551.55 (747) (285 : 71 : 73)

SECTION II.—GENERAL METEOROLOGY.

ANEMOMETER RECORDS ON A BUFFALO OFFICE BUILDING COMPARED WITH THOSE SECURED NEAR THE SURFACE OF LAKE ERIE.

By Benjamin C. Kadel.

[Instrument Division, Weather Bureau, Mar. 6, 1917.]

INTRODUCTION.

In order to obtain information concerning the relation between the velocity of the wind on a high city office building and the velocity near the surface of Lake Erie, comparisons were made at Buffalo, N. Y., between the regular Weather Bureau anemometer and an anemometer exposed at the Coast Guard station from January 1 to May 17, and from October 1 to December 31, 1916.

The regular Weather Bureau anemometer at Buffalo has one of the freest exposures in the United States, being mounted on a 40-foot steel tower on the roof of the New York Telephone Co. Building, a modern high office building, the Robinson anemometer being 280 feet above the ground at the base of the building, and 308 feet above mean lake level. The New York Telephone Co. Building is about 2,000 feet due east of the lake front, the intervening space being occupied with city buildings of the business type, none of which rise high enough to shield the anemometer from the wind.

The Coast Guard station is on the outer pier at the mouth of Buffalo River. A 50-foot steel tower, maintained at the Coast Guard station by the Weather Bureau for the display of storm warning signals, was utilized for the installation of the comparative anemometer, the instrument being mounted on a cross arm attached to the flagstaff just above the apex of the tower at a height of 65 feet above the mean level of Lake Erie. The anemometer is thus 243 feet lower than the Weather Bureau anemometer.

The winds have been separately tabulated for the eight principal points of the compass during the period under consideration, the direction determined from the recording wind vane on the same steel tower with the anemometer at the regular Weather Bureau station being used for both stations. The construction of the automatic wind vane is such that the winds recorded under a given direction include those from all points of the compass within 22½° of the given direction.

The indications of the Robinson anemometer as interpreted by the formula $v = V/3$, in which V = the velocity of the wind, and v = the speed of the centers of the cups, have been accepted without correction for the purposes of this paper.

The field work involved in the experiment was carried out under the supervision of Mr. David Cuthbertson, in charge of the Buffalo Weather Bureau office, and the records were transcribed from the automatic register sheets and computed by Mr. Frank A. Math of the same office.

WIND EXPOSURE.

North winds reach both anemometers over a course but little obstructed by buildings or otherwise, such buildings as exist in the region to the north being of a low type as compared with the section to the northeast and east of the Coast Guard station.

There was but little north wind at Buffalo during the period under consideration, the movement from the north representing but 2 per cent of the total, while such north winds as did occur were relatively light and unimportant. The north winds, however, differed from those from other points in that the movements were nearly always greater at the Coast Guard station than at the Weather Bureau station, the ratio of the former to the latter for the entire period being 1.10.

References to the unpublished detailed record show that the Coast Guard anemometer registered less than the Weather Bureau anemometer in 14 instances, that it registered the same in 4 instances, and that it was ahead in 39 instances of the 57 occurrences of north wind during the comparison. Just why the movement of the north winds at the Coast Guard station should exceed those at the Weather Bureau station, does not appear.

Northeast winds must cross the high-buildings section of the city of Buffalo before they arrive at the Coast Guard station. They constituted 13 per cent of the total movement, and were for the most part light, the most important northeast winds of the period occurring on February 12 and 13, when, during a period of 22 hours, 394 miles were recorded at the Weather Bureau anemometer, and 336 miles or 85 per cent as much at the Coast Guard station. The detailed records show but one important instance when there were more northeast winds at the Coast Guard station than at the Weather Bureau station.

East winds, from which the Coast Guard anemometer is most effectively sheltered by the city, were of infrequent occurrence and were generally light and of short duration, constituting 8 per cent of the total. During the entire period the Coast Guard anemometer registered 69 per cent as much as the Weather Bureau anemometer, while during individual east winds the percentage differed, ranging from 74 per cent during a 20-mile wind that continued 21 hours on January 29, to 47 per cent during a 19-mile wind that continued 20 hours on November 20.

Southeast winds skirt the low-lying region along the lake shore and the Buffalo River before their arrival at the Coast Guard station, and therefore suffer but little obstruction. They constituted but 3 per cent of the total, and were for the most part light and of short duration. The most important southeast wind of the period occurred October 19, the maximum velocity for a five-minute period at the Weather Bureau anemometer reaching 48 miles per hour, while at the Coast Guard station the maximum velocity at the same time was but 36 miles per hour. With the gradual clockwise shift of the wind, however, the relative movement at the Coast Guard station increased and at times the Coast Guard anemometer ran ahead, notably when the wind blew from south-southeast; but it fell behind again as soon as the wind reached southwest. It appears that the wind at the Coast Guard station exceeds that at the Weather Bureau office only when it is blowing in a northerly or southerly direction, roughly in the course of a valley or channel that is formed by the Buffalo River to the southeast and the Niagara River to the north.

TABLE 1.—*Hourly wind direction and movement from 7 a. m. to 6 p. m., Oct. 19, 1916; to illustrate change in ratio with clockwise shift of wind.*

	A. M.					P. M.					
Hour	8	9	10	11	XII	1	2	3	4	5	6
Direction	SE.	SE.	SE.	SE.	SSE.	SSE.	S.	S.	S.	SW.	SW.
Hourly movement:											
Weather Bureau	37	39	19	28	33	28	25	27	22	25	24
Coast Guard	26	25	17	24	28	36	33	24	18	19	16
Ratio	0.70	0.64	0.89	0.86	0.85	1.29	1.32	0.89	0.82	0.76	0.67

from the full expanse of the lake, and may therefore be presumed to reach both anemometers free from any but local influences. It is rather surprising, therefore, to find that the average ratio of the Coast Guard anemometer to the Weather Bureau anemometer is nearly as low for southwest and west winds as it is for east winds from which the Coast Guard anemometer is shielded by the city.

RESULTS OF OBSERVATIONS.

Table 2 shows, for each month, the total movement from the various directions for both anemometers,

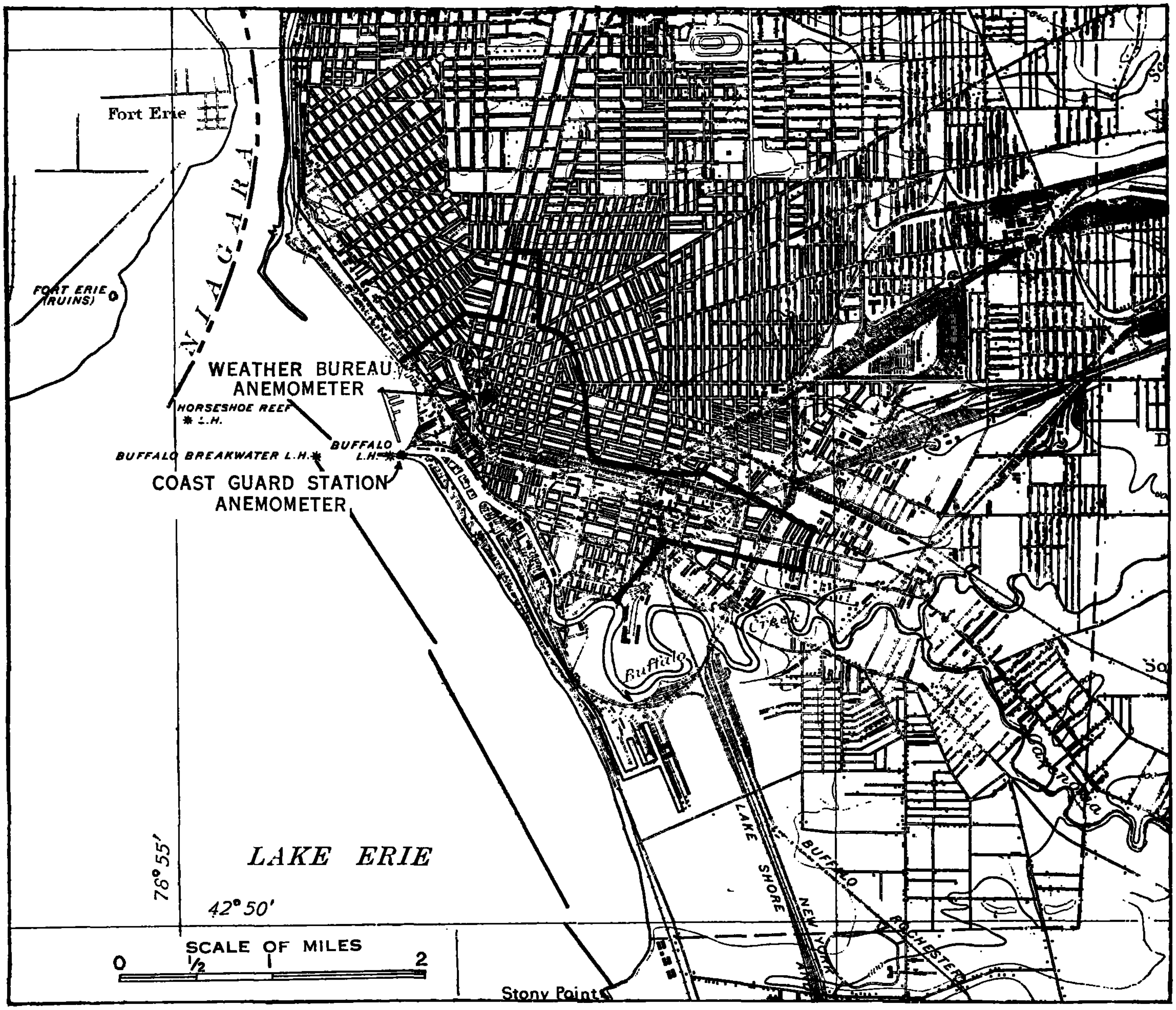

FIG. 1.—Map of Buffalo, N. Y., and vicinity, showing positions of Weather Bureau and Coast Guard exposures relative to city and to lake. Heavy black line incloses area occupied by business houses of the high-building type. (From U. S. Geol. Survey, topographic sheet "Buffalo, N. Y.")

Southwest and west winds are of greatest import to the marine interests, both because they are the offshore winds and because the winds from southwest and west, which together constituted 64 per cent of the total during the experiment, are the prevailing winds of the region and include the high velocities. Winds from points between south-southwest and due west reach Buffalo together with the ratio of the Coast Guard anemometer to the Weather Bureau anemometer. An examination of the table shows that the total wind movement at the Coast Guard station exceeds that at the Weather Bureau station only for winds from the north, a relation consistent through the months of record. The lowest ratio occurs with east winds, probably because the Coast

Guard anemometer is in the lee of the city; but the ratio for southwest and west winds is likewise low.

The total travel by the wind during the entire period was 66,924 miles at the Coast Guard station and 86,422 miles at the Weather Bureau station. Thus the difference or increased travel at the latter station amounts to 22,498 miles, which is 33.8 per cent in 243 feet, or 14 per cent per 100 feet as the average vertical difference between these two anemometers. But it is apparent from a consideration of the data presented that any rule for reducing the readings at one anemometer to those at the other must take direction into account.

The percentages of the total run blowing from each direction, as determined by the Weather Bureau anemometer, are as follows: North, 2; northeast, 3; east, 8; southeast, 3; south, 10; southwest, 26; west, 38; and northwest, 10.

Table 2.—*Total monthly movement, miles, from each direction recorded at the Weather Bureau, total recorded at the Coast Guard, and ratio of Coast Guard total to Weather Bureau total.*

Date.	Station.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Total.
1916. January	Weather Bureau	233	168	842	121	1,672	6,259	5,754	1,554	16,603
	Coast Guard	273	150	592	109	1,343	4,159	4,107	1,171	11,904
	Ratio	*1.17*	*0.89*	*0.70*	*0.91*	*0.80*	*0.66*	*0.71*	*0.76*	*0.72*
February	Weather Bureau	606	868	998	239	123	1,892	6,169	2,047	12,942
	Coast Guard	695	743	758	213	118	1,354	4,703	1,772	10,356
	Ratio	*1.15*	*0.85*	*0.76*	*0.89*	*0.96*	*0.72*	*0.76*	*0.87*	*0.80*
March	Weather Bureau	260	1,246	1,633	694	485	2,053	4,232	2,038	12,641
	Coast Guard	272	1,001	1,173	559	391	1;539	3,263	1,791	9,989
	Ratio	*1.05*	*0.80*	*0.72*	*0.81*	*0.81*	*0.75*	*0.77*	*0.88*	*0.79*
April	Weather Bureau	245	462	1,341	510	982	2,652	3,186	1,415	10,793
	Coast Guard	258	335	918	360	607	1,547	1,819	1,120	6,964
	Ratio	*1.05*	*0.73*	*0.68*	*0.71*	*0.62*	*0.58*	*0.57*	*0.79*	*0.65*
May [1]	Weather Bureau	8	99	516	180	677	3,179	2,781	533	7,973
	Coast Guard	5	77	341	135	454	1,947	1,785	395	5,139
	Ratio	.....	*0.78*	*0.66*	*0.75*	*0.67*	*0.61*	*0.64*	*0.74*	*0.64*
October	Weather Bureau	481	350	733	651	1,954	4,608	3,616	824	13,217
	Coast Guard	520	258	427	522	1,685	3,703	2,762	762	10,639
	Ratio	*1.08*	*0.74*	*0.58*	*0.80*	*0.86*	*0.80*	*0.76*	*0.92*	*0.80*
November	Weather Bureau	160	1,106	868	359	2,717	3,622	6,055	466	15,353
	Coast Guard	169	843	539	313	2,078	2,799	4,771	421	11,933
	Ratio	*1.06*	*0.76*	*0.62*	*0.87*	*0.76*	*0.77*	*0.79*	*0.90*	*0.78*
December	Weather Bureau	125	427	605	447	1,677	2,487	7,552	1,215	14,535
	Coast Guard	129	352	453	418	1,507	1,936	5,779	1,157	11,731
	Ratio	*1.03*	*0.82*	*0.75*	*0.94*	*0.90*	*0.78*	*0.77*	*0.95*	*0.81*
Period	Weather Bureau	2,118	4,726	7,536	3,201	10,287	26,752	39,345	10,092	104,057
	Coast Guard	2,321	3,759	5,201	2,629	8,183	18,984	28,989	8,589	78,655
	Ratio	*1.10*	*0.80*	*0.69*	*0.82*	*0.80*	*0.71*	*0.71*	*0.85*	*0.76*

[1] For 17½ days only.

An examination of the six individual storms analyzed in Table 3 brings out interesting details that the ratio of totals does not show. Considering only hours during which the total movement at the Weather Bureau anemometer exceeded 49 miles, we find 34 such hours for west winds as against 12 hours for southwest winds. Moreover, the west winds showed considerable uniformity in the ratio between the two anemometers which was between 0.75 and 0.80 in 28 of the 34 cases, with only one doubtful instance higher than 0.80, and with the remaining instances all above 0.71. These ratios for the higher velocities are higher than the average ratio for the period.

For southwest winds the ratio was subject to wider fluctuations, ranging from 0.56 to 0.84 for the 12 hours for which southwest winds exceeding 49 miles per hour were examined.

Table 3.—*Hourly wind direction, movement in miles, and ratio of Coast Guard's to Weather Bureau's record during six important storms in 1916.*

Date.		Hour. 1	2	3	4	5	6	7	8	9	10	11	12
1916 Jan. 13, A. M.	Direction	....	....	....	....	w.	w.	w.	w.	w.	w.	w.	w.
	Weather Bureau	....	....	....	....	59	65	67	69	72	67	62	58
	Coast Guard	....	....	....	....	44	48	52	54	57	52	49	44
	Ratio	....	....	....	....	*0.75*	*0.74*	*0.78*	*0.78*	*0.79*	*0.78*	*0.79*	*0.76*
P. M.	Direction	w.	w.	....	....	....	....	....	....	....	....	....	....
	Weather Bureau	52	46	....	....	....	....	....	....	....	....	....	....
	Coast Guard	43	35	....	....	....	....	....	....	....	....	....	....
	Ratio	*0.83*	*0.76*	....	....	....	....	....	....	....	....	....	....
Feb. 7, A. M.	Direction	w.	w.	w.	w.	w.	w.	w.	w.	nw.	wnw	w.	w.
	Weather Bureau	27	36	42	46	52	54	53	52	47	53	56	58
	Coast Guard	20	27	32	35	41	43	41	42	33	42	44	46
	Ratio	*0.74*	*0.75*	*0.76*	*0.76*	*0.79*	*0.80*	*0.77*	*0.80*	*0.70*	*0.79*	*0.79*	*0.79*
P. M.	Direction	w.	w.	w.	w.	w.	w.	w.	w.	w.	w.	w.	w.
	Weather Bureau	61	63	64	59	51	49	51	45	47	43	37	34
	Coast Guard	47	49	48	46	39	38	38	36	37	34	30	30
	Ratio	*0.77*	*0.78*	*0.75*	*0.78*	*0.76*	*0.78*	*0.74*	*0.80*	*0.79*	*0.79*	*0.81*	*0.88*
Mar. 7, A. M.	Direction	....	....	....	....	....	....	sw.	sw.	w.	w.	w.	w.
	Weather Bureau	....	....	....	....	....	....	34	42	56	65	64	63
	Coast Guard	....	....	....	....	....	....	25	30	41	52	48	49
	Ratio	....	....	....	....	....	....	*0.74*	*0.71*	*0.73*	*0.80*	*0.75*	*0.78*
P. M.	Direction	w.	w.	....	....	....	....	....	....	....	....	....	....
	Weather Bureau	59	51	....	....	....	....	....	....	....	....	....	....
	Coast Guard	42	38	....	....	....	....	....	....	....	....	....	....
	Ratio	*0.72*	*0.74*	....	....	....	....	....	....	....	....	....	....
May 10, P. M.	Direction	....	....	....	....	....	....	....	sw.	sw.	sw.	sw.	w.
	Weather Bureau	....	....	....	....	....	....	....	35	48	54	61	47
	Coast Guard	....	....	....	....	....	....	....	25	31	30	37	29
	Ratio	....	....	....	....	....	....	....	*0.71*	*0.64*	*0.56*	*0.61*	*0.62*
May 11, A. M.	Direction	sw.	sw.	sw.	w.	w.	sw.	sw.	sw.	sw.	sw.	sw.	sw.
	Weather Bureau	36	42	41	39	36	32	40	47	47	46	50	50
	Coast Guard	24	26	24	23	22	22	27	30	31	32	35	35
	Ratio	*0.67*	*0.62*	*0.59*	*0.59*	*0.61*	*0.69*	*0.68*	*0.64*	*0.66*	*0.70*	*0.70*	*0.70*
P. M.	Direction	sw.	sw.	sw.	w.	w.	w.	w.	nw.	nw.	....	....	....
	Weather Bureau	52	56	57	57	49	40	30	32	32	....	....	....
	Coast Guard	36	38	40	39	34	28	22	22	21	....	....	....
	Ratio	*0.69*	*0.68*	*0.70*	*0.68*	*0.69*	*0.70*	*0.73*	*0.69*	*0.66*	....	....	....
Oct. 16, P. M.	Direction	....	....	....	....	....	....	ssw.	sw.	sw.	sw.	sw.	w.
	Weather Bureau	....	....	....	....	....	....	20	37	45	46	56	54
	Coast Guard	....	....	....	....	....	....	17	29	38	37	47	42
	Ratio	....	....	....	....	....	....	*0.85*	*0.78*	*0.84*	*0.80*	*0.84*	*0.78*
Oct. 17, A. M.	Direction	w.	w.	w.	w.	w.	w.	w.	w.	nw.	nw.	....	....
	Weather Bureau	53	53	52	51	53	49	43	37	38	40	....	....
	Coast Guard	41	41	42	41	40	38	31	27	31	42	....	....
	Ratio	*0.77*	*0.77*	*0.80*	*0.80*	*0.76*	*0.78*	*0.72*	*0.73*	*0.81*	*1.05*	....	....
Dec. 9, A. M.	Direction	s.	s.	s.	s.	s.	s.	sw.	wsw.	sw.	wsw.	wsw.	wsw.
	Weather Bureau	21	20	23	17	22	24	53	56	56	56	62	64
	Coast Guard	23	21	22	19	21	22	43	44	43	45	50	57
	Ratio	*1.10*	*1.05*	*0.96*	*1.12*	*0.95*	*0.92*	*0.81*	*0.79*	*0.77*	*0.80*	*0.81*	*0.89*
P. M.	Direction	sw.	sw.	sw.	w.	w.	w.	....	....	....	....	....	....
	Weather Bureau	66	62	57	57	41	37	....	....	....	....	....	....
	Coast Guard	54	51	48	44	34	33	....	....	....	....	....	....
	Ratio	*0.82*	*0.82*	*0.84*	*0.77*	*0.83*	*0.89*	....	....	....	....	....	....

An interesting fact brought out by a detailed examination of heavy blows, which have been collected in Table 4, is that the maximum velocity frequently occurs at or near the time of the shift from southwest to west, and that the shift from southwest to west is often the signal for an increased velocity, which is contrary to what we might expect, considering that the southwest winds have free course over Lake Erie while the west winds blow along the Canadian shore where, presumably, their free flow is more or less interfered with.

TABLE 4.—*Maximum wind velocity, in miles per hour, for a five-minute period, midnight to midnight, at Weather Bureau anemometer, and time of occurrence as referred to the time of shift from southwest to west.*

Date.	Maximum velocity.	Direction at time of maximum.	Time relative to shift.
1916.	*Mis./hr.*		
Jan. 2	58	w	5½ hours later.
5	60	nw	3 hours later.
10	50	sw	4 hours earlier.
10	50	w	On time.
13	76	w	4 hours later.
Feb. 7	70	w	No evidence.
Mar. 7	80	w	1½ hours later.
Apr. 14	56	w	10 minutes later.
Oct. 25	60	w	50 minutes later.
Nov. 23	52	w	1 hour later.
24	72	w	No evidence.
Dec. 5	68	w	On time.

It would be interesting to know just why the winds that reach the Coast Guard anemometer in full force from the lake are retarded nearly as much as are those from directions which are sheltered by the city. It might be suggested that the retarding effect of the city extends to windward because of the banking of the wind; or that the velocity of southwest and west winds at the level of the Weather Bureau anemometer is increased by the presence of the city or of the building, the air that would ordinarily flow at the lower levels being constrained to flow with the layers normal to the height of the anemometer, thus rendering necessary an increased velocity in order that the greater volume of air may pass in the same time. The evidence furnished by the northerly and southerly winds that suffered no obstruction to their flow, either before or after they had passed the Coast Guard anemometer, indicates that in the case of southwest and west winds the Coast Guard anemometer is slowed down, rather than that the Weather Bureau anemometer is speeded up by the presence of the city. If this is correct, then the Weather Bureau anemometer is more nearly representative of the true velocities over the lake at the height of the Coast Guard anemometer than is the Coast Guard anemometer itself, even though the latter is on the lake shore.

A similar comparison made at Chicago in 1911, showed lake winds stronger at the Life Saving Station than on the Federal Building, and land winds nearly the same at both stations; but in this instance the exposure on the Federal Building was admittedly faulty.[1]

SOME NEW INSTRUMENTS FOR OCEANOGRAPHICAL RESEARCH.

By Dr. HANS PETTERSSON.

[Dated: Göteborgs Högskola, Oceanografiska Institutionen, Feb. 7, 1917. MS. received Mar. 29, 1917.]

When considering the remarkable progress made by meteorological science during the last decades, one should not overlook the fact that this advance has been made possible by a parallel and not less remarkable development in the technique of the science, viz, of its instrumental resources. Both as regards general meteorology and perhaps still more within such specialized branches as the study of radiation or high upper air altitude research (where American scientists take a prominent part) we owe the wonderful equipment of modern research to the inventive genius of men like Cleveland Abbe, R. Assmann, C. G. Abbot, C. F. Marvin, etc. As to recording instruments of all kinds the meteorologist of to-day is perhaps better equipped than any other student of natural phenomena, and certainly much better than the followers of the younger sister science of oceanography.

In a previous note in this REVIEW (see issue for June, 1916, 44: 338) I have tried to set out the reasons for a close cooperation between meteorologists and oceanographers in an extensive study of the North Atlantic Ocean, of the variable physical conditions of its surface sheet, and of the influences direct and indirect which these latter undoubtedly exert on the weather and the climate of the surrounding continents. In the following pages I intend to give a brief description of some novel instruments which highly facilitate the collection of oceanographical data.

Ever since scientific marine research was for the first time taken up on a broad basis by the International Council for the Study of the North Sea, it has become more and more manifest that if results of any practical value for the fishing industries or for meteorological forecasts are to be derived from this work then the net of investigation must be drawn tighter, the frequency of observations increased, and the field of research expanded. This is specially the case in coastal regions where our investigations have proved physical conditions in the fluid element to be almost as variable as they are in the atmosphere. From our research station Bornö in the Gullmarfiord (west coast of Sweden) we possess unique series of continuous hydrographical observations (salinity and temperature measurements at different depths) which have been made daily for over seven years with few breaks. The results prove that the different water layers, differing in density from each other, instead of being at rest are in a state of almost incessant motion with large displacements both vertical and horizontal taking place in a very short time. Thus the boundary surface between two water layers may, from one day to the next, fall by 10 or even 20 meters, which of course involves a radical change in the hydrographical situation, millions of tons of brackish water being swept out to sea and replaced from below by a simultaneous invasion of saltier water of North Sea origin. At the suggestion of the author a series of synoptic parallel observations of these internal movements, previously only studied at Bornö, were carried out at five different localities during November, 1915, by the Swedish Hydrographical-biological Commission. The results prove that the more considerable internal movements are of a general character and that parallel displacements of the boundary occur almost simultaneously at all the different points of observation.

As regards the practical importance of these movements, they must obviously have a profound influence on fish life. O. Pettersson has repeatedly found particularly large upheavals of the boundary surface to coincide with rich catches of herring during the winter fisheries. The author has compared the above-mentioned hydrographical series with statistics from the local fishery and found that the chances of catching mackerel at Bornö in summer are from four to six times better when the boundary surface of 30 per mille salinity is below its average level than in the opposite case.

[1] *Cox, H. J. & Armington, J. H.* The weather and climate of Chicago, Chicago, Ill., 1914 (Geogr. Soc. Chicago, Bull. 4), pp. 286-289.