U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE 13

NEW EQUIPMENT FOR JNWP
THE AVCO MULTI TELETYPE COLLATOR SYSTEM

H. A. Bedient
JNWP
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE NO. 13
JNWP
NATIONAL METEOROLOGICAL CENTER

NEW EQUIPMENT FOR JNWP
THE AVCO MULTI TELETYPE COLLATOR SYSTEM

H. A. Bedient

JNWP started experimenting with automatic input of upper air data into computers in 1955. The first system was put together with existing commerical equipment for tape to card conversion and operated on the IBM 701 and 704. At the present time this equipment is handling 5000 cards per shift which is way beyond its convenient capacity. In 1956 JNWP and the Air Weather Service begun experimenting with computer originated teletype messages using commerical card to tape equipment. This has now risen to the order of 20,000 words per shift, and is also beyond the capacity of the equipment.

In the fall of 1958 this problem was described to the electronics industry in Weather Bureau RFP2-59, and an invitation for proposals was tendered. There was wide interest in this problem and 17 proposals were received. One of the automatic solutions was accepted and with financial support from the FAA a contract was signed. The system is manufactured by the Crosley Division of the AVCO Manufacturing Company, and will be delivered in September 1959.

The heart of the AVCO system is the compressor-expander which they have developed for commerical applications. This is a two speed device which will operate on a teletype line at a low speed either recording or transmitting. It is read out or entered from a high speed line at some much higher speed. The compressor-expander is a home type magnetic tape recorder built for simple maintenance and low cost. Essentially it will replace paper tape as a storage medium and a speed converter in this switching system. The compression ratio does the same thing to the signal as the high speed rewind on a home recorder.

The figure shows a block diagram of the AVCO MTC system. At the left are the compressor-expanders on the teletype lines. They are shown as 20:1 compression ratio but this is only a nominal figure. Regardless of whether the teletype line is 75 wpm, 100 wpm or 650 wpm the compression ratio of the recording unit will be such that the read out rate will be the same. Thus internally the equipment will not know what speed line is being handled. Because of the compression ratio a line that is recorded for one hour at 100 wpm will be read out in three minutes. Thus it will be possible for the system to read out successively from 15 teletype lines without falling behind. The switch block programs read out of the teletype lines. It cuts in on a circuit at an end of line signal and replaces the appropriate compressor-expander with a spare so that nothing will be lost on the line and proceeds to read it into the reversing compressor-expander. The reversing compressor-expander eliminates the need for rewinding tapes by reading them out backward. Passing through the reversing compressor-expanders the message comes out forward again to the translator with the speed now stepped up to the order of 12,500 wpm. The translator takes the five-hole teletype code and converts it into a six-hole IBM code remembering the figure shift and letter shifts as they occur. The message is then stored in a 120 character "core" memory and written on the computer tape in 120 character blocks.

Tape was chosen as the final connection to the computer because it allows the computer to finish a job get it out then go on without waiting to something else. In the future at JNWP two computers will be coupled by a tape exchanging system so that computer outage delays should be practically eliminated. Then the communications ban be passed to either computer.

The reverse operation of the system will take mixed messages off the computer tape with circuit address designators, run them through into the designated compressor-expanders and leave them there for transmission on the circuits. During the time output is taking place to some circuits read out through the switch block will be stopped but compressor-expanders that are still receiving will continue until they are called on.

Initially it is proposed to connect the system into seven circuits. When the FAA service"0" is converted to 100 wpm soon extra compressor-expanders will be converted to enter the FAA 850 wpm service A system line. Some special Air Force circuits may be connected into it and also provisions may be made for special high speed computer to computer lines.

The Electronic Associates Tape Driven Curve Plotters

JNWP has had a system of chart production for some time which uses an IBM tape driven printer. These charts then have to be traced and labeled for reproduction. As the use of JNWP products has increased the job of tracing and labeling maps has become a limiting factor. Several other systems have been examined at various times but cost, questions about the state of development, or the computer time required has seemed to be an obstacle. In the fall of 1958 a piece of equipment was announced by Electronic Associates which seemed to meet the requirements and steps were taken to procure this equipment.

Mechanically driven curve plotters which use servo motors to push a pen around have been around for some time. Heretofore the principle applications have been of one dimensional type where something is plotted as a function of time, or have been low speed devices for plotting straight line segments.

The presently proposed equipment is a two dimensional plotter with a top pen speed of about 30 inches per second which can be driven quite stably at about about 10 inches per second. The plotter is essentially a voltmeter which attempts to match a position on the paper with a voltage at the x-terminal or the y-terminal. If the x voltage is one half full scale the pen will move one half way across the paper. If the system is standing still the voltage will be matched very closely. If the system is having changing voltages applied then its dynamic response comes into play and it averages and lags the applied voltage curve. The plotter we are acquiring will plot on a 30 X 30 inch surface. It is horizontally mounted and has an auxiliary arm which carries a small printing wheel capable of plotting numbers.

The signals to drive this board will come from a magnetic-tape digital to analogue converter. Digital numbers figured by the computer representing x y locations on the board will come off the tape, be converted to voltage pulses and be run through a controllable smoothing net so that an arbitrary voltage shape can be produced. Since this will be done independently for x and y, closed curves can be drawn.

Some experiments were performed on this plotter at ten inches per second pen travel speed. Very satisfactory lines could be drawn. In order to test the capability of the machine, points to define the lines were only determined to the nearest sixteenth of an inch. This means that the curves had one eighth inch steps in them. It was desired to see how crude a determination we could get away with as it is easy to see that locating 4000 points on a 500 mb chart could consume some appreciable computer time. When the plotter was run with minimum filtering the steps showed in the curve plot. At tight turns the turns were displaced in the direction of pen travel. When mild smoothing was applied the steps disappeared, the curve was ideal but had some tendency to systematically cut corners. The symmetry showed that the pen was four or five points behind the read out from the tape. Our last job was to design an acceleration correction which would lead the pen out on the turns so as to correct the plot down to very short radii.

The accuracy requirementss for meteorological maps are not very high. If gradients are required we will furnish maps of the gradients. The maps must have good pictorial appearance. The machine must however have a good stable absolute accuracy so that the scale does not wander since we wish to draw contours on $\frac{1}{2}$ pre-printed maps and have them superimposed in the correct places. This means that the machine must be a precision device.

Some interesting problems arise in designing a program to find all of the lines in any possible field. You can go around the edge and find all of the points that cut the edge and follow them. If the field is continuous and single valued and there are no internal boundries, they must return to the edge. What about the curves that don't cut the edge, must you go all about looking for all of them? If you locate a line at two different points how are you sure you are not repeating yourself especially if you must write each line on the tape to save room in the memory?

A little reflection will show that internal maxima and minima are "winding points" in the mathematical sense for contour lines. If there are no internal maxima or minima in a field all contours must come to the edge and so begin and end. Internal maxima and minima may be surrounded by closed lines. So we have devised a code which runs over the field and quickly locates all the maxima and minima. Tabs are kept as a curve is followed as to which maxima and minima are surrounded and which are not. Each curve separates a region of high values from a region of low values. So if a maxima is surrounded by a curve which should be surrounding minima then a second value of the same contour must lie around that maxima. Our rule is that if you locate an internal line by going out from a given maximum and follow it around to its close and if you thus surround the maximum you started from, then an additional contour must surround all of the maxima greater than this contour not surrounded and around all of the minima less than this contour surrounded. Careful definition of the term "surround" and the search procedure for successive values will allow you to draw the water level contour around an island in a lake on an island in a lake and get a unique solution without forgetting any contours!

An operational feature of the machine is that we will be able to raise and lower the pen on signal so that we can make dashed lines at will, do cursive writing as the Teleautograph machine does, and eliminate tails on small closed curves by dropping the pen when the plotter has reached a stable speed and picking it up before stopping so as to allow a smooth follow through. We expect to be able to draw 1000 inches of line on a one in thirty million northern hemisphere chart in about one and one-half minutes and label the centers in another minute. We will also be able to change the scale and draw the same map at more than one scale for different purposes.

BLOCK DIAGRAM AVCO MTC SYSTEM

2011

75
100
650
wpm

Compressor
Expanders

Switchblock

Reverser
5:1

Compressor
Expander

Translator

Bandot

to
IBM

120 Character Core
Memory

Tape

Input
Output
Recorder

2500 wpm

12500 wpm