

on the 11th. The average precipitation was 0.47; the greatest monthly amount, 1.62, occurred at Scipio, while none fell at Loa.—*J. H. Smith.*

Virginia.—The mean temperature was 34.3°, or slightly below normal; the highest was 78°, at Barboursville on the 10th, and the lowest, 9° below zero, at Guinea on the 2d. The average precipitation was 0.94, or 3.05 below normal; the greatest monthly amount, 1.85, occurred at Bigstone Gap, and the least, 0.39, at Christiansburg.—*E. A. Evans.*

Washington.—The mean temperature was 41.4°, or about 5.5° above normal; the highest was 69°, at Sunnyside on the 13th, and at Sedro on the 27th, and the lowest, 5°, at Hunters on the 19th. The average precipitation was 5.88, or about 2.00 above normal; in the western portion it was 3.50 above, and in the eastern it was somewhat below normal; the greatest monthly amount, 17.51, occurred at Tatoosh Island, and the least, 0.14, at Sunnyside.—*G. N. Salisbury.*

West Virginia.—The mean temperature was 32.7°, or slightly below

normal; the highest was 74°, at Uppertract on the 12th, and the lowest, 13° below zero, at Nuttallburg on the 3d. The average precipitation was 1.84, or about 1.00 below normal; the greatest monthly amount, 3.38, occurred at Huntington, and the least, 0.64, at Uppertract.—*H. L. Ball.*

Wisconsin.—The mean temperature was 20.7°, or 2.7° above normal; the highest was 60°, at North Crandon on the 11th, and the lowest, 27° below zero, at Hayward on the 1st. The average precipitation was 1.52, or 0.36 above normal; the greatest monthly amount, 3.76, occurred at Port Washington, and the least, 0.44, at Medford.—*W. M. Wilson.*

Wyoming.—The mean temperature was 29.0°, or 5.0° above normal; the highest was 65°, at Greenriver on the 15th, and the lowest, 11° below zero, at the same station on the 9th. The average precipitation was 0.29, or 0.32 below normal; the greatest monthly amount, 1.65, occurred at Sheridan, while none fell at Fort Washakie, Greenriver, and Wamsutter.—*W. S. Palmer.*

RIVER AND FLOOD SERVICE.

By PARK MORRILL, Forecast Official, in charge of River and Flood Service.

The flood wave which occurred in the Ohio River during January passed down the lower Mississippi the past month; at the end of the month the river was decidedly lower at all points than at its beginning. The crest passed Cairo on the 1st, Memphis on the 5th, Vicksburg on the 13th, and New Orleans on the 17th. A moderate freshet occurred in the upper Ohio during the latter half of the month, but the Tennessee and Cumberland remained low, and the rise at Cairo was slight. The western tributaries all remained low.

The highest and lowest water, mean stage, and monthly range at 116 river stations are given in the accompanying table. Hydrographs for typical points on seven principal rivers are shown on Chart V. The stations selected for charting are: Keokuk, St. Louis, Cairo, Memphis, and Vicksburg, on the Mississippi; Cincinnati, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

The following résumé of river stages and conditions of navigation in the respective streams is compiled from reports by the officials of the Weather Bureau at various river stations and section centers:

Hudson River. (Reported by A. F. Sims, Albany, N. Y.)—On the 1st of February the watershed of the Hudson had a covering of snow varying from a trace at the mouth of the river to 20 inches at its source, and the cold wave attendant upon the heavy snow which ushered in the month strengthened the weak spots in the river ice and caused accretions varying from 14 inches at Waterford to 3 inches at Newburg. All ice harvesters took advantage of the situation and pushed the harvest with much vigor. The mild conditions which followed on the 8th and 9th softened the ice and threatened to cause a suspension of the harvest. As a general rule, ice harvesting in February is precarious, and if the ice holds its own during the month it does well, for the reason that the recurring effect of the sun's heat during the day offsets the accretions due to the cold of night.

At 1 p. m. of the 11th the ice in the river began to move southward from the Greenbush bridge, and, after reaching Douws Point, became stationary and piled in the river channel. From the afternoon of the 13th to noon of the 14th the water on the crest of the State dam had risen from 12 to 24 inches; below the State dam, the water was 33 inches above the normal, having risen 19 inches in twenty-four hours. Mill owners and merchants along the river made preparations, as they were in fear of the ice going out above the State dam. On the 14th the ice in the Mohawk was gradually breaking up and there was a clear channel 50 feet wide on the south side of the gorge at Schenectady, and the islands in that district were covered with water. By the 17th the river closed at Troy for the third time this winter, and by 10 a. m. the ferryboats were compelled to cease running. The end of the month finds the ice in the Hudson breaking up at Poughkeepsie, and between Poughkeepsie and Coeymans there are 4 inches of snow on the ice, which is very much water-soaked; from Newburg to New York City the river is open; at Hudson and Catskill the ice is 6 inches thick and very poor; in front of Albany the ice is much honey-combed and a freshet of 4 feet would carry it out. The ice harvest is practically over along the Hudson; only a very limited amount is now being crabbled from behind the dykes. The crop to date is 50 per cent of the average.

Susquehanna River. (Reported by E. R. Demain, Harrisburg, Pa.)—The cold spell beginning the last week in January and continuing

several days into February caused a gradual fall in the waters of the Susquehanna river system and a general closing of all streams above Sunbury, as well as the Juniata branch. This was followed by mild weather and a general breaking up of the ice from the 11th to the 13th on a flood of several feet, which reached its maximum height about the middle of the month. Another moderate cold wave on the 16th and 17th caused a second gradual fall and the closing of the streams at a few of the stations on the upper river and a general closing of the Juniata. The general storm of rain and moist snow from the 18th to the 21st was followed by a moderate freshet, which carried out nearly all the ice, except in places where it lodged along the shores and will lie until it melts unless floated out on a flood. The breaking up of the ice was attended by little or no damage to property. The last week of the month was characterized by falling waters in all streams.

The average stage of water for the month exceeded that for the corresponding period last year by about 0.6 foot, although the rainfall in the river basin was only about 61 per cent of the quantity which fell in February, 1897. This increase was due doubtless to the discharge of a larger volume of snow water than occurred last year, and is a condition very gratifying to those interests liable to damage by floods, since thaws at intervals during the winter months render the occurrence of a great flood less probable than when continued low temperatures cause a large accumulation of snow on the watershed, which, when melted by a decided warm period at the opening of spring, attended perhaps by a general and heavy rain, is likely to do serious damage to property of various kinds at many places along the river. At the close of the month but little snow remained, and this was confined principally to wooded tracks and to the north side of mountains. In February, 1897, 15 river stations gave an average stage of 3.3 feet of water and 18 stations an average rainfall of 2.41 inches, while for February, 1898, the average river gauge readings of 18 stations was 3.9 feet and the average rainfall of 17 stations 1.46 inch.

Rivers of the South Atlantic States. (Reported by E. A. Evans, Richmond, Va.; C. F. von Herrman, Raleigh, N. C.; L. N. Jesunofsky, Charleston, S. C.; D. Fisher, Augusta, Ga.; and J. B. Marbury, Atlanta, Ga.)—Although an unusually light February precipitation obtained over the basin of the James River, it did not have an appreciable effect upon the stage of water. This was probably due to the slow melting of the snow which was deposited over the headwaters of the stream on January 30. During the first decade the gauge readings were slightly above zero, but with a falling tendency. On the 15th the lowest stage for the month, -0.1, was reached and maintained until the 21st, when under the influence of moderate amounts of precipitation it again went a little above zero, and remained so until the close of the month. The cold weather of the 1st to 5th caused considerable ice in the upper river, and fairly heavy ice above the falls and near Nine Mile Lock. Some of this broke and moved down on the 8th, entering the rapids and being crushed before reaching navigable water so that no damage was done by it. The shore ice remained stationary and gradually melted. There was sufficient water for milling purposes, and navigation was free throughout the month.

The Roanoke and Cape Fear rivers both maintained uniform stages throughout the month of February, and the fluctuations in the smaller streams were very slight. In fact the river conditions were quite devoid of noteworthy features, except that the continuation of the drought in North Carolina has kept all streams quite low, and much below the average for this month. The rainfall was small, occurring chiefly from the 18th to the 22d, and the State deficiency is about 3 inches. Many wells which had dried up last fall have not yet received a sufficient supply of water. The minimum stage in the Cape Fear, about 2 feet on the gauge at Fayetteville, occurred February 15, after which there was a slight rise. There was barely sufficient water to permit transportation between Wilmington and Fayetteville. River business above tidewater is about suspended on other streams.

The rainfall of the past month in South Carolina was the least of any February of which there is record. At Charleston it was the driest February (rainfall 0.51 inch) in one hundred and sixty years; the next driest, 0.53 inch, having been recorded in the year 1758. The rainfall over the drainage areas of the streams in South Carolina during February, 1897, averaged 7.25 inches; in February, 1898, it averaged only 1.03 inch. Although no rainfall occurred between the 1st and 17th, the streams were at a fairly navigable stage during that period, having received the full drainage from the moderate precipitation during the last decade in January. From the 18th to the 28th there was a slow downward tendency, although all the rainfall for the month occurred during that period. The Great Pedee, above Smiths Mills, was unnavigable the entire month, as likewise the Congaree above Granby Falls. The low condition of the streams throughout the entire month has entailed great loss to the lumber interests of eastern South Carolina. Ninety per cent of the valuable logs and cut timber remains in the swamps and at the sawmills on the upper streams awaiting favorable freshets for booming to the lower streams. Only seven rafts of logs and cut timber were received at Charleston and Georgetown during the month. Lumbermen state that such low-water conditions as those experienced during the past month have not been noted within twenty-three years; there is ordinarily at least one good freshet in February, while during this year none has occurred at all.

The rainfall for February averaged 0.68 of an inch over the upper Savannah basin, which is about 13 per cent of the usual quantity, and the bulk of that which fell occurred during the second decade of the month; this small rainfall kept the river at a stage which varied but slightly from day to day, the entire monthly range reaching but 2 feet, while the mean river was 6.3 feet, making the lowest February average on record at Augusta. In consequence of this marked deficiency the boating interests were somewhat jeopardized, as only partial loadings were carried to points both up and down stream, and from the uncertainty by reason of the shallow river many merchants resorted to rail shipments until the river steamers should be favored with a sufficient stage to enable them to be freighted to their full capacity.

The month was characterized by abnormally dry weather throughout the entire State of Georgia, and, as a consequence, all streams are low. According to records extending back to 1891, the water has not been as low in any other February as during the month just closed. At Reynolds, on the Flint, the water was below the zero point on the gauge on twenty-three days, while the highest point, at Albany on the same stream, was 1.4 foot above zero. The rains during the month were light and occurred at wide intervals, so that the water that fell was immediately absorbed by the ground and had no appreciable influence on the rivers. Many smaller streams, which act as feeders to the larger ones, have entirely dried up, something very uncommon for this season of the year. Considerable loss has been sustained by steamboat men, occasioned by the protracted low water. Shipping of all kinds has to be done by rail, much of which could have been done by steamer had the rivers been higher.

Mobile River and branches. (Reported by F. P. Chaffee, Montgomery, Ala., and W. M. Dudley, Mobile, Ala.)—The rainfall over the watershed of the Alabama and tributaries was generally light and so distributed as to exert but little effect on the rivers of this system, which gradually fell from a height of 10 to 14 feet in the Alabama and Coosa, at the beginning of the month, to scant navigable stages during the last few days; fairly good rains from the 17th to 19th and on the 26th and 27th prevented a still more rapid decline. Boats made regular trips on the Alabama during the entire month, and, owing to the slight variation in river stages, freights were handled at all river landings at comparatively little expense and trouble. Not much timber was handled, owing to insufficient water to float it to the larger rivers. The mean river stages at the several stations averaged decidedly lower than for February of past years.

The month opened with good navigable stages in the Tombigbee and Warrior rivers, and these continued, although there has been a gradual and marked decrease in all river stages since the first of the month, with the stages threateningly low at the close. This condition is of course due to the lack of rainfall to check the falls. While rain fell at intervals during the month, it was at such scattered periods that it made no material change in the river stages, and the total monthly rainfall at the several stations in this district ranged from about 1 to 1.5 inch. The water in the Warrior and upper Tombigbee rivers at the beginning of the month ran rapidly off into the lower Tombigbee, giving stages above the danger line (35 feet) at Demopolis up to and including the 5th, when the fall became sudden and continuous, and there was some apprehension as to difficulty of navigation, owing to the low stages of water in all the rivers.

Ohio River and minor branches. (Reported by F. Ridgway, Pittsburg, Pa.; H. L. Ball, Parkersburg, W. Va.; S. S. Bassler, Cincinnati, Ohio; S. P. Gresham, Louisville, Ky.; and P. H. Smyth, Cairo, Ill.)—The month opened at Pittsburg with a fair packet stage of water, carrying considerable newly made ice. Under the influence of low temperatures during the first few days the Alleghany River for the second, and the Monongahela River for the first time this winter, were closed. This condition was, however, of short duration, the mild weather and moderate rains beginning with the 7th resulting in rises out of both

rivers, bringing all of the ice with them, and producing on the 14th a stage of about 16 feet at Pittsburg. Conditions favorable for the movement of packets and heavy towing craft continued during the remainder of the month. The inclement weather and increased stage of water have interfered generally with all river construction work.

During the first week the Ohio from Wheeling to Huntington was heavy with broken and drifting ice, and its smaller tributaries were at times frozen over. Small craft were compelled to tie up, but most of the larger packets made their regular runs. The Ohio and its tributaries in West Virginia and Ohio fell slowly until the 8th or 9th. A change to decidedly warmer weather about that time caused a rapid thaw, and this, with the light and general rains of the following days, brought a slow rise, which culminated about the 15th. A second rise occurred about the 23d. At Parkersburg the first rise brought a stage of 22.1 feet on the 15th; the second, a similar stage on the 23d. After the 9th all the rivers were practically free of ice, excellent boating stages prevailed, and navigation was uninterrupted.

The month of February has come to be regarded as preeminently the month of extreme high water in the Ohio River, and the highest stages on record have occurred in that month. February, 1898, was, however, an exception, and, although an excellent boating stage prevailed throughout the month, there was at no time any apprehension of a troublesome rise. The month began with the first severe cold weather of the season, two successive cold waves, with more or less snowfall, giving a wholesome taste of winter. The river rapidly receded from the high stage of the preceding month until the 10th, when the decline ceased at a stage of 13.3 feet at Cincinnati. From the 11th to the 25th it had a steadily rising tendency, reaching 33.5 feet on the 25th, after which it again steadily fell, with every prospect of getting sufficiently low to carry off a considerable amount of spring rain without causing serious trouble. River business was good throughout the month, and, in illustration of the importance of the Ohio River as a carrier, it may be mentioned that on the 2d the steamer *Iron Age* passed this port with twelve barges, each containing one thousand tons of steel rails. To transport this tow by rail would require four hundred cars, which would make a train more than 3 miles long.

The highest stage of the river at Louisville during February was 17.1 feet, on the 1st, having fallen rapidly to this from a flood stage of 29.8 feet on January 27. The water continued to recede till February 11, when the lowest stage for the month, 6.7 feet, was recorded. A vast quantity of mud was deposited on the levees as the water receded, and it required considerable labor to clean off the landings. A slight rise in the river began on the 12th and continued to the 19th, reaching 11.3 feet. This stage was maintained up to the 25th, when another slight rise occurred. At the close of the month the river was 11.3 feet and falling. The average stage of water for the month was 10.0 feet. Navigation was not interrupted by anything during the month. All conditions in regard to the water and weather were particularly favorable, and, in consequence, all river business was carried on with energy.

At the beginning of the month the Ohio was above the danger line at all points from Evansville to the mouth, but with a falling river. At Evansville the fall continued until the morning of the 14th, the total fall amounting to 29.7 feet. The stage passed below the danger line at 4 p. m. on the 6th, and by the 7th the water had receded from all flooded lowlands in the vicinity, permitting families to move back into their dwellings. During the last half of the month the river rose, except from the 24th to 25th, when it was practically at a stand. At Paducah the fall commencing on the 1st continued until the morning of the 16th, the river declining 32.7 feet during this period. A rise from the upper river, together with a slight rise out of the Cumberland, started the river up on the 16th, and continued it at a rising stage to the end of the month. Navigation to and from nearly all points has been regular and uninterrupted. The Tennessee and Cumberland river boats are all doing good business, and so also are the Evansville regular packets. The Cincinnati and the Memphis and New Orleans boats seem to be taxed to their full capacity.

At Cairo the river fell from 44.3 feet at the beginning of the month to 17.0 feet on the morning of the 16th, passing below the danger line on the 6th. From the 8th to 11th the daily fall averaged very nearly 3.4 feet. A rise out of the Mississippi backed the Ohio up at Cairo on the morning of the 16th, and this rise, together with occasional slight rises out of the upper Ohio and Cumberland, kept the river rising until the night of the 25th. A slight fall set in on the 26th, and continued to the close of the month. Considerable lumber has arrived at Cairo during the month, in fact more lumber has been handled during February than has been the case for any month during the past six months, and the prospects are that March will show an increase over February.

Tennessee and Cumberland Rivers. (Reported by L. M. Pindell, Chattanooga, Tenn., and H. C. Bate, Nashville, Tenn.)—During the entire month boats were able to run on the Tennessee although the river was falling slowly except on the 22d, when a slight rise started in at Chattanooga. The river has been navigable for the past twenty years during the month of February. The highest water recorded in February at Chattanooga was 37.5 feet on the 14th, in 1891. In 1897 the highest water at Chattanooga was 35.1 feet on the 26th, against 7.9 feet this year on the same date. The river remained low at the headwaters

during the month; at Speers Ferry, Va., the river was at a stage of one foot or less the entire month except on the 1st, 22d, and 23d. The rainfall was exceedingly light over the watershed during the month, the amount at Chattanooga being the least recorded in the past twenty years. More snow fell this year in February than in 1897. Five inches fell at Bluff City, N. C., and Speers Ferry, Va., and 6 inches at Tazewell, Tenn. The month closed with the river falling slowly and with conditions favorable for navigation, closing to large boats during the early part of March, when the river will probably be below the 3-foot stage.

The Cumberland River was at good stage but falling rapidly at the opening of the month. It continued falling till about the 12th, and was closed to navigation above Celina for several days at that time. Light rains soon brought it to a navigable stage again, and have held it practically stationary ever since. At the close of the month it is falling slowly and, without immediate rains, will be closed above Carthage by the 5th of March.

Mississippi River and minor branches. (Reported by P. F. Lyons, St. Paul, Minn.; M. J. Wright, Jr., La Crosse, Wis.; F. H. Duff, Davenport, Iowa; F. Z. Gosewisch, Keokuk, Iowa; H. C. Frankenfield, St. Louis, Mo.; P. H. Smyth, Cairo, Ill.; S. C. Emery, Memphis, Tenn.; R. J. Hyatt, Vicksburg, Miss.; and R. E. Kerkam, New Orleans, La.)—There is more snow on the watershed above St. Paul than there was at the end of January, but it hardly averages 4 inches in depth, and hence there need be no fear of a more than ordinary stage of water from that source the coming spring. The rivers remained frozen over all the month, and at its close the ice was strong and firm; by actual measurement it was 18 inches thick at St. Paul, the greatest thickness, 20 inches, being measured on the 7th.

The moderately heavy rains on the 10th had but little effect aside from decreasing for a few days and about 3 inches the thickness of the ice, and increasing to a corresponding degree the stage of the water in the river. It is estimated that a maximum stage of 3.2 feet had attained at St. Paul on the 15th, and a minimum of 2.6 feet on the 28th.

The river in the vicinity of LaCrosse was closed during the entire month, the ice ranging in thickness from 13 to 21 inches. The ice harvest was completed about the 20th, which is somewhat earlier than usual, the weather having been favorable for the harvest throughout the season. The present season was one of the best during the past twelve years. An unusually warm period prevailed from the 8th to the 11th, which interfered to some extent with lumbering operations in the Black River country on account of the general thaw which occurred. The outlook for river business the coming season is said to be good, provided there is sufficient water in the spring to drive the logs.

Ice in varying thickness, from 15 to 16 inches, continued in the river at Dubuque during February. Rain and moderately high temperatures softened the surface and shore ice somewhat during the second week, but colder weather hardened it again on the 15th. There were 3 inches of snow on the ground at the close of the month.

At LeClaire, Iowa, about 15 miles above Davenport, the river remained frozen all the month. On the 13th the ice went off the rapids between LeClaire and Davenport, the river becoming open as far as the bridge between Davenport and Rock Island. On the morning of the 14th the water marked 10 feet on the gauge, and the ice piled up considerably opposite the central part of the city, but near the lower end of town it hardly moved at all; after the 14th the water gradually fell. On the 19th floating ice began to fill the open space at the bridge, and on the morning of the 20th this ice was stationary. On the 21st the river was frozen to a point about one-fourth mile above the bridge, and by the morning of the 22d the stationary ice had been added to until the river was frozen three-fourths of a mile from the bridge. By the 25th the river was again frozen for a short distance above the city limits. The river remained frozen all the month from West Davenport to Muscatine, about 28 miles below. At the close of the month the ice was about 18 inches thick opposite West Davenport, while it was not more than 8 or 10 inches in thickness above the bridge.

The ice, which remained solid at the close of January, began breaking on the Des Moines Rapids during the night of the 10th, large fields being loosened by the current, breaking up and packing below. This movement continued during the 11th and 12th, swelling the stage of water to 10 feet. During the night of the 12th the gorges south were broken by the increased pressure of the water released from the north and the channel opened. On the 21st the channel was reported open to Burlington bridge, though the ice remained solid north of that point. At the close of the month the channel remains open to Burlington, while heavy shore ice continues in shallow water. Fluctuation in the river stage between the 13th and 19th was sudden and irregular, caused by the release of volumes of water by the breaking away of masses of ice north. Since the 19th the fall has been steady and the month closes with a stage of 2.2 feet. The liability of the river ice shifting at this point renders it undesirable for ice cutting; the Des Moines Rapids Canal, however, offers a field easy of access and safe.

Owing to the prevailing warm weather during the greater portion of February, the snow and ice farther south melted rapidly, resulting in a steadily rising river at St. Louis until the last week of the month, notwithstanding the fact that the precipitation had been somewhat

deficient. At Hannibal the extreme range of the water was over 6 feet, while at St. Louis it was 9 feet. The cold wave which commenced on January 31 continued until February 4, and caused a general re-formation of ice gorges as far south as Hannibal bridge. Below the bridge the river was well filled with floating ice as far south as St. Louis on the 1st, and navigation, both north and south, was entirely suspended on the 2d, with the exception of the ferryboat service at St. Louis. On the 3d a slight gorge prevailed above the St. Louis bridge for a short time, compelling the North Market Street ferryboats to suspend operations for a few hours. On the 4th people were again crossing on the ice at Hannibal, and at St. Louis it was fast on the east shore. On the 7th the river was once more clear at St. Louis. On the 9th the ice disappeared at Grafton and Louisiana and moved slightly at Hannibal, blocking again, however, in a short time. At 7:30 p. m. on the 10th this gorge finally broke and the ice all ran out, leaving the river clear to Quincy. On the 22d and 23d colder weather again caused light ice at all points, but it rapidly disappeared under the influence of higher temperatures which followed.

The Illinois River was practically closed until the 8th, when the ice commenced to move.

Navigation south was fully resumed on the 9th, and on the 11th the steamer *Eileen* arrived from the north for the second time this year. By the 12th navigation northward was fairly opened for the season as far as Clarksville, Mo. On the 14th the steamer *Hill City* departed for New Orleans, being the first through packet to leave St. Louis.

From St. Louis to Cairo the low stage of the river from the 1st to the 9th permitted of navigation in only a light way, but during the remainder of the month a good boating stage was maintained. Light ice, not sufficient to interfere with navigation, passed down the river on the 3d and 8th.

At Cairo there was very little change in the stage during the first week of the month; a steady fall then set in and continued until about the 18th. Combined rises out of the Ohio and upper Mississippi started the lower river up on or about the 19th, and kept it rising during nearly the remainder of the month. At the end of the month conditions were favorable for an early decline.

On February 1 the Mississippi River from Cairo to Memphis was above the danger line, and at Helena it was only about 2 feet below that mark, and rising. The stage at Memphis on February 1 was 33.3 feet, and by February 3 it had increased to 33.6 feet, the maximum stage, where it remained until the 7th, and then a fall set in. For the first two or three days the fall in the river was only moderate, but by the 18th it had become much more rapid, and during the following week the daily decline amounted to 1.5 foot. The lowest stage for the month, 11.9 feet, was reached on February 19, when a further lowering of the water was prevented by a slight swell which had for several days previous, been working its way down the Ohio River. This second rise began at Memphis on February 20, and continued up to the end of the month, the gauge reading at that time being 17.9 feet. The rapidity which marked the subsidence of this flood wave is even more remarkable than its rise. The time intervening between the first rise and the point of decline was twenty-three days, the average daily rise being 1.2 foot. The fall to a normal stage occurred in twelve days, the daily average amounting to 1.8 foot. The total fall amounted to 21.7 feet, 92 per cent of which occurred in eight days.

The movement of the flood wave was as follows: The crest passed Cairo January 31 at a 44.4-foot stage; Memphis, February 5, with 33.6 feet on the gauge; and Helena on February 8, when the river stood at 43.1 feet. At these stages the river was bank-full, and in many places flowed over into the lowlands of Arkansas. Opposite Memphis a considerable area became covered with water, at depths varying from 2 to 6 feet, but no great damage resulted therefrom. After the subsidence of the flood, a good boating stage existed over the whole distance from Cairo to Helena, and business was fully up to the average for this season. Reports from the levee camps are of a very favorable character. The Craghead Point levee is nearly closed, and when this is done the St. Francis levee line will be complete to a point within 30 miles of Memphis. South of Memphis the levee work is progressing satisfactorily, and now that the water has subsided, there is no longer any doubt in regard to the closing of all crevasses before the spring rise.

The rivers south of Memphis were fairly high during the month, with the stage of water above danger line at Vicksburg from the 4th to the 17th. Work on the levees was pushed to meet this stage, and no damage occurred except at the Reid levee, about 6 miles below Vicksburg on the Louisiana side, where the protection levee broke, causing considerable delay in the work on the main line of levee. Navigation and river traffic continued good during the month. Heavy fog was reported along the river at intervals during the month, slightly impeding business. The river bank above Greenville was reported caving and filling the river with foam.

The Mississippi, below Vicksburg, continued rising until the middle of the month, after which a fall began just below Vicksburg and continued to the close of the month. The maximum stage of 15 feet at New Orleans occurred on the 17th.

The Ouachita continued its rapid fall at Camden during the first decade of the month, and during the same period a slight rise continued at and below Monroe. The decline in the lower Ouachita set in about

the middle of the month. There was ample water for purposes of navigation during the month.

Missouri River. (Reported by L. A. Welsh, Omaha, Nebr.; P. Connor, Kansas City, Mo.; and H. C. Frankenfield, St. Louis, Mo.)—From a point above the mouth of the Yellowstone, near the line between North Dakota and Montana, southward to a few miles above Omaha, the Missouri River remained frozen throughout the month. At all points along the upper river the ice is reported to be weak and rotten, and the early breaking up of the ice is generally predicted. On the night of the 24th and 25th the ice in the river at Omaha began to break up and run out. The break first began at a point a little above the Douglas street bridge, and a channel about 300 feet wide was soon opened that extended down the river past the city, becoming much wider below the Union Pacific Railway bridge. By the night of the 27th the river had opened as far north as Florence, Nebr., or about 6 miles above Omaha, and reports received from below Omaha indicate that the ice is running out.

The river at St. Joseph, Mo., was closed until the 13th, when the ice began to break up and run out. At Kansas City floating ice appeared from the 1st to 6th and from the 19th to 24th; otherwise the river was clear. There was a range of 4.3 feet in the stage of the river, the lowest being on the 4th and the highest on the 18th. Nothing of importance transpired along the lower Missouri River during the month. Light floating ice was observed at various times until the 26th, and the stage of water averaged somewhat higher on account of absence of cold weather.

Arkansas River. (Reported by J. J. O'Donnell, Fort Smith, Ark., and F. H. Clarke, Little Rock, Ark.)—The month was exceptionally droughty in the central Arkansas Valley. The result was a steadily falling river until the 12th. However, the heavier rains through Oklahoma and the Canadian Valley caused a rise of 5.5 feet from 5 p. m. of the 12th to 11 a. m. of the 15th, the gauge at Fort Smith then registering 8.1 feet. After remaining stationary for a few hours the river began to fall, and continued steadily falling to the end of the month. Owing to backed water from the Arkansas work on the bridge over the Poteau River, one mile above its mouth, was discontinued for three days. The river gauge to be fixed at Webbers Falls was shipped there on the 15th. The establishment of a gauge at that point will be of very great benefit to navigation from Fort Smith, besides being useful in determining the volume of water that comes from the upper Arkansas and the Grand and Verdigris rivers, as Webbers Falls is 14 miles west of the mouth of the Canadian River. Excepting the first half of the second week navigation was pursued uninteruptedly and advantageously during the month between Fort Smith and all points to Webbers Falls.

The Arkansas River south of Fort Smith declined steadily to February 11, when a slight rise was felt, which was lost on the following day; it then rose steadily for the three following days, reaching its highest stage for the month at Dardanelle on the 17th, and at Little Rock on the 20th. During this rise the river rose 5.1 feet at Fort Smith, 5.3 feet at Dardanelle, and 4.3 feet at Little Rock, the crest of the rise taking two days to travel from Fort Smith to Dardanelle, and four days to reach Little Rock.

A good boating stage was maintained in the river south of Little Rock throughout the month, but it was too low for profitable navigation between Dardanelle and Little Rock from the 9th to 14th and on the 27th and 28th. No ice was reported in the river during the month, nor drift that impeded navigation.

Red River. (Reported by C. Davis, Shreveport, La., and R. E. Kerkam, New Orleans, La.)—Despite the absence of notable precipitation in its watershed, the Red River was characterized by stages amply sufficient for navigation. At Shreveport the month opened with 10.8 feet on the gauge; decreasing stages prevailed until the 17th, when the lowest reading, 5.4 feet, for the month was recorded; the latter part of February was marked by a rise of several feet, followed by a gradual fall at its close.

Heights of rivers above zeros of gauges, February, 1898.

Stations.	Distance to mouth of river.	Danger line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
<i>Mississippi River.</i>	Miles	Feet.	Feet.		Feet.		Feet.	Feet.
St. Paul, Minn. †	1,957	14						
Reeds Landing, Minn. †	1,887	12						
La Crosse, Wis. †	1,822	10						
North McGregor, Iowa †	1,763	18						
Dubuque, Iowa †	1,702	15						
Leclaire, Iowa †	1,612	10						
Davenport, Iowa †	1,596	15						
Keokuk, Iowa †	1,466	14	9.8	13	2.2	27, 28	4.4	7.6
Hannibal, Mo.	1,405	17	6.1	18	0.1	2	3.1	6.2
Grafton, Ill.	1,307	23	9.2	21	3.0	3, 4	6.0	6.2
St. Louis, Mo.	1,264	30	12.3	22	3.2	6	7.4	9.1
Chester, Ill.	1,189	30	8.5	23	2.1	7, 8	5.1	6.4
Cairo, Ill.	1,073	40	44.3	1	17.0	16	27.9	27.3
Memphis, Tenn.	843	33	33.6	3-6	11.9	19	23.6	21.7
Helena, Ark.	767	44	43.1	7, 8	18.8	21, 22	32.2	24.3
Arkansas City, Ark.	635	42	43.6	11	24.1	24, 25	36.0	19.5
Greenville, Miss.	595	40	37.9	11	19.6	25	31.0	18.3

Heights of rivers above zeros of gauges—Continued.

Stations.	Distance to mouth of river.	Danger line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
<i>Mississippi River—Cont'd</i>	Miles.	Feet.	Feet.		Feet.		Feet.	Feet.
Vicksburg, Miss.	474	41	43.0	13-14	26.0	28	38.0	17.0
New Orleans, La.	108	16	15.0	17	11.1	28	13.8	3.9
<i>Arkansas River.</i>								
Wichita, Kans.	730	10	2.7	12, 13	1.4	1-3	2.0	1.3
Fort Smith, Ark.	345	22	7.9	15	2.6	11, 12	4.1	5.3
Dardanelle, Ark.	250	21	6.8	17	1.5	12-15	3.0	5.3
Little Rock, Ark.	170	23	8.1	20	3.8	13, 15, 16	5.4	4.3
<i>White River.</i>								
Newport, Ark.	150	26	8.7	1	3.5	21-24	5.0	5.2
<i>Des Moines River.</i>								
Des Moines, Iowa †	150	19						
<i>Illinois River.</i>								
Peoria, Ill.	135	14	13.2	22-24	6.9	9, 10	10.2	6.3
<i>Missouri River.</i>								
Bismarck, N. Dak. †	1,201	14						
Pierre, S. Dak. †	1,006	14						
Sioux City, Iowa †	876	10						
Omaha, Nebr. †	561	18						
St. Joseph, Mo.	373	10	2.9	17	0.7	9	1.9	2.2
Kansas City, Mo.	280	21	9.2	18	4.9	4	6.5	4.3
Boonville, Mo.	191	20	8.0	20	3.5	6	6.0	4.5
Hermann, Mo.	95	24	7.5	20	2.6	7	5.0	4.9
<i>Ohio River.</i>								
Pittsburg, Pa.	966	22	14.4	14	2.5	4	7.7	11.9
Davis Island Dam, Pa.	960	25	13.5	13	4.3	4	8.8	9.2
Wheeling, W. Va.	875	36	21.4	14	5.8	6	12.2	15.6
Parkersburg, W. Va. †	785	35	22.1	15, 23	8.0	7-9	14.8	14.1
Point Pleasant, W. Va.	703	36	26.0	24	6.7	8	16.3	19.3
Catlettsburg, Ky.	651	50	30.5	24	9.0	8	20.1	21.5
Portsmouth, Ohio	612	50	31.5	24	10.7	9	21.7	20.8
Cincinnati, Ohio	499	45	36.9	1	13.3	10, 11	25.0	23.6
Louisville, Ky.	367	24	17.1	1	6.7	11	10.0	10.4
Evanville, Ind.	184	30	41.4	1	11.7	14	23.5	29.7
Paducah, Ky.	47	40	43.7	1	11.0	16	23.2	32.7
<i>Alleghany River.</i>								
Warren, Pa.	177	7	8.2	13	1.8	9-10	3.5	6.4
Oil City, Pa.	123	13	10.2	13	2.3	5, 6, 8, 9	4.2	7.9
Parkers Landing, Pa.	73	20	13.0	13	2.5	6-8	4.8	10.5
Freeport, Pa.	26	20	16.1	13	3.8	7	8.5	12.3
<i>Conemaugh River.</i>								
Johnstown, Pa.	64	7	3.6	12	1.7	6-8	2.5	1.9
<i>Red Bank Creek.</i>								
Brookville, Pa.	35	8	2.5	13	0.7	7-11, 28	12.2	1.8
<i>Beaver River.</i>								
Ellwood Junction, Pa.	10	14	6.9	13	1.7	27-28	3.2	5.2
<i>Cumberland River.</i>								
Burnside, Ky.	434	50	7.0	14	2.8	10, 11	4.5	4.2
Carthage, Tenn.	257	30	9.3	1	3.7	11	5.2	5.6
Nashville, Tenn.	175	40	19.2	1	5.8	12-14	8.2	11.0
<i>Great Kanawha River.</i>								
Charleston, W. Va.	61	30	7.9	22	3.0	4-6	5.3	4.9
<i>New River.</i>								
Hinton, W. Va.	95	14	3.2	22	1.3	4, 5	2.1	1.9
<i>Licking River.</i>								
Falmouth, Ky.	30	25	9.0	21	2.2	11	4.0	6.8
<i>Miami River.</i>								
Dayton, Ohio	69	18	4.3	21	1.9	8	2.8	2.4
<i>Monongahela River.</i>								
Weston, W. Va.	161	18	5.0	2	0.4	28	1.9	4.6
Fairmont, W. Va.	119	25	7.8	21	1.2	8	3.2	6.6
Greensboro, Pa.	81	18	13.0	22	8.2	1, 27, 28	9.2	4.8
Lock No. 4, Pa.	40	28	16.6	22	7.3	5	10.1	9.3
<i>Cheat River.</i>								
Rowlesburg, W. Va. †	36	14	6.0	19, 21	2.9	10, 11	4.5	3.1
<i>Youghiogheny River.</i>								
Confluence, Pa.	59	10	5.8	12	1.5	28	2.9	4.3
West Newton, Pa. †	15	25	5.8	11	1.6	28	3.2	4.2
<i>Muskingum River.</i>								
Zanesville, Ohio	70	20	17.3	22	8.0	4	12.0	9.3
<i>Tennessee River.</i>								
Knoxville, Tenn.	614	29	3.8	1	1.7	19, 20, 28	2.4	2.1
Kingston, Tenn.	534	25	3.7	1	1.2	27, 28	1.8	2.5
Chattanooga, Tenn.	490	33	7.9	1	3.2	21, 32	4.2	4.7
Bridgeport, Ala.	390	24	6.8	1	1.8	20-24	2.7	5.0
Florence, Ala.	220	16	10.3	1	1.9	25-26	3.5	8.4
Johnsonville, Tenn.	94	21	23.8	1	3.4	27	7.6	20.4
<i>Clinch River.</i>								
Speers Ferry, Va.	156	20	1.8	22	0.2	17, 19	0.6	1.6
Clinton, Tenn.	46	25	7.0	1	4.1	12, 13	5.0	2.9
<i>Wabash River.</i>								
Mount Carmel, Ill.	50	15	21.9	1	6.9	12, 13	10.8	15.0
<i>Red River.</i>								
Arthur City, Tex.	688	27	8.7	17	3.0	4, 5	4.8	5.7
Fulton, Ark.	565	28	10.4	18	3.6	10	6.2	6.8
Shreveport, La.	449	29	10.8	1	5.4	16, 17	7.1	5.4
Alexandria, La.	139	33	16.9	1	10.8	18	13.0	6.1
<i>Atchafalaya Bayou.</i>								
Melville, La.	100*	31	32.2	17, 18	28.0	28	31.1	4.2
<i>Ouachita River.</i>								
Camden, Ark.	340	39	25.3	1	9.5	28	13.4	15.8
Monroe, La.	100	40	35.9	12, 13	32.3	28	34.8	3.6
<i>Pazoo River.</i>								
Yazoo City, Miss.	80	25	23.8	16-18	21.2	28	22.9	2.6
<i>Chattahoochee River.</i>								
Columbus, Ga.	140	20	2.5	1	0.5	17, 27, 28	1.0	2.0
<i>Flint River.</i>								
Albany, Ga.	80	20	2.3	23	1.4	17	1.8	0.9
<i>Cape Fear River.</i>								
Fayetteville, N. C.	100	38	6.0	23	2.2	15	4.1	3.8
<i>Columbia River.</i>								
Umatilla, Oreg.	270	25	10.3	17	2.5	3-6	5.4	7.8
The Dalles, Oreg.	160	40	16.5	18	2.5	2	8.1	14.0

Heights of rivers above zeros of gauges—Continued.

Stations.	Distance to mouth of river.	Danger line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
<i>Willamette River.</i>	Miles.	Feet.	Feet.		Feet.		Feet.	Feet.
Albany, Oreg.....	99	20	10.3	8	4.0	1,2	7.0	6.3
Portland, Oreg.....	10	15	11.3	19	3.4	2	8.2	8.9
<i>Edisto River.</i>								
Edisto, S. C.....	75	6	3.5	1,2	2.3	16	2.8	1.2
<i>James River.</i>								
Lynchburg, Va. *.....	257	18	1.5	1,23	0.4	17-19	0.8	1.1
Richmond, Va.....	110	12	0.7	1	- 0.1	15-21	0.2	0.8
<i>Alabama River.</i>								
Montgomery, Ala.....	265	35	10.5	1	1.2	26,27	2.7	9.3
Selma, Ala.....	212	35	14.8	1	1.4	25-27	3.6	13.4
<i>Coosa River.</i>								
Rome, Ga.....	225	30	3.6	1	1.2	17-28	1.7	2.4
Gadsden, Ala.....	144	18	5.5	1	0.6	27,28	1.8	4.9
<i>Tombigbee River.</i>								
Columbus, Miss.....	285	33	13.2	1	- 0.9	16,17	1.6	14.1
Demopolis, Ala.....	155	35	46.0	1	4.9	28	16.7	41.1
<i>Black Warrior River.</i>								
Tuscaloosa, Ala.....	90	38	21.7	1	3.6	26,27	7.4	18.1
<i>Pedee River.</i>								
Cheraw, S. C.....	145	27	2.9	23,23	0.9	17,18	1.6	2.0
<i>Black River.</i>								
Kingstree, S. C.....	60	12	3.7	2,3,8,9	3.0	26-28	3.4	0.7
<i>Lumber River.</i>								
Fairbluff, N. C.....	10	6	2.5	4	0.9	18,19	1.7	1.6
<i>Lynch Creek.</i>								
Effingham, S. C.....	35	12	6.9	3	3.5	17,18	4.5	3.4

Heights of rivers above zeros of gauges—Continued.

Stations.	Distance to mouth of river.	Danger line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
<i>Potomac River.</i>	Miles.	Feet.	Feet.		Feet.		Feet.	Feet.
Harpers Ferry, W. Va....	170	16	5.7	22	2.0	8,9	2.6	3.7
<i>Roanoke River.</i>								
Clarksville, Va.....	155	12						
<i>Sacramento River.</i>								
Redbluff, Cal.....	241	23	12.0	28	0.4	1-3	3.7	11.6
Sacramento, Cal.....	70	25	15.3	9,26,27	9.3	1	13.2	6.5
<i>Santee River.</i>								
St. Stephens, S. C.....	50	12	7.4	2-4	1.3	18-20	3.5	6.1
<i>Congaree River.</i>								
Columbia, S. C.....	37	15	1.5	1,2,21-24	1.0	26	1.3	0.5
<i>Wateree River.</i>								
Camden, S. C.....	45	24	5.6	1	3.0	27,28	3.8	2.6
<i>Savannah River.</i>								
Augusta, Ga.....	130	32	7.8	1	5.8	27	6.3	2.0
<i>Susquehanna River.</i>								
Wilkesbarre, Pa.....	178	14	11.0	13	4.0	18,28	7.8	7.0
Harrisburg, Pa.....	70	17	7.8	24	2.7	4-7	4.9	5.1
<i>Juniata River.</i>								
Huntingdon, Pa. †.....	80	24	5.2	12-14	4.0	4,26-28	4.5	1.2
<i>W. Br. of Susquehanna.</i>								
Williamsport, Pa.....	35	20	8.4	13	2.1	4	4.4	6.3
<i>Waccamaw River.</i>								
Conway, S. C.....	40	7	2.1	24,25	1.0	18,19	1.5	1.1

† Frozen entire month. * Record for 16 days. † Record for 26 days. ‡ Record for 27 days. § Record for 20 days. ¶ Record for 24 days. †† Record for 17 days.

SPECIAL CONTRIBUTIONS.

THE SEARCH LIGHT FOR WEATHER SIGNALS.

By EDGAR B. CALVERT.

The recent sinking of the battleship *Maine* in the harbor of Habana recalls to the minds of many Weather Bureau officials the first experiments made by the Government on an elaborate scale for the purpose of demonstrating the availability and value of a search light in disseminating warnings of frost, cold waves, and storms. In the early part of February, 1895, by courtesy of the Navy Department, the search light for the battleship *Maine*, then nearing completion, was loaned to the Department of Agriculture for temporary use at the Chicago office of the Weather Bureau. The Secretary of Agriculture asked the Navy Department for the loan of the instrument at the suggestion of Col. H. H. C. Dunwoody, at that time Assistant Chief of the Weather Bureau. The experiments were conducted by the present Chief of the Weather Bureau, who was then in charge of the Chicago office. The apparatus was erected on the coping of the Auditorium building at an elevation of 270 feet above street level. Its lens was 30 inches in diameter, and its electric light was estimated at about 100,000 candle power.

After some experimentation the following code was adopted:

Revolving beam of white light: Cold-wave or frost.

Revolving beam of red light: Marine storm with high easterly winds.

Revolving beam of red and white (pencil of light half and half each color): Marine storm with high westerly winds.

The white light was adopted for both cold wave and frost, because no confusion in the meaning of the signal was anticipated, as it would always mean frost in the early spring, after vegetation had started, and in the early fall, before a killing frost had occurred. It was found that the red light had a penetrating power a little less than 60 per cent of that of the white light.

The instrument was installed and the necessary electric connections made about February 15, 1895, but an opportunity for a practical demonstration of the value of the search light as a means of giving warning of impending meteorological conditions did not occur until the evening of February 28, 1895. At that time forecasts for the northwestern States were made at Chicago. The morning charts of that

date indicated the possibility of a cold wave for Chicago and vicinity, preceded by high northwest gales; but the conditions were not sufficiently marked to warrant the issuing of cold-wave and storm warnings. Special observations were called for from stations in the region of the cold wave to the west. These reports were received at the Chicago office and charted about 1 o'clock in the afternoon, and from them it became apparent that the cold wave would reach that city by the following morning. After the forecast was prepared it was too late for the information to be published in the afternoon papers, as they go to press about 2 p. m. The search light had to be depended upon to give immediate warning of the coming cold.

The temperature during the afternoon of February 28 reached a maximum of 62°, and by the afternoon of the next day there was a fall of 42°, fully justifying the prediction.

The conditions were peculiarly favorable for a successful trial, the night being dark and cloudy. Shortly after the last rays of twilight had faded away the search light was adjusted, and the electric current turned on. A great beam of intensely white light pierced the blackness of the night. The machine was slowly revolved at the rate of one revolution in five minutes, and for about one and one-half hours the light was flashed over the city. To those stationed on the tower of the building the beam appeared intensely bright. It seemed to rest on the dense cloud of smoke that almost continually envelops the city. Its effect was striking and beautiful.

The press of the city had been notified in the late afternoon that a practical test would be made, and several editors had stationed observers in the various suburbs of the city at distances of 10 to 30 miles from the Weather Bureau office to watch for the light. From these observers and other persons it was ascertained that the signal was clearly seen at a distance of 20 miles. It was impossible to make an estimate of the number of persons who observed the light and understood its meaning, but as nearly 2,500,000 people reside in the district within a radius of 25 miles from the Auditorium building, the number must have been considerable, especially in view of the fact that the local press had on several occasions previous to this trial given notice of the presence of the search light in the city and explained its contemplated use. Many