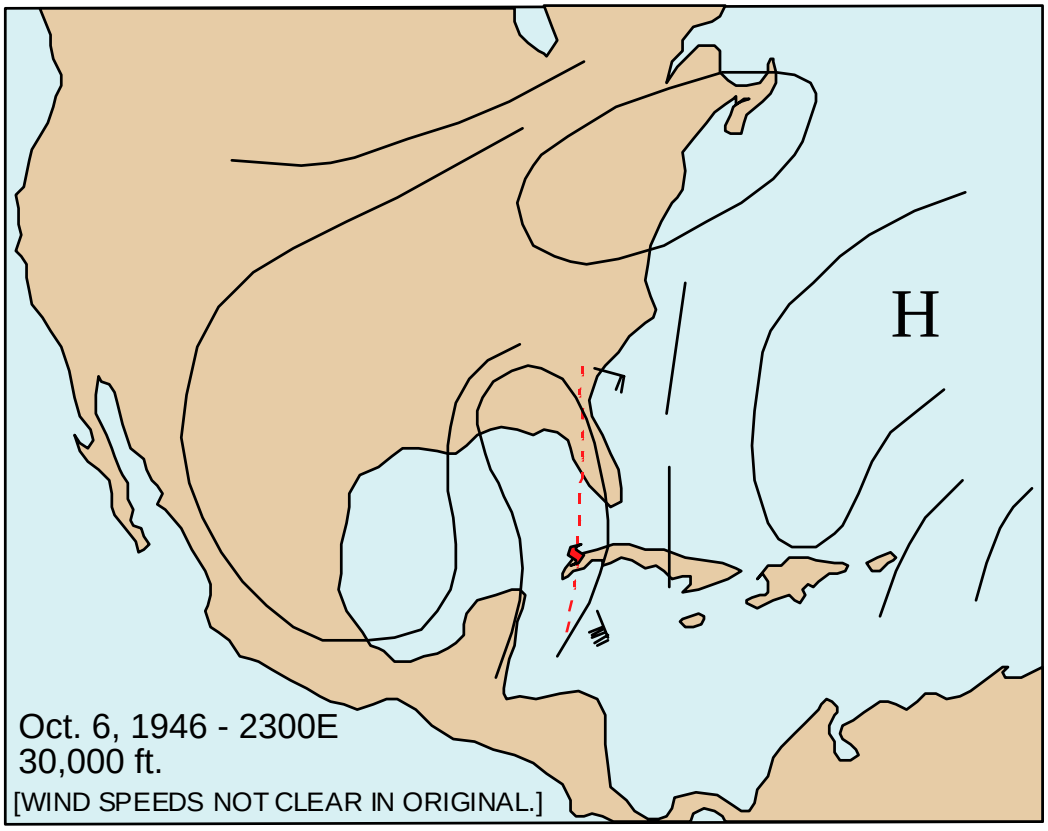
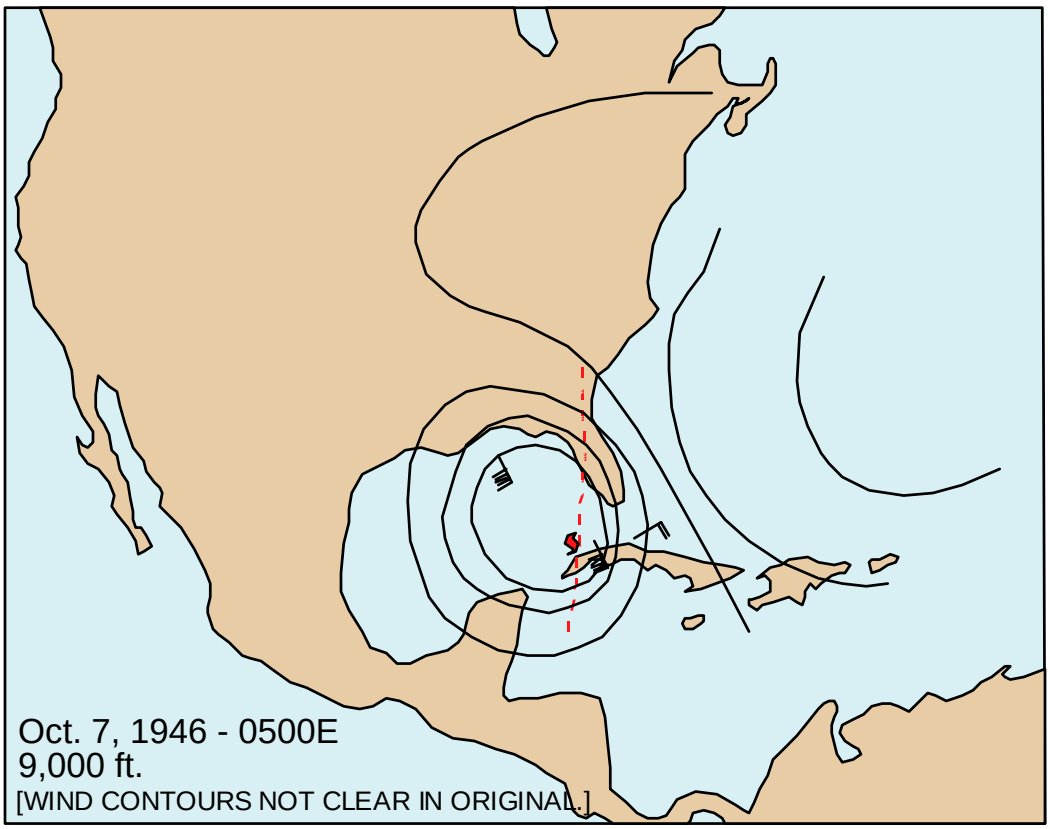
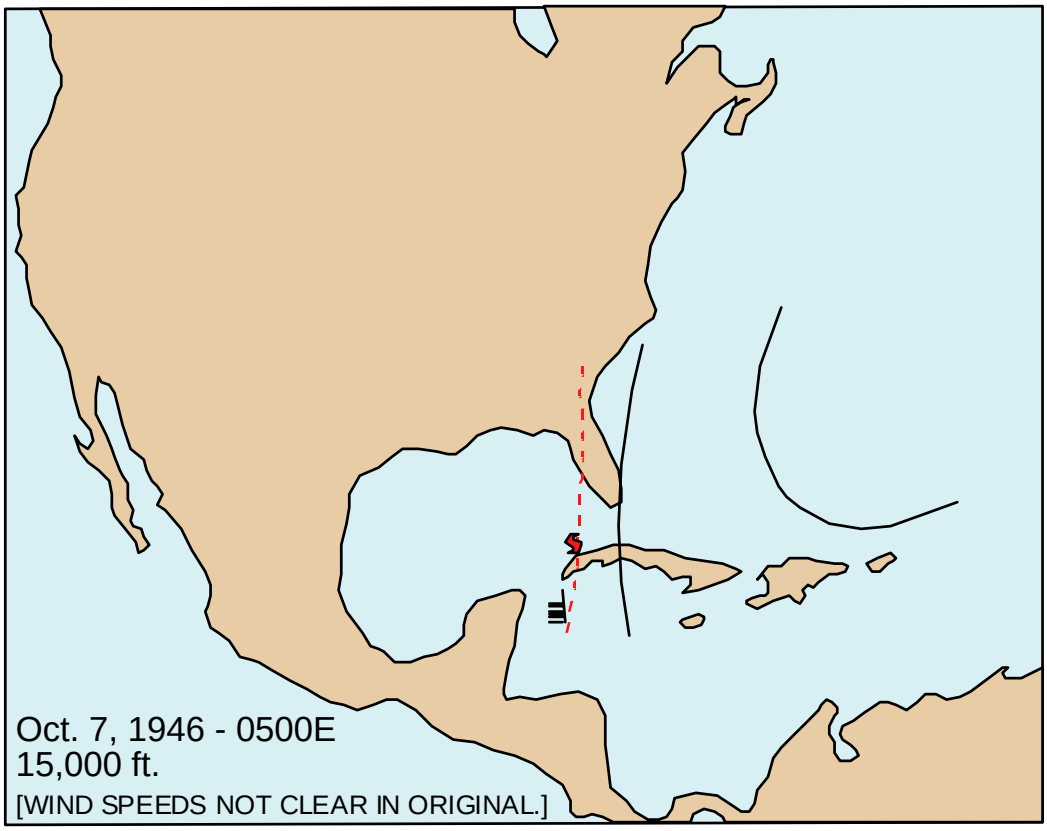

H
Oct. 6, 1946 - 2300E
30,000 ft.
[WIND SPEEDS NOT CLEAR IN ORIGINAL.]

Figure 3. Charts for 9, 16, 20, 25 and 30 thousand feet six hours later than Figure 2 showing meager data, but few stations indicate no change from previous map. Oct. 7, 1946, 0500 E.



Oct. 7, 1946 - 0500E
9,000 ft.
[WIND CONTOURS NOT CLEAR IN ORIGINAL.]



Oct. 7, 1946 - 0500E
15,000 ft.
[WIND SPEEDS NOT CLEAR IN ORIGINAL.]


Oct. 7, 1946 - 0500E
25,000 ft.
[WIND SPEEDS NOT CLEAR IN ORIGINAL.]


Oct. 7, 1946 - 0500E
30,000 ft.
[WIND SPEEDS NOT CLEAR IN ORIGINAL.]

ADDENDUM

ON THE PREPARATION OF HURRICANE ADVISORIES

FORM OF ADVISORIES

A. Summary

1. Holding: Date, Miami Weather Bureau Advisory No. - 0930E

2. Paragraph I: Description and forecast. (Warning hoist order comes first if any are issued.)

3. Paragraph II: Precautionary advices.

4. Paragraph III: Area covered by warning displays and/or changes thereof.

5. Paragraph IV: Transfer of responsibility to next center (when required).

6. Subscription: Forecaster's name followed by Weather Bureau, thus: Norton Weather Bureau.

B. Terminology

1. Description

   a. Classification:
      1. Tropical disturbance (slight or moderate gale intensity)
      2. Tropical storm (winds of gale force less than 60 mph)
      3. Hurricane (over 60 mph when there is any likelihood of higher velocities - whole gale warnings are not issued in connection with tropical cyclones) (76 mph and above technically)

   b. Location:
      Latitude and longitude in degrees and tenths and also some well known land reference point (distance and direction from)

   c. Direction and speed of movement:
      Cardinal points and miles per hour

   d. Size of storm or area of destructive winds.

   e. Highest wind and lowest pressure (if known)
      Cardinal points and miles per hour

2. Forecast

   a. [CROSSED OUT IN ORIGINAL.]
   b. Coastal and island areas to be affected in next 24 hrs.
   c. Time wind will begin to increase on coastal points.
   d. High tides and danger therefrom.

3. Precautionary measures

    a. Advice for evacuations, sheltering of small craft, aircraft, etc. (Boarding up terms)
    b. High winds and high tides for specific locations.

4. Recapitulation of warning displays

PUBLIC RELATIONS IN THE HURRICANE SERVICE

The "Manual of Instructions for the Hurricane Warning Service" WB. No. 1324 (as amended by Cir. 81-43 and 93-43), contains detailed instructions on the form of advisories, alerts, bulletins, and warnings. This manual is rather out of date, since the last issue was in 1941. Quite a number of changes and additions have been introduced since that time, which have been issued in the form of multiple-addressed letters, amendments, etc. It is out understanding that a new, up-to-date manual is in process of compilation, and will be available for the coming hurricane season. In the mean time the examples of form and composition have undergone a number of changes and improvements. It is not the purpose of these comments to assure the prerogatives of the administrative in prescribing the manner in which advisories are to issued, such as timing, paragraphing, etc.

But regardless of the form that may be prescribed in the manual, there are a number of things that go into a good, effective, advisory that must rest with the forecaster who is preparing it. The Central Office may prescribe the general form, paragraphing, timing, etc., but it is the forecaster who chooses the words and phrases that go into the composition. Up to this time, at any rate, it is the forecaster's privilege to use his own selection of words. I wouldn't be surprised, however, if this being more and more prescribed all along and we can never be sure what turn it may take next! Then, we should take advantage of this precious freedom while it is still available to us.

When you sit down to write an advisory, alert, or warning, it should be with the purpose of making yourself clearly understood by the people who are to receive the advice and act upon it. We should not write for the professional meteorologist, because if they are interested they can study the weather man and form their own ideas, and can theorize or discuss it in all its beautiful technicalities. When we write an advisory, there are a few rules that should be constantly in mind:

(a) Use simple words and sentences.
(b) Be straightforward.
(c) Be brief.
(d) Avoid technical expressions.
(e) Make warnings explicit.
(f) Avoid sensationalism.
(g) Be factual.

The appeal of simple words and sentences is amply attested by the great popularity of such publications as TIME MAGAZINE, READERS DIGEST, and others. In these we have a style and sentence structure so simple and easily understood that it can be read by the relatively uneducated sixth-grader, but at the time it is perfectly understandable to the professor of language or the doctor of philosophy. Everyone can understand simple, plain, language, but if we affect a stilted, scientific style, expressed in long and involved sentences and ten-dollar words, we lose a large part of out listeners. They simply do not know what we are saying, or they get it mixed and garbled over the radio, and pretty soon you are flooded with a lot of misconceptions and wild rumors. In writing a hurricane warning or advisory, write it for the person with a sixth-grade education and you can be sure of being understood. Hambone once said: "I sho do like dat new person 'case he put de fodder down where the calves can reach it". Our advisories should be put down where the humblest, most illiterate fisherman in the remotest fishing village will have no difficulty understanding us. It is our job to be of service to all the people in helping them save their lives and property. Those who feel the urge to give graduate lectures on physical and dynamic meteorology, had better confine themselves to the lecture stage or the classroom. And remember you will have a chance to use your calculus and your thermodynamics in research papers after the storm is over! That field hasn't been exhausted yet.

Then we should be straightforward in our expressions. There is no place for the ambiguous and the obtuse in a hurricane warning. We should endeavor to make them carry punch and conviction by using words and phrases that arrest the attention and male an impression. Think of the fellow out there with his ear glued to the radio, and write so he will understand. Try to separate any quantitative statements by several phrases or sentences if possible. I once saw an advisory (I don't think I wrote it) that read about as follows:

"A hurricane 200 miles in diameter is moving northwestward 20 miles per hour with center about 175 miles east of Nassau attended by winds of 100 miles per hour near center."

What do you think the average radio listener's impression was?! He had the storm moving 200 miles per hour, or was it 125, attended by winds of 175 miles an hour, or was it 200 miles per hour, and it was 25 miles

from Nassau and would hit Miami before noon! Hysteria followed this garbled mix-up, and near panic ensued. Now, suppose you had separated all those values by a sentence or two. The chance of confusion would have been practically eliminated. It is a good habit to make liberal use of the period. Don't try to say too much in one sentence. Make them short but make them draw fire. It is a good habit to avoid "probably" and "possibly" and "maybe" and learn to say "will" and "is" and "dangerous." The former are fuzzy and full of uncertainty, while the latter sizzle with meaning.

Wonder if that old bromide would stand another repetition? I know it is threadbare and should not be displayed in good society, but "brevity is still the soul of wit" and a lot more beside. Beside being the retort amusing, it is the way to write hurricane advisories that carry conviction and understanding. And besides, it saves a lot of time and telegraph money! It is true that we are not concerned very much about what it costs to distribute our warnings, since there are plenty of funds to take care of that, but are very greatly concerned about the time required to get the information to the recipient over all kinds of communications channels. We should not sacrifice clarity and completeness in order to shorten the advisory or to save telegraph expense, but you would be surprised how effectively you can say the same thing better many times with half the words. Someone has said the three rules for writing and speaking are: "Have something to day, say it, and quit!" Or, as the late President Roosevelt out it: "Be sure. Be brief. Be seated." Should I remind you again that you can write that long-winded dissertation on tropical cyclones when the storm is over? A short advisory on warning can be prepared that will express the essentials and all necessary protective advices just as well as a long, tiresome one. Then, I suggest you write it down , then get your blue pencil and go to work on it and see how much dead wood you can prune without damage. I think you will be surprised.

The use of technical words or expressions that are common parlance with the profession, may be entirely over the heads of the average layman. Mention has already been made about the necessity for simple words and short sentences, but it will bear repeating. We should constantly guard against the little-understood scientific terms. This may be rather hard for the newly graduated, who has had intensive training in the use of the language of the profession and thinks all men should understand meteorological terms. Every profession has it Glossary of technical names, expressions, and so on, and they are perfectly understandable to the fraternity, but Greek to the outsider. There is not better way to be misunderstood, or to bring down the wrath and ridicule of the public and the newspaper editors, than to parade your professional jargon in time of a hurricane. Come down off the high horse and tell the people there is a hurricane coming and that they should take emergency measures at once to protect their lives and property. That is language they understand. Never mind the why's and the wherefore's, the theories and the dynamics. There is enough dynamics in the one word "hurricane" to freeze men in their tracks!

I went to a doctor of medicine for an examination. I wasn't feeling well and couldn't walk very good because of pain in my hips. After throwing his whole laboratory at me and grunting mysteriously a few times, he said:" You have arthritic changes in your sacro-illiac articulations and neuro-esthenic circulatory myocarditis!" I got to feeling much worse immediately and began to think about making a will, but then I had a bright idea and asked him to explain that in English. He said:" Well, you have rheumatism in your hip joints and nervous strain has caused a tiredness of the muscles of the heart." I understood that and decided to postpone the purchase of a lot in Resthaven Park!

The advices and warnings should be explicit. There should be no equivocation or vacillation. It is admittedly true that we cannot be certain of ourselves in all cases; the element of error in our predictions is well known to all of us who have tried to forecast. But in this work, the stakes are too high, and the menace to life too great, to vacillate or side-step, or hedge. Remember that fellow out there whose name is legions, with his ears to the loudspeaker depending on you for information and guidance. His life and property are in danger and he is depending on you to tell him in crystal clear language just what the situation is. Cultivate an attitude of assurance and certainty in your advices that will inspire confidence. (But you'd better be right as well!) If you are not sure in your own mind, don't let a hint of it find its way into the advices.

I visited a fishing village in one of the remotest places in Florida. It was 50 miles to the nearest settlement. When my identity became known, they said "We gathered around the radio and kept listening to you during the storm. The water had risen six feet and was lapping up between the boards of the floor and the wind was estimated at 60 mph, but when you said the center of the storm would pass us and it wouldn't get any worse here, we went to bed and to sleep." Think, forecaster! Such confidence must not be betrayed. Not only is the remote fisherman depending on you, but great corporations and businessmen, and men of all walks of life. Be explicit.

Study to avoid sensationalism like a plague. The people are on tentions enough at best when there is a hurricane around. The newspapers will blare news about it in great headlines and play it up in spite of all you can do, but in our advices we should assume an attitude and style of quite dignity and calm expression. There is a great temptation to throw the book of blood-curling adjectives at them; the occasion seems to

demand it. But you will recall that a sensational statement by a certain radio commentator in a time of world tension, precipitated a panic in the stock exchange. We do not want to inspire panic and hysteria by our statements, but rather to calmly advice and warn the people, like it was something that should be taken in stride. In order to do this the forecaster must remain calm himself and free from exciting or hysterical influences, and he must know what he is doing so he will not get panicky himself. A good way to do this is to get your warning out well in advance.

PUBLIC RELATIONS IN THE HURRICANE SERVICE

The definition of "Public Relations" was asked of several of the best public relations men of my acquaintance, and to my surprise not a single one had a ready answer. The general ideas expressed about it might be summer dup as "The Great Intangible Asset," which in turn is composed of a myriad of lesser intangibles. It seems to me that it is these innumerable things that causes the other fellow to have good will for us and respect our integrity and honesty of purpose. At any rate, whatever goes into the making of good public relations, they constitute about half of our battle. I have frequently said that I believe our work consists of a high standard of warnings in the first place, and then good Public Relationships to complete the job. General Electric makes a good refrigerator in Erie, but I venture that most of them would stay in Erie if it were not for the pleasing advertising carried on the printed page and over the radio, and the salesmen throughout the nation who are all too well prepared to demonstrate the excellent advantage inherent in them to the housewife.

Then, our first concern is to produce a dependable product, that will inspire confidence. This is essential, and if the Weather Bureau is to retain the good will and cooperation of the public we must continue to put out a product that has a high standard of excellence. But then comes the selling job, or the Public Relations. But in reality, the first requirement is a high standard of accuracy in our advice and warnings. If we go to the people with a poor product, poorly presented, and not of any certain value, we cannot expect confidence and good will. Naturally, we will meet sales resistance to an inferior product, despite all the efforts of the salesman.

Next, after being assured of a dependable product, I would want to understand something of the psychology of the people I am going to sell it to, and something of their ways and habits of life. Now do they react to various kinds of stimuli which my product will bring to bear upon them? Now shall I approach them in order to get their attention and the desired action? Naturally, you wouldn't try to force your product at the point of a gun. That was Hitler's method, but here we have found less forceful methods that get better results. We should know the language he understands, and learn to speak it. I dare say that a New England Yankee would scarcely be able to make himself understood to a Cracker from the Florida scrub! (No disrespect to brother Dunn [NOT CLEAR]!) There is a distinct advantage in knowing how to approach your people. Would you say "Here is a good product and it is good for you - Take it or leave!"? (they would take it) to their Congressman! The wording of advices has been commented on at length under that special topic on the agenda, but it will bear repeating here. We must write our advices in the language the people understand, if we are to expect their good will and cooperation. [HAND WRITTEN NOTE ON MARGIN NOT CLEAR.]

Then, we must have some means of getting in touch with them promptly and frequently. For this reason I believe the Hurricane Teletype Circuit was the greatest boost to public relations of the past dozen years. This was psychological as well as utilitarian. The mere fact that the people knew that every particle of available information was on that circuit to their home town, and that they could get the best advice available on short notice, did more to solve the public relations problem than any other thing. The rapid and instantaneous communications permitted the forecaster and other officials to quickly exchange information, and prevent public misunderstanding. If there were weak spots in relations we could go to work to correct the trouble at once. Rapic, dependable communications is always at our disposal over the hurricane circuit. It is regretted that it has been necessary in recent years to give drops on this circuit to other agencies, for it has placed a restraining hand on the freedom of exchanges that formerly existed. However, this has not caused any serious crippling, because FWX or Long Distance fills the gap!

The next link in the chain that has forced good public relations in time of storm in the Radio Broadcasting Stations. With the frequent broadcasts of storm information, you send out good will wholesale. We need those microphones in all our Weather Bureau Offices, and then we need good men to give out information over them. The part of the forecaster is to furnish the material for frequent broadcasts so that listeners can turn on the radio at practically any time day or night and get the latest information about the storm in a few minutes. We have made it standard practice to issue a bulletin for radio at least every two hours, and every hour if possible, when the storm is threatening. Keep the people fully informed by radio. Never let them be more than a few minutes without information - it makes them like you and your service, and that is what I consider good public relations. But it can be spoiled by too much talk over a microphone (see note below). If we do not have microphones in our offices, we must have some way of getting the advices to the radio stations promptly so that announcers can broadcast them. This is one point that needs stressing at this time. There are many radio stations in towns not connected with out fast communications system (or press association wires) and they are feeling slighted because the stations in the big cities get first service on storm information through our teletype circuits. We use every method possible to get out advices promptly to

all radio stations in the area likely to be affected by the storm, but the only weakness in public relations that developed in the 1946 season was due to our inability to serve all radio stations on a synchronous priority basis. In these days people everywhere depend on the radio for news, and they expect to get it not once or twice a day, but if it is important, they like to hear something new about it every time they take the trouble to listen...Let's give it to them. The radio stations will give us all the time we want.

> (A note of caution. Give out short, simple, easily understood bulletins - Long-winded gabfests are not favorably received down our way. The people want a short, dignified statement about the storm they can remember and repeat without confusion.)

High on the list of the agencies that assist us in our public relations are the newspapers and press associations. Without them our relations would suffer to a degree all too well known to some of the older of us who have been through a period of unfavorable press. Somebody said "Don't fight a newspaper unless you own one," but I would go further and say that no greater agency, for good or ill, exists for the hurricane service than the press. Then, it is one of our primary objectives to cultivate good relations with the newspapers. They will carry our message to the people in a manner that will either create a favorable and cooperative reaction; or, if they are critical and biased against us, no amount of effort of our part can overcome the criticism and bitterness that is engendered. We like to become acquainted with the men of the press. They are a fine lot, and usually human. They just want some hurricane news that they can depend on, and I like to be able to give it to them as to an old friend. They will never let you down if you meet them halfway, with a cooperative attitude. On a few occasions we have had to deal with inexperienced reporters. Here is the greatest danger of being misquoted or misrepresented. Unless you know your newspaper men well, it is usually best to be extremely careful what you say. An example of a bad break along this line occurred a few years ago while I was consulting with another forecaster on the various possibilities of a hurricane. We thought the press representatives were off in another room, but before we know it a young girl who represented one of the press associations had slipped into the forecast room unawares to us and taken down our conversation in shorthand. You can imagine my chagrin and surprise when I saw my speculations quoted verbatim in a news story! Fortunately, it was not too bad, but I certainly would not have been allowed such a quote if I had known about it.

In our hurricane forecast centers, a room with telephones should be provided for the use of the newspapers and press associations in time of storm, and it is a good thing to cultivate good relations at all times. If we have suitable conveniences for the press, we can keep their good will and helpful attitude, and at the same time keep them from breathing down our necks in the forecast room and recording our thoughts. I hope that I shall never see another period in our relations with the newspapers that was prevalent about the time Special Hurricane Services was organized. Today we have a favorable press throughout the hurricane area; let's be careful that it stays favorable. This has been greatly aided by the annual visits of the forecasters and administrative officials to the various cities before each hurricane season and talking over our service with the newspaper people.

Another group that has a great deal to do with favorable public relations is the municipal, county and state officials. The police, the mayors, the country sheriffs, the highway patrol, and governor and his cabinet... These reach out into every political subdivision of the State and make contacts that result in extensive public relations for us. We are wise to recognize this very important medium of contacting the people and creating good will for our cause. To that end, we have a microphone of the Police and Highway Patrol network of Florida in the Miami Office whereby we can give priority warning service to all law enforcement agencies and public officials. Arrangements have been effected with the Police and Highway Patrolmen to copy our advice verbatim as received by radio. This places the latest information in hands that carry it directly to the public. People are advised and assisted by those officials in preparation for the storm, and hysterical action and unfounded rumors are prevented. This is public relations on a scale that has meant much to the success of our efforts.

And then there are the other Federal agencies that take part in dealing with the people in times of hurricane. The Red Cross and the Coast Guard, to mention but a couple, are very important links in making our warnings and advices effective. We must see to it that cordial relations are maintained at all times with these agencies and that they have the official advices on a priority basis for the intelligent direction of evacuation and rescue work. When we keep our relations working smoothly with these other governmental agencies we are building our own public relations through them. We should remind ourselves at all times that these people become, to some extent at least, our good-will representatives when they take our warning message to the public.

The telephone becomes at once the prime nuisance and the best friend in time of storm. Did you ever try answering a telephone steadily for a day or two?! There is nothing that wears down the patience, or exhausts the mind like that forever jangling telephone with some screwball or railroad president on the other end! They

may want to visit with you, or weep on your shoulder, or get some kind of reassurance, or they may be just plain "stewed" and don't know what they are doing but feel that they must talk to the weather man.... It takes the patience of Job and the endurance of steel to stand it all day without becoming irritated and giving short answers. You know they have all heard it a dozen times over the radio and read it in the newspaper, but if you value your public relations you'd better be patient the 8000th time! (32,000 people called, only 8,000 could be answered in a day!) Yes, we have answered that many calls in a single day. There is no better way I know of to kill public good will and arouse all kinds of unfavorable reactions than by telephone. We should have experienced people on the telephones and keep on giving courteous answers no matter how frayed our nerves or raspy our voice. It might be the senator, or the bank president, or the power and light manager that is calling, even though he may seem a bit befuddles and incoherent - Just a few bad answers over the telephone and you mat have some of the most important people in town offended. They can do more harm to your public relations in a short time that can be built up in years - It shouldn't be the forecaster's job to answer the telephone, but don't ever think you can get out of it. You will be doing your best to concentrate on the preparation of an advisory or warning, when you get "Long Distance calling, my Horton" and what can you do but drop everything and answer it. I have had to stop as many as twelve times while writing a single advisory! Of course, this should not be the case, but it is, and we have to make the best of it, for it may be the President of the Railroad or the headquarters of the Red Cross, or some equally important person. You must be courteous and tell him all he wants to know even if it takes 10 minutes of your times when you are trying to meet a deadline for a radio broadcast over a hook-up, with that advisory - and there are a dozen such calls!

One of the weak public relations links in many places is the telephone. In late years we have had to depend on untrained and inexperienced girls, who know nothing of meteorology and should not give an opinion or discuss the matter. This has resulted in an unusually heavy load being diverted to the forecaster. I certainly hope that we can soon remedy this, for in some places it has already had its effect on both public relations and the forecaster. We don't want to keep on killing forecasters - Goodness knows, they have enough to do it they issued the advices and warnings - and we don't want to kill a good part of our public good will by having green girls give out hurricane misinformation.

The last item I would mention is personal contacts. In time of hurricanes we are going to have to deal with a large number of people individually in spite of the widespread efforts to keep this to a minimum. People will listen to the radio and read the papers and even call you on the telephone, and still come up to see you! In dealing with them we must remember that they are probably ready to crack with hysteria, and we have to tailor each contract to fit the individual. In Miami in the hurricane a couple of years ado, when the wind was a hundred miles an hour and the old 20-story building was swaying like a drunken man, a man walked up these 20 flights of steps (because he was afraid of the elevators) and wanted to talk to the forecaster. One look indicated the fellow was scared nearly to death and had a bad heart beside, and only deed the wrong thing said to him to finish him. He was calmly told to sit down, that the worst was over and it would be getting better soon since the barometer had started to rise. That satisfied him. We hope the days are over when it will be necessary to call out a military guard to protect the weather man in time of hurricane from the frenzied, hysterical mob that jams his office and destroys the furniture and instruments, but we still have to deal with many people in a personal way. We must courteously endeavor to satisfy their needs and give them the information they desire. A little planning to handle people in such emergencies will go a long way to making the job easier. A reception room should be available where someone is kept supplied with the latest information in printed or mimeographed form to hand to those calling. I believe nine out of ten will be satisfied with such a service.

Of course, we are dealing with the individual problems of many who do not call personally. I can imagine Mr. Stevens in his dealings with the Dow Chemical Company or the Freeport Sulphur President. We must give individual service so far as possible to these larger interests, in order that they may protect their extensive property and move thousands of employees who are in danger. However, this is done mostly through communications rather than personal contacts in time of storm. But let us bear in mind the scriptures, where it says:" One sinner destroyeth much good" -- One dissatisfied customer may do out public relations a great deal of harm.