ALASKA TELEMETERING NETWORK FOR THE CORPS OF ENGINEERS AND THE U. S. WEATHER BUREAU[1/]

By

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In August 1967, the worst flood in the history of Fairbanks, Alaska occurred when the Chena River went over its banks. Newspapers and residents pointed out the disastrous proportions of the flood and left no doubt that it was far greater than any previously known flood. The City of Fairbanks, Alaska, and the most heavily populated suburbs are located on both banks of the Chena River and North of the Tanana River. The Chena River flows into the Tanana River approximately 10.5 miles downstream from the City center.

The main flood season for the Chena and Tanana Rivers is in the spring and summer. Most of the higher floods have resulted from heavy spring runoff and the sometimes accompanying ice jams. However, floods due to intense rains can occur in the summer, and large floods may occur any time between 1 April and 1 October, particularly on the Chena River. The flood of August 1967 was the result of intense rains in the Chena River basin.

In response to the problems created by the August 1967 flood and reinforced by the previous floods of the Chena and Tanana Rivers, a totally new river level reporting system was developed <u>to provide rapid information for flood warning and forecasting</u>.

This system was developed through the co-ordinated efforts of the U.S. Weather Bureau, U.S. Geological Survey, and the U.S. Army Corps of Engineers.

The primary purpose of the system is to provide information through the use of a teletype reporting system to the Alaska District, Corps of Engineers at Anchorage and the U.S. Weather Bureau at Anchorage and Fairbanks for flood warning and river level forecasting. This will enable the Weather Bureau to forecast river stages with greatly increased precision for more effective protection of property and life.

The Alaska Telemetering System provides for the gathering of river level data at six remote locations. It has been designed for expansion and eventually we hope to obtain rainfall and snow cover data at strategic locations throughout the river basins.

The system diagram, figure 1, and the map of the region, figure 2, show the sites chosen for the remote stations.

The locations representing the remote reporting stations were chosen to give adequate warning of impending high water at potential damage areas downstream. Housed at these remote stations are river level sensing devices and electronic equipment for translating and transmitting these readings into VHF radio signals. These RF signals are sent to the central interrogation relay station at Moose Creek Bluff. In the case of four of the reporting stations, the Upper Chena, Salcha River, Tanana River and the Nenana, radio repeater stations are employed for extension of the VHF link.

The central interrogation station is located at the Moose Creek Bluff Army Installation. It sends out pre-programmed automatic time-clock controlled requests over a radio link for river level readings at regular intervals. The remote reporting stations then respond with this information. Manual interrogation may also be made at any time from any teletype station along the network. Information received at the central interrogation station is then converted for teletype transmission. At this point, the data is sent along the White Alice and the Alaskan Communications multichannel microwave link.

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Three of the six stream gauging stations are located on the Chena River system. Furthest upstream is the gauge on the bridge at about Mile 35 on the Chena Hot Springs Road. This will provide early information on runoff in the Upper Chena Basin. A second gauge on the Little Chena River bridge crossing on the Chena Hot Springs Road will furnish information on the Little Chena River, a major tributary of the Chena River which reacts more quickly to rainfall or snowmelt than does the main stem.

Information on the actual conditions in the Fairbanks area will be furnished by the third gauge on the Chena located slightly upstream of the Wendell Street bridge in Fairbanks.

Just upstream of the highway bridge on the Salcha River, a fourth gauge will provide information on inflow into the Tanana. It will be especially valuable in providing an index to the magnitude of Chena River floods because the Salcha River reacts more quickly to rainfall but is otherwise similar to the Chena basin.

Of the two gauges located directly on the Tanana River, the most upstream one, near Harding Lake, will provide necessary data to forecast Tanana River stages at Fairbanks and Nenana as well as other downstream points on the Tanana. The second gauge will be located at Nenana to furnish information on the river level there.

These unattended remote stations must maintain reliable operations in a fail-safe mode over extended periods of time. To insure continuous operation at all times, the internal batteries are charged by thermal units or solar cells. Therefore the power drain has to be minimized. The stations must be extremely rugged for reliable operation under the adverse environmental conditions that a remote Alaskan site can provide. To guarantee the high performance necessary for this system, the circuitry of this equipment must be all solid state. An exploded view of the remote station is shown in figure 3.

Transmission of the data is to be accomplished by the use of digital techniques such that the accuracy of the data will not be affected by the transmission method or temperature extremes. In the digital transmission system, security coding and redundancy are to be used extensively. Other advantages of using digital techniques are the ease of dissemination of the information to a number of potential users over existing communications facilities and transposition to teletype or computer input.

With the employment of the system being so flexible, and the need for future expansion most important, modular construction is indicated. Also, servicing problems have to be simplified because competent electronic technicians are not always available. With modular construction, repairs can easily be made by substitution. This feature allows for easy expansion, modification or adaption as well as ease of maintenance. These stations are to be maintained by replacing a standard set of printed circuit plug-in modules. As a result of these techniques, we are to have stations that are small and light-weight enough to be installed and removed by a helicopter or even a dog-team sled. Typical circuit boards are shown in figure 4.

The Alaska Telemetry System developed by Motorola utilizes a binary encoded digital data link specifically designed for use with VHF-FM radio equipment. The latest generation of all silicone integrated circuits are used in the data converters and programming logic. All the radio equipment is composed of high reliability solid state devices. The central station with its teletype printer is shown in figure 5. Figure 6 is the central station functional block diagram. At the central station, pre-programmed automatic interrogation is done in terms of a preset time interval in hours and minutes which establishes an 8, 4, 2, 1 BCD format relating to this time. When the built-in digital clock output corresponds to this coded time, an interrogation cycle begins automatically. The cycle can be started manually from any remote teletype unit in the system as well as the push button at the central station.

Once the interrogation cycle has started, the VHF transmitter at the central station is turned on. The transmitter uses FSK modulation as well as an additional tone corresponding to the "private line" feature of the radio system. The FSK modulation is sent for a period of 60 milliseconds to one second to insure capture of the remote receiver and any repeater stations necessary. The desired remote station address in a BCD format is then transmitted. The addresses of all remote stations are permanently stored in BCD

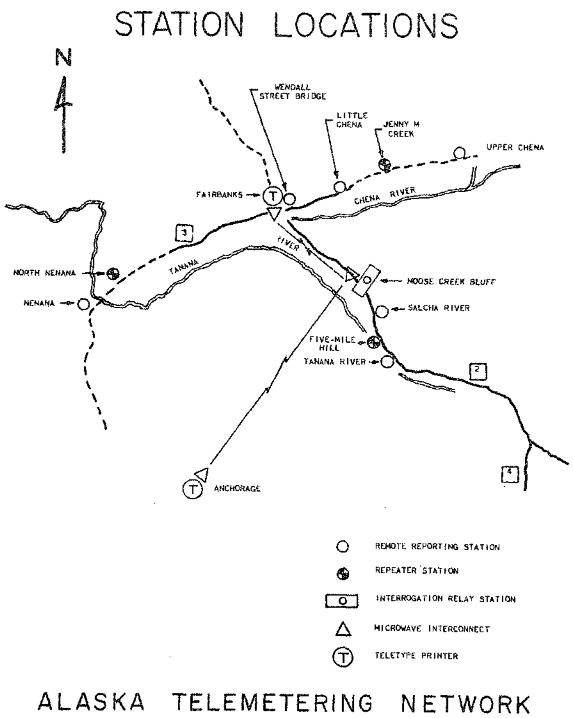


Figure 1.

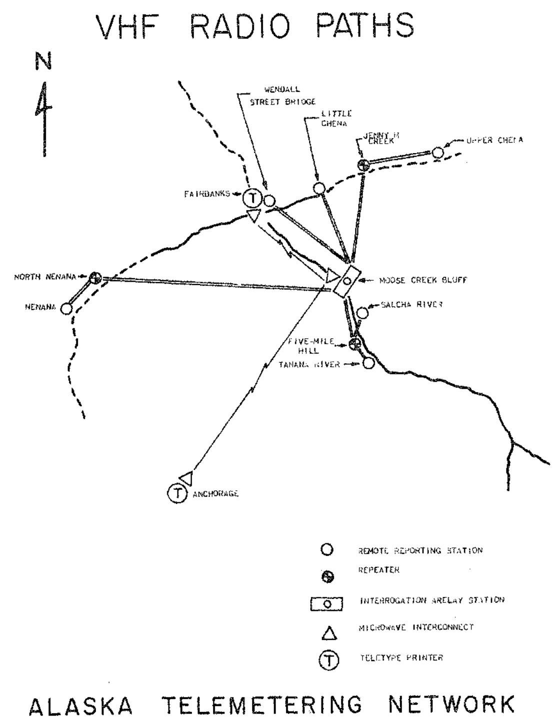


Figure 2.

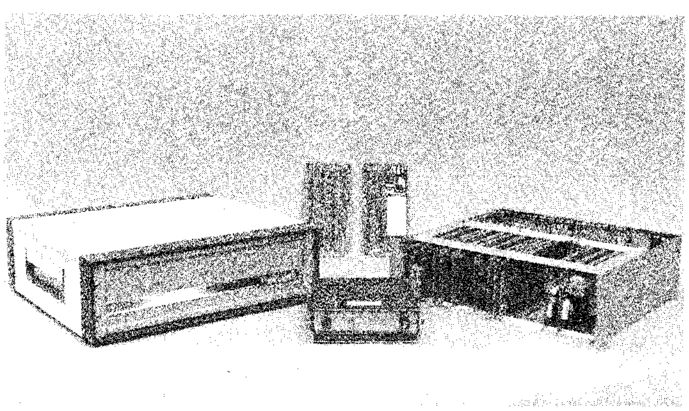


Figure 3.

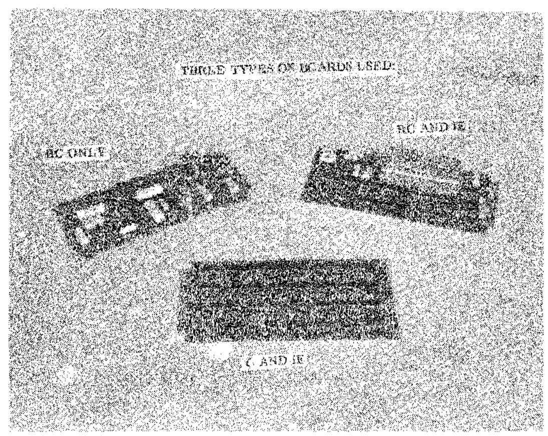


Figure 4.

notation at the central interrogation station. This address transmission must be repeated twice to activate the decoder and logic circuitry to insure against false replies under noisy conditions. In most instances this transmission is repeated four times for reliability. After the remote station decodes this address information, the reply sequence begins. If the remote station does not reply at first, the cycle is repeated up to four times. If there is still no reply, or the reply is garbled by noise, the teletype printout cycle is initiated which leaves a blank line. The central station then advances to the next remote station and begins the process again. Figure 7 shows the remote station functional block diagram.

If the remote station replies, the data is then printed out on a type 33 (ASCII, 8 level code) teletype at 75 words per minute. This printout contains the date, time, station address, the data from the remote sensors and an indicator of which power source is operating.

When the remote station recognizes its own validated address, it will then turn on its encoder. At this time, all the hydrological data, which has been converted by the Fisher-Porter analog-to-digital recorder, and its associated memory equipment, is entered into the parallel-to-serial converter. The serial readout is in the form of "mark-space" pulses. These pulses are encoded through an FSK modulator and sent back to the central station for decoding. For reliability, the message is repeated four times in succession, then the remote station returns to the standby mode.

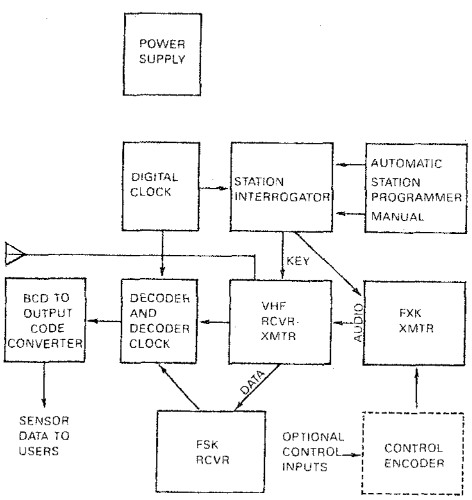
At the central station, the FSK bit train is decoded into a series of pulses and entered into a shift register. At this point, a comparator checks for bit-by-bit coincidence on succeeding messages. If the coincidence is valid, the message is then stored temporarily in a parallel memory register. It is from this register that the teletype format or computer input is obtained. The bit-by-bit comparison assures valid results even when the signal-to-noise ratio is as low as 6 db. It also insures that if valid data is not received, there is no output.

In order to assure accuracy and security, the entire cycle for a remote station with 8 decimal digits of data takes only one to three seconds to enter into a computer. The time variation is due to RF path, RFI, repeater operation and carrier versus private line squelch operation. For direct printout, an additional 3 to 10 seconds is needed as a function of the length of the format.

The system described was designed for a high degree of reliability through its inclusion of the many new developments in the science of data telemetry. The Alaska system provides a completely integrated network for the acquisition, transmission, and recording of data from these remote locations. This network is capable of expansion of its interrogation function to as many as 99 remote units. Each of these stations could then be equipped to measure as many as 12 different parameters. In this way specific warning signals such as stream level, snow pack water content, wind velocity, temperature, and liquid precipitation can safely provide advance warning of impending dangers. By providing a prototype for a modern Alaska-wide flood forecasting system, this system will also serve as a model for the several new warning networks planned for the smaller states.

Figure 5.

CENTRAL STATION



DAY	YEAR	HOUR	STATION	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	ALARM
105	68	0700	01	29.88	03.8	11.40	00.00	0
105	68	0700	02	29.88	03.5	12.22	00.05	0
105	68	0700	03	29.87	03.6	12.00	00.07	0
105	68	0700	04	29.88	03.8	11.47	00.03	0
105	68	0700	05	29.84	02.9	14.18	00.15	0
105	68	0700	06	29.88	03.5	12.14	00.01	0

Figure 6.

REMOTE DATA STATION

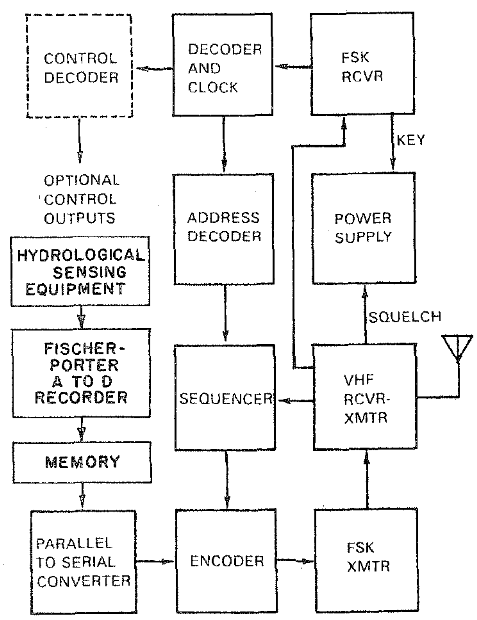


Figure 7.