An Automatic Voice Readout System

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THE rapid development of electronic data processing systems has created a need for improved man-machine coupling equipment. In systems where the human operator is part of the control loop, the need for optimizing this coupling is even greater. To date, most display devices have utilized the human sense of sight. Additonal opportunities for improving the man-machine coupling lie in the use of the other senses, particularly the sense of hearing. The automatic voice readout systems (AVRS) described here makes use of this sense of hearing. This permits the operator the simultaneous use of his sense of sight for other forms of data display.

Typical Application

One example of an application of the AVRS is in air traffic control systems. Such systems are, in reality, closed loop control systems and many of the well-known closed loop techniques may be applied to the analysis of them. Fig. 1 shows a very simple example of the complete loop.

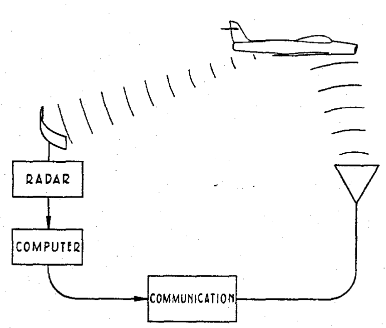

Fig. 1—Closed loop control system.

The position of the aircraft is obtained by the radar and fed to the computing element. The computing element, depending on the system, may range anywhere from a sophisticated electronic system to the human controller. The guidance commands which are outputs of the computing element must be communicated to the pilot for the necessary aircraft position correction. As automatic computers such as form part of the FSQ-7, GPA-37, or TSQ-13 systems become operational, the capability to control large numbers of aircraft at high data rates requires automatic, high speed communications. Where these systems are being used today with human operators relaying guidance commands, over-all system performance may degenerate due to time lags or operator error. This is one of the big reasons for the great interest and activity in the development of automatic data links.

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History

During the development of the Tactical Air Control System, AN/TSQ-13, at Air Force Cambridge Research Center, a project was initiated to develop a voice readout unit for the digital data display [1], [2]. This unit gated together previously recorded words to form the desired voice message. As the readout unit progressed, it was felt that as a computer readout it could also be used to transmit the output of the ground-controlled-intercept-return-to-base computer to the aircraft in the absence of the digital data link. One problem always present in the system tests was the shortage of digital data link-equipped aircraft. It was and still is obvious that it will be many years before the majority of our operational aircraft are so equipped. For this reason an automatic voice data link which requires no additional equipment in the aircraft can be used to match the ground data processing equipment, now becoming operational, to the present day operational aircraft. In addition, it will serve to provide automatic data link capability for those aircraft which, for various reasons, may never be equipped with digital data links, as well as a back-up for the digital data link in the event of equipment malfunction. It should be pointed out here that the automatic voice data link does not significantly decrease the bandwidth nor speed up the data rate over that of the manual operator system, as do the digital links. It does, however, provide the same automatic, error free advantages as the digital links while providing improved intelligibility over the manual link. Moreover, the innate redundancy in spoken languages provides the ability to transmit through some fading and certain forms of jamming.

Returning briefly to the discussion of the history of the automatic voice readout system, a breadboard unit was constructed at AFCRC and flight tests were run at L. G. Hanscom Field in mid-1955. Reports from pilots taking part in these tests showed that the clear enunciation of the words and the crisp concise message made for more intelligible and efficient communication. During the last two years improved techniques have been incorporated into a model of this automatic voice readout system at Fairchild Controls Corporation. It is this equipment which is discussed here.

Description

The inputs to the automatic voice readout system are the output commands from the computer. In some cases these are serial digital or parallel digital, while in other cases they may be shaft position or analog voltage outputs. The readout system converts these inputs into a series of messages, the variable portions of which are controlled by the inputs. These messages are then transmitted to the aircraft

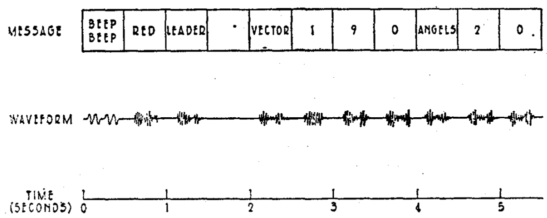

Fig. 2—Message structure.

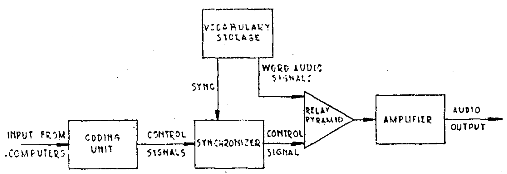

Fig. 3—AVRS block diagram.

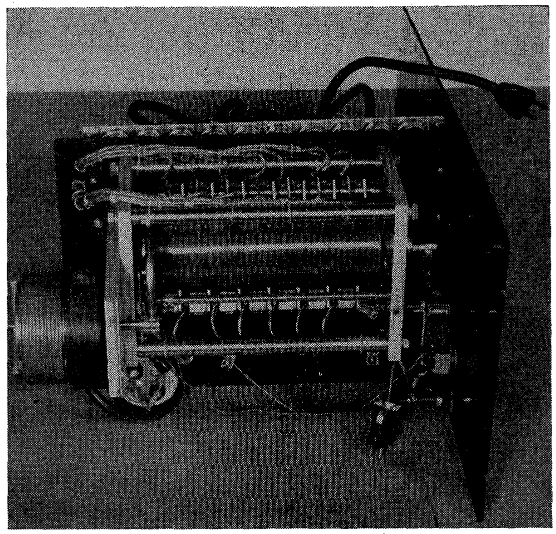

Fig. 4—Vocabulary storage unit.

using a standard voice channel transmitter such as the GRC-27. Fig. 2 shows a typical message structure. It is composed of words, one-half second or less in duration. An unlimited number of message formats may be programmed and the variable portions controlled by the input signals. In the example chosen, the aircraft address illustrated as red leader, the command heading shown as one-nine-zero degrees and the altitude shown as 20,000 feet are the variable portions of the message. In addition, one or more message formats may be selected by the computer outputs so that in addition to a command-heading-command altitude message, a range-bearing message, a landing assignment message, or any other prescribed format may be transmitted. The double beep tone transmitted at the beginning of each message serves to alert the pilot and to provide an indication of the message beginning. Fig. 3 shows a block diagram of the basic voice readout equipment. It is composed of five basic units.

The word storage unit is the heart of the system. It is shown in the photograph of Fig. 4. It consists of a magnetic drum rotating at two revolutions per second and a set of recording-playback heads. The drum is approximately two and one-half inches in diameter, four inches long and has a nine ten-thousandths thickness coating of magnetic oxide. The magnetic heads are spaced one and one-half thousandths from the drum face and may be stacked, ten tracks per inch. Such stacking allows about 35 tracks in the full drum length. Storing one word per track provides a vocabulary of 35 words. The basic numerals, "zero" through "nine," the programmed words such as "vector," "angels," "range," "bearing," and twenty call signs can be included in the 35-word vocabulary. It is to be noted that vocabularies up to 100 words are possible on a single drum. Such large vocabularies would be required where large numbers of aircraft call signs were to be used.

All words stored in the vocabulary are recorded in phase so that during any one-half second interval all words are being reproduced simultaneously at the magnetic heads. This then allows the sequential switching between heads to form the complete message.

The switching between heads to form the message is performed by a relay pyramid. The five digit control signals required to control the pyramid are supplied from the coding unit and the synchronizer. The output of the relay pyramid drives the audio amplifier which in turn feeds the transmitter or other output devices. The audio amplifier is of standard design requiring only the equalization necessitated by the magnetic playback heads.

The synchronizer serves as the basic timing unit within the system. Synchronization pulses are received every drum revolution, or ½ second, and are used to advance the synchronizer to the next word interval. The simplest synchronizer consists of a six-bank, twelve-position stepping switch. The incoming control signals from the coding unit are thus sampled in sequence and the programmed words such as "vector" and "angels" are sampled at the proper interval.

The coding unit will vary considerably depending on the types of computer outputs which must be accepted. These must be converted into the five digit parallel code used to drive the relay pyramid. Diode matrices are used to provide the digital coding. Coded commutators may be employed where the computer outputs are shaft positions.

An additional unit is generally required where several computers are feeding the same voice data link. This sampling unit which is not shown in the block diagram must sample the various outputs and feed them one at a time to the coding unit. It is conceivable that the computer outputs could be sampled, coded and transmitted in sequence, but in all probability a priority system will be required. This will allow more efficient use of the command channel since it will be necessary to transmit only when a command is required. As an example, the original test model voice data link was programmed to transmit only when a heading change of ten degrees or more was re-