ture at that point −20° F. The only low area present was 30.10 inches in the northwest, centered around Calgary. The high area continued over the eastern half of the country throughout the series of flights, the center moving over the Lakes and thence to New York State. On the 29th, the sixth day of the series, the high area had backtracked apparently and had built up again over the Lakes and Michigan, with a center of 30.70 inches at Sault Ste. Marie. At this time storms had formed in the southern Rockies, with a low center of 29.40 inches at Denver. A summary of the series follows:

TABLE 6.—*Balloon flights, January 24–30, 1922.*

	Jan. 24.	Jan. 25.	Jan. 26.	Jan. 27.	Jan. 28.	Jan. 29.	Jan. 30.
Surface	NNE. 2.2	SSE. 2.7	E. 2.7	NE. 2.7	NNE. 3.1	ENE. 2.7	ESE. 2.2
1,000	NNE. 2.9	SSE. 6.4	SE. 4.7	ESE. 7.5	ENE. 6.7	E. 7.1	SSW. 5.0
2,000	NNW. 8.4	WSW. 4.0	S. 1.3	ENE. 3.2	ENE. 5.6	NE. 6.4	SSW. 9.0
3,000	NNW. 11.2	W. 4.2	SW. 4.0	E. 2.0	NE. 4.1	ENE. 5.0	SSW. 11.8
4,000	NW. 16.2	WNW. 6.3	WSW. 5.0	SW. 1.0	NNE. 3.2	NNW. 2.0	SW. 11.3
5,000	WNW. 24.0	W. 6.0	SSW. 4.5	NNW. 2.0	NNW. 7.0	N. 5.2	SW. 11.8
6,000	WNW. 27.5	WNW. 5.3	SSW. 3.5	....	NNW. 12.3	NNW. 12.0	....
7,000	....	NW. 4.6	WSW. 4.2	....	NNW. 16.0	NW. 22.9	....
8,000	....	NW. 6.3	....	....	WSW. 12.0	WNW. 25.7	
9,000	....	NW. 9.0	....	....	NW. 10.0	WNW. 34.5	....
10,000	....	WNW. 15.2	....	....	....	....	....

Flights of great altitude have been obtained on several occasions, as instanced by that of May 12, 1922, when an altitude of over 15,000 meters was obtained. The winds were light until an elevation of 12,000 meters, at which point the balloon entered a northwest current and velocities increased steadily to 27 m/s. at 15,900 meters' altitude. The weather map showed an area of high pressure of 30 inches over the Great Lakes and Ohio Valley and a low of 29.50 inches at North Platte, Nebr. Reaching high altitudes is largely dependent upon light winds, which in turn usually result from a high-pressure area centered over or near the observing station. The greatly increased velocities indicated above 10 kilometers are probably faulty in some instances, because of a leaking balloon, although many recent double theodolite observations show that accurate results are obtained as a rule up to 15 kilometers, at least.

Several flights with extreme velocities have been recorded. On November 18, 1919, a maximum of 58 m/s. was observed near the 6,000-meter level. A high velocity was reported also from Madison, Wis.; the weather map showed a low area of 29.55 inches over the Great Lakes and a high of 30.40 inches at North Platte, with closely placed isobaric lines and a steep gradient.

On December 17, about a month after the instance noted above, the highest velocity ever recorded at Lansing was obtained, 83 m/s. from the northwest at about 7,000 meters' altitude. A large increase in velocity with altitude was also observed at Madison, Wis., but the balloon was followed only to 2 kilometers where the wind was NW. 26 m/s. The pressure was high with a crest of 30.50 inches at St. Paul and there was a low area of 30 inches moving off the Atlantic coast.[1]

Light winds are recorded more or less frequently during the summer months. On July 4 and 5, 1921, with a high pressure of 30.20 inches over the Great Lakes and down through Illinois, Missouri, and Oklahoma, flights of 9,000 m. and 6,000 m., respectively, were obtained and very light winds prevailed throughout, averaging 3 and 4 m/s. On July 13, 1921, a high pressure of 30.30 inches over the Great Lakes and small gradients gave light air currents up to 10,000 meters, where the balloon was lost.

[1] For more detailed discussion of this high wind see MO. WEATHER REV., 47; 853–854.

An interesting device has been employed at this and several other upper-air stations. A tag is attached to the balloon with request that finder return it, together with any information as to where and when found, was it seen falling, and finder's name and address, so that return may be acknowledged. The tag is of lightweight cardboard, measuring about 2″ by 3″, the additional weight being considered in calculating the total lift. By means of the tag it is possible to obtain interesting data as to the course of the winds after the balloon has been lost to view through clouds or distance. About 10 per cent of the tags are returned, the percentage being greater than that during summer and less in winter. While most of the returns are from points in Michigan, indicating that the balloons generally burst before going any great distance or altitude, there have been a number of reports from Canadian points and from near-by States, West Virginia, Ohio, and Pennsylvania.

One flight of particular interest was made on December 28, 1919. The winds were WNW. at 7,000 meters where the balloon was lost through distance. The tag attached to it was returned from near Rutland, Vt., where the balloon had been picked up. It had not been seen falling. The return was interesting as indicating a southwest current above 7,000 meters, the necessary conclusion, since the course of the winds where the balloon was lost to view would have carried it south of Vermont. Perhaps as many as 25 tags have come back from Ontario, in the brief period since ascensions were started here.

ADDITIONAL NOTE.

By W. R. GREGG.

In the application of free-air data to aviation it is found that increasing importance can be given to *resultant* winds. They have no significance whatever in the case of an individual flight, but, when a regular daily schedule over a considerable period of time, a year for example, is considered, the resultant winds determine what cruising speed an airplane must have in order that a given flight schedule may, on the average, be maintained. Or, to express the same thing in another way, a knowledge of resultant winds will enable a commercial aeronautical firm to bid intelligently on furnishing regular service between two or more points on the basis of the help or hindrance that will, on the average, be experienced from "following" or "head" winds, respectively. Hence it seems appropriate to include resultant wind values in any statistical study of free-air winds. This I have done for Lansing, using for this purpose the figures given in Table 4 of Mr. Ray's paper. The results are given in Table 7, which, for purposes of comparison, contains also wind resultants, previously published,[2] for stations not far distant from Lansing.

TABLE 7.—*Annual resultant winds (m. p. s.) at four stations in North Central United States.*

Altitude above station.	Lansing, Mich.	Royal Center, Ind.	Drexel, Nebr.	Ellendale, N. Dak.
m.				
Surface	S. 72° W. 0.9	S. 53° W. 1.8	S. 37° W. 0.9	N. 48° W. 1.3
250	S. 69° W. 2.6	S. 53° W. 3.5	S. 50° W. 1.5	N. 68° W. 1.8
500	S. 81° W. 3.9	S. 60° W. 4.6	S. 65° W. 2.2	N. 74° W. 2.3
750	S. 84° W. 4.4	S. 65° W. 5.5	S. 74° W. 3.2	N. 75° W. 3.1
1,000	S. 89° W. 5.0	S. 72° W. 6.4	S. 84° W. 4.6	N. 76° W. 3.9
2,000	N. 71° W. 7.8	S. 77° W. 7.8	N. 89° W. 8.1	N. 76° W. 7.5
3,000	N. 69° W. 10.6	S. 83° W. 10.0	N. 86° W. 11.3	N. 75° W. 11.2
4,000	N. 65° W. 13.1	S. 83° W. 11.4	N. 83° W. 13.2	N. 77° W. 12.5
5,000	N. 63° W. 14.5	....	N. 76° W. 14.4	....

As shown in the table, resultant speeds at these four stations agree rather closely, except in the lower levels, where they are somewhat greater at Lansing and Royal Center than at Drexel and Ellendale. A point well brought out by the figures is the latitudinal variation in resultant direction, the north component increasing with latitude and being quite pronounced at Ellendale, where it persists at all altitudes. At Royal Center a south component is found, although it is small in the upper levels. There are, of course, seasonal variations, the north component being strongest in winter, and weakest in summer. Seasonal values have not yet been computed for Lansing, but they have been published for the other three stations.[2]

[2] An Aerological Survey of the United States, Part I. Results of observations by means of kites, Mo. WEATHER REV. Supplement No. 20, Table 4, 1922.

RELATION OF CROP YIELDS TO QUANTITY OF IRRIGATION WATER IN SOUTHWESTERN KANSAS.

By J. B. KINCER.

[Review of Bulletin 228, Kansas Agricultural Experiment Station.]

While Kansas is one of our leading agricultural States, the more western portion usually receives rather scanty rainfall. The 20-inch annual isohyet extends across the State in a north-south direction about 60 miles from the western border, which means that some 7,000,000 acres of land receive less than 20 inches of precipitation annually. This amount of rainfall is usually considered about the minimum necessary for successful farming under ordinary cultural methods and, consequently, in extreme western Kansas, farming is more or less precarious from the standpoint of returns, unless special methods are employed for artificially supplying or conserving soil moisture.

Up to the present time irrigation has not been practiced in this section to any great extent, although nearly 100,000 acres are so treated, about 80 per cent being in Finney and Kearny Counties through which the Arkansas River flows. Owing to the existence of large supplies of readily available underground water, however, especially in the southwestern portion of the State, it is quite likely that irrigation at some future time may be practiced very extensively. In view of this, the Kansas Agricultural Experiment Station is maintaining at Garden City, Finney County, a branch station chiefly for experimental purposes to secure information applicable to both present and prospective irrigation problems.

There are two questions of primary interest to every irrigation farmer: (1) The kind of crops best suited to irrigation farming, and (2) the most economical amounts of water to apply. To aid in answering these a series of experiments was started by the branch station at Garden City in 1914 and continued for five years, under the supervision of Mr. George S. Knapp, superintendent. The results are set forth in Bulletin 228, Agricultural Experiment Station, Manhattan, Kans., and may be briefly reviewed as follows:

Experiments were conducted with seven crops, including milo, kafir, sumac, Sudan grass, wheat, oats, and barley, grown in duplicate series on plats containing one-twentieth of an acre. Each crop was grown on four plats, designated, "A," "B," "C," and "D," each of which received a different amount of water. All plats were irrigated during the winter, and in addition, the A plats were irrigated sufficiently during the summer to maintain the moisture content of the soil at about 20 per cent; the B plats at about 16 per cent, and the C plats at about 12 per cent. The D plats were not irrigated during the growing season. Because of the seasonal variation of rainfall and a lack of knowledge concerning the amount of water actually required by the crop under test, the moisture content of the soil was determined at intervals as a basis for the application of water. Whenever the moisture content dropped a few points below the predetermined condition for a given plat, water was applied in sufficient quantity to raise the moisture content a few points above the fixed amount. From 2 to 4 inches of water were applied at each irrigation.

Five-year average productions for milo grain were: Plat A, 53.7 bushels; B, 47.3; C, 40.7; and D, 15.3. While each increase in the amount of water showed a definite increase in yield, the greatest difference was between the D and C series, where an increase of 4.1 inches, or 47 per cent of the amount of water applied increased the yield 22.4 bushels, or 146 per cent.

In the case of kafir, the amounts of water required to maintain the soil moisture were almost the same as for milo, but the yields were not so large and showed a smaller range on the different plats. The yields in like serial order were 33.7, 29.6, 23.8, and 13.3. While these results in the main agree with those for milo, there was a less definite response with increased application of water, from which it appears that kafir is not so productive a crop as milo to raise under irrigation, unless produced for forage as well as grain.

In general, the response of sumac to water was about the same as for milo and kafir, although the conclusions are quite different, because this crop is used primarily more for forage than for grain. There was a gradual increase in the amount of forage, but the difference was not great in the three plats receiving water during the growing season. Throughout the experiment, it was observed that the sorghum crops most plentifully supplied with water invariably matured earliest. This appeared to be due to the plants becoming dormant when moisture was deficient and resuming growth when water was applied, while those receiving sufficient moisture made continuous growth and consequently matured earlier.

One of the most striking results with Sudan grass was its failure to respond significantly to increased quantities of water in both seed and stover. There was a slight increase in the yield of stover, but it was very small compared with the amount of water used. It might be supposed that the lack of response to increased water indicates a small water requirement of the crop, but at the same time more water was necessary to maintain the soil moisture at the required degree than for any other sorghum crop in the experiment, which would indicate that it took up water more rapidly than the others. The grass was planted in rows, however, and it is probable that had it been drilled and harvested as a hay crop, the yield of hay would have been much larger and there would probably have been a wider variation for the different plats.

In the case of wheat, there was in general an increase in yield with increased application of water, but there were large variations in yield from year to year, notwithstanding the soil moisture was maintained at an approximately uniform degree. Mr. Knapp concludes from this that wheat yields were influenced nearly as much by gen-