WHAT IS THE EFFECT OF HEAVY RAINS WITH HIGH WINDS ON THE RUN OF CUP-WHEEL ANEMOMETERS?

By CHARLES F. MARVIN
[Weather Bureau, Washington, September 1933]

Inquiry has been received as to the possible effect on the indications by cup anemometers of wind velocities due to the bombardment of rain drops under conditions of comparatively high winds and very heavy rains.

This is an interesting question which has perhaps not been very carefully investigated experimentally. Nevertheless, a seemingly conclusive answer is possible on analytical grounds.

Two obvious effects require consideration. First, the cups become thoroughly wetted by the addition of a certain amount of water and therefore slightly heavier. The second effect arises from the collisions with numerous water drops striking against both the concave and convex faces of the cups.

By measurement it is found that the actual weight of water on any of the cup wheels of the Weather Bureau anemometers amounts to 6.1 grams, which is 2.2 percent of the weight of the standard light-weight cups and, of course, a still smaller percentage of that of the heavier cup systems. Wind-tunnel tests with steady wind velocities show conclusively that when the length of the arms and other dimensions are the same the run of these anemometers is wholly independent of small changes in the mere weight of the cups. In the case of gusty winds the lag of the anemometer in following the wind is, of course, greater the greater the weight of the cups. For this reason heavy rain tends to make the cups lag behind the true wind velocity more than they do in the same wind without rain, and conversely when the wind velocity is falling off rapidly the cups overrun slightly. These effects are quite inconsequential on the average run of the cups. In other words, the effect of the increased weight of the cups due to rainfall may be regarded as negligible and unimportant.

As to the effect of the bombardment of the cups by the raindrops, reasoning indicates that the convex cups which are advancing in the wind collide with the raindrops at relatively high velocities. We are thinking here of the horizontal component of the motion of the raindrops with reference to the surfaces of the cups at the instant of collision. The concave cups, however, are advancing *with* the wind and the kinetic energy involved in the collision of the raindrops and these cups because of the smaller relative velocities is certainly much less than the corresponding kinetic energies involved in the collisions of the raindrops with the convex cups. The ultimate result of these collisions must therefore be a tendency to retard the speed of rotation of the cups. As already stated, no wind tunnel or other measurements are availble by which the amount of this retardation can be evaluated.

On the other hand, we do have carefully made measurements of the effects of moderate degrees of friction in retarding the motion of the cups as compared to the almost complete absence of friction. These friction tests show that even quite appreciable amounts of friction have an inappreciable or very small effect in retarding the speed of the cups in high winds and it is certain that the effects of the bombardment of the raindrops is quite appreciably less than the moderate amounts of friction which have been subjected to tests.

The final conclusions of the foregoing analysis are therefore (1) that rain tends to make the anemometer more sluggish by a very small amount in responding to fluctuating gusty winds, although the average run of the cups in such gusty winds is not appreciably affected and (2) that heavy rains in high winds retard the run of the cups substantially as does friction, but that the amount of this retardation, while not exactly known, certainly is inconsequential and unimportant.

We may conclude this consideration by asking how the cups would behave if exposed in perfectly still air during a heavy downpour of rain. A little analysis indicates that the action of the rain on each one of the cups would tend more or less to turn it backward. The combined force on all the cups might even be sufficient to actually turn a nearly frictionless anemometer cup wheel backward. In this way, too, falling rain tends to oppose motions caused by the wind.

TROPICAL DISTURBANCES OF AUGUST 1933

By R. HANSON WEIGHTMAN
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The number of tropical disturbances this month was unusually large, 7 disturbances being reported, 4 of which were of slight intensity and 3 of hurricane intensity.

August 12–20.—The first disturbance of the month made its appearance in the region of Barbadoes, West Indies, whence it moved first west-northwest, passing south of Jamaica, then northwestward over Grand Cayman, thence more to the northward over extreme western Cuba, and finally northward to a point off the northwestern Florida coast where it lost intensity. The few reports availble would indicate that the winds of this storm may have reached gale force while its center was south of Jamaica; otherwise, it was of minor consequence. Heavy rains attending thunderstorms, caused damaging floods in eastern Jamaica.

August 16–21.—A disturbance of slight intensity appeared over the Windward Islands on the 16th and moved westward. It was last traceable about 300 miles east of the Honduras coast on the 21st.

August 17–26.—This disturbance originated some distance to the east of the Windward Islands. It was first located from telegraphic reports on the morning of the 18th, about 900 miles east of Puerto Rico. The S.S. *Western Prince* in latitude 19°30′ N., longitude 51° W., reported barometer 29.76 inches, wind northeast 42 m.p.h. with heavy southeast swell. It moved westward until the 18th, then followed a course northwest by north until the 21st, when it was central about 150 miles southwest of Bermuda, a maximum wind velocity of 64 miles from the east being reported at St. Georges. During the next 24 hours it bore more to the westward, with somewhat decreased speed and then turned to the northwest, passing nearly over but slightly to the east of Cape Hatteras, with lowest barometer 28.67 inches and maximum wind velocity 64 m.p.h. from the northeast. When the disturbance was about 150 miles southwest of Bermuda on the morning of the 21st, storm warnings were ordered between Cape Hatteras and Boston, with the information