are for the purpose implied by the name and will naturally be employed to try to prove out the simulation and model results. Even during these field-test phases we are to utilize simulation techniques. In this context the 709 will be linked to that part of the system being subjected to evaluation in a field operational environment; a single thread employment of equipment will be supplemented by simulation of the remainder of the system. (See Fig. 2.) That is, the computer will provide the data sink to introduce input into the system and to absorb output from these echelons actually being operated.

The Computer Center became operational in February, 1959. The larger part of the application studies are completed, and detailed analysis has begun on several of them with demonstration runs already made on at least two. The major hardware items of the prototype system are on order, with the first to be delivered this coming Fall. Combining this progress with that reported by Captain Luebbert on hardware, transmission, and programming aids we remain confident that our objectives can be attained.

In summary, this paper has reported on an ambitious and futuristic program undertaken by the Signal Corps to provide the Army with a vast tactical Automatic Data Processing System. The proposed system in prototype form is to be operational by 1963 and will incorporate the very latest developments in digital techniques, *i.e.*, new miniaturized general-purpose data-processing devices, computer-to-computer communications, and automatic programming. The research efforts in this project, and certain standards derived, are bound to have an effect on and contribute to related commercial data-processing activities.

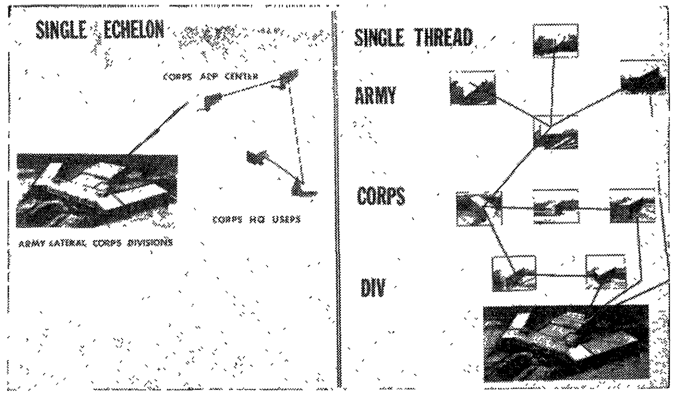

Fig. 2—The IBM 709 will serve as a source and destination of system input and output by simulating the missing echelons during field tests.

Data Transmission Equipment Concepts for FIELDATA

W. F. LUEBBERT†

FIELDATA is an integrated family of data processing and data transmission equipment being developed for Army use. A unique feature of this family is the almost complete disappearance of conventional distinctions between communications and data processing. This paper deals primarily with the concepts and techniques developed to create this evolutionary merger emphasizing the ways in which conventional communications concepts have been adapted to achieve a high degree of interoperability with computers and other data processing equipment, and an extraordinary degree of flexibility and adaptability of application.

In order to explain and illustrate the FIELDATA concepts, this paper makes extensive use of specific examples of design decisions, particularly those dealing with common features such as codes, voltage and impedance levels, data rates, etc. Among the equipments of the FIELDATA family developed in accordance with these concepts and common standards are the following, all of which are scheduled for completion prior to the end of 1960: the MOBIDIC computer (Sylvania), the BASICPAC and LOGICPAC computers (Philco), the AN/TSQ-35 19,200 bit/second data transmission equipment (Bendix-Pacific), the AN/TSQ-33 2400 bit/second data transmission equipment (Collins), the AN/TSQ-32 1200 bit/second data transmission equipment (Stelma), the DATA COORDINATOR, a facilities coordination and control equipment for an integrated communications and data processing system (IBM), and a host of miscellaneous equipments such as magnetic tape transports (Ampex), a flexowriter-like electric typewriter (Smith-Corona), high-speed printers (Anderson-Nichols), security equipment (Collins), etc.

The fundamental capabilities of data processing equipment can be described as the ability to transform

† U. S. Army Signal Res. and Dev. Lab., Fort Monmouth, N. J.

information into more desirable or useful forms. Using the same viewpoint, the fundamental capability of conventional communications equipment can be described as the ability to transfer information to a more desirable or useful location. Of course, from an abstract logical viewpoint a transfer is merely one special kind of transformation, one in which only physical location is changed. Combining these descriptions, one is led to the concept of a generalized data handling system capable of performing generalized transformations, of which conventional one-location data processing would be one special case and conventional no-processing data transmission would be another special case. In such a system there would be no fundamental distinctions between data processing and data transmission, but only distinctions of convenience based upon application, use, and design emphasis.

Is such a concept a reasonable one, and does it have any practical utility? The answer to the first part of this question will be examined in detail in this paper; the answer to the second part will be determined by the success in actual use of the equipment and system concepts it generates, the concepts explained in this paper which are receiving initial implementation in the FIELDATA family of equipments.

An examination of the information flow and manipulation in typical data processing and data transmission equipments shows almost immediately that there is a very considerable mixture of functions going on in both types of equipment. A very considerable amount of the activity going on inside any computer or data processor consists of simple transfers of information from one part of the processor to another. Within data processing equipment a major part of the activity is concerned with the generation, manipulation, and other processing of information used for control, supervisory, and error reduction purposes. In many cases nearly identical operations go on in both data processing and data transmission equipments, with the differences, if any, being matters of design emphasis based upon application and use.

Many practical cases of this similarity are immediately obvious, particularly in the area of devices used for data entry and output. For example, computers frequently use paper tape readers similar to those used in teletypewriter transmitter distributors, and paper tape punches that could easily be used in teletypewriter reperforators. Similarly the idea that kinds of input-output devices such as card readers and punches and magnetic tape transports which are widely used for data processing can effectively be adapted for use of communications lines is also being exploited in equipments such as the IBM transceiver, the Collins Kinetape, etc.

FIELDATA emphasizes this kind of exploitation to the extreme, particularly encouraging it by assuring that interconnection of semiautonomous equipment modules be made in accord with common standards without distinction whether these equipments are conceived primarily for computer-associated or transmission-associated functions. This makes it possible for the same data terminals to operate not only with data processing-type inputs and outputs such as computers, paper tape, magnetic tape, and IBM cards; but also for it to operate with real time weapons system data and with telegraphic data.

Control circuitry is so devised that pure binary as well as alphanumeric (*alpha*betic-*numeric*) data may be handled. Since any digital code, be it Baudot (teletypewriter) code, Holerith (IBM card) code, or any of a wide variety of computer codes may be represented in binary bit-by-bit form, the FIELDATA devices have the potential of transmitting or handling any type of digital data. Thus, they could be used with digitized voice, digitized facsimile, or other types of digitized analog signals.

The use of common standards, codes, and standard data rates makes possible the kind of data transmission equipment concept shown in Fig. 1. This concept leads naturally to a division of the subassemblies of data transmission equipment into three kinds:

1) *Input-output transducers* are devices for converting information from some human or machine usable form such as paper tape, magnetic tape, punched cards, analog electrical voltages, strokes on a keyboard, etc., into digital form.
2) *Transmission transducers* are devices for converting data in digital form into appropriate signals for transmission over radio, wire or other kinds of propagation media.
3) *Embolic*[1] *equipment*, normally inserted between input-output transducers and transmission transducers, is used primarily to perform control and supervisory functions, error detection and/or correction, buffering, and/or speed conversion, code conversion, or encryption necessary for proper system operation of the data transmission equipment. The functions of embolic equipment are information processing functions. Inputs and outputs will both be digital in form, although supplementary analog information may also be available particularly in some kinds of error control schemes. A general-purpose computer is potentially a very powerful and flexible type of embolic equipment, but the necessary functions can often be performed much more economically by specialized equipment.

This division of subassemblies may be a physical division into separate items of equipment, into semiautonomous parts of a single equipment (either in a separate box or in a single box) or it may be merely conceptual with no physical implementation.

[1] Embolic is a coined term from the Greek *embolisimos* meaning to put between or insert. This word is also used in medical, astronomic, and ecclesiastic literature to describe other specific kinds of intercalations.

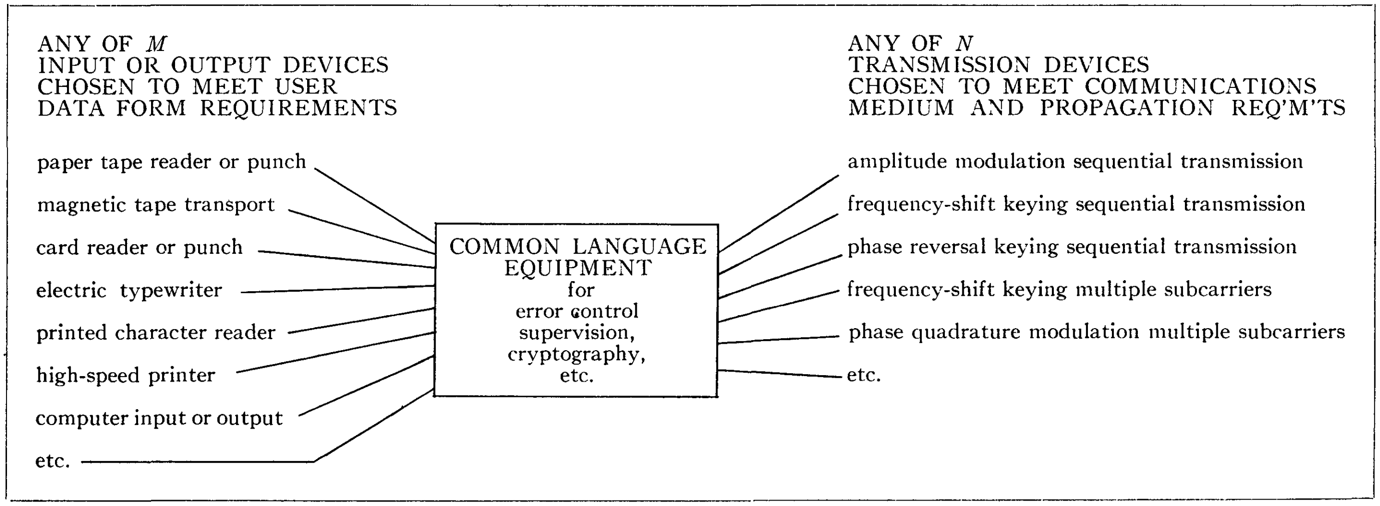

Fig. 1—FIELDATA equipment modularity concept.

Obviously maximum flexibility and adaptability can be achieved if any input-output transducer can operate with any transmission transducer. This permits one to tailor equipment to meet the requirements of a particular situation. It permits one to choose the in-out device suitable for the user's most convenient data form (paper tape, magnetic tape, IBM cards, etc.) independently of the nature of the transmission facility available. One can then choose the transmission transducer on the basis of the transmission medium used (VHF radio relay, HF radio, loaded cable, carrier transmission on wire, etc.) independently of the user's data form. Then join the two together taking advantage of common standards of interconnection or intercommunication between modules to create a well-tailored combination.

The question then arises, "Why embolic equipment?" Certainly by proper choice of common interconnection or intercommunications characteristics one can minimize requirements for code conversion, buffering, speed conversion, etc. Ideally one should be able to join the input-output transducer to the transmission transducer without embolic equipment, so why have it? The answer is that there are three important functions in a data terminal which seem convenient to separate from both in-out transducers and transmission transducers: 1) communications supervision, 2) error control, 3) cryptographic security.

Supervisory functions are conveniently separated from the input-output transducers and the transmission transducers because supervisory requirements may be strongly influenced by both. Error control requirements may also be strongly influenced by both the in-out data and the transmission situation, and may even in some cases not be desired at all. Thus it is best treated as a module which can be tailored to the paired requirements of in-out and transmission or completely omitted. Cryptographic security is conveniently a separate module so that it may be omitted in those cases where security is not required or desired.

In order to discuss supervisory activities conveniently it is desirable to make a distinction between two kinds of information which flow through a communications system:

1) *Primary information* is that which a user wishes transferred to another location, that is, the information to be communicated.
2) *Secondary information* is added to the primary information either by the originator or by equipment of the communications system which is used to perform functions of supervision, routing, error control and related activities necessary or desirable to permit the primary data to be effectively communicated. This information is used by communications equipment and personnel and is normally of no use or interest to the ultimate recipient of the primary information.

A basic requirement for maximum flexibility and adaptability is that the user, who enters data at an input device and receives data at an output device, need not be required to exercise judgment or knowledge, to perform special activities, to use or to interpret secondary information. This, in turn, makes it desirable to isolate secondary information from the input-output devices, which are the user's point of contact with the communications system. A convenient way of establishing and enforcing this isolation is the creation of a distinct embolic module which generates, receives, interprets, and/or acts upon secondary information and passes on action requirements derived from this secondary information over local control lines to its associated input-output transducer and transmission transducer. It is important to note that such equipment need not have any ability to interpret or act upon primary data, and thus its operation can be made completely independent of the coding used for primary data so long as there is a unique method of distinguishing primary from secondary data.

In the FIELDATA family of equipments the segregation of primary and secondary data is accomplished in a particularly simple way by providing separate transmission symbol "alphabets" for primary and secondary data. The basic unit of data in FIELDATA codes is a six-bit character. For primary data this may be merely a six-bit block with no specific meaning assigned to specific bits within it, and no restrictions on the permissible code combinations which may be transmitted. If this information is alphanumeric in form so that specific bit meanings must be assigned for electric typewriters, printers and similar input-output transducers to operate, then the FIELDATA alphanumeric code given in Appendix I is used. A similar but distinctly different six-bit FIELDATA supervisory data code has also been created and is outlined in Appendix II. Message heading and addresses, dialing information, multiplexing information, signals indicating start and end of message blocks, and control signals are all created using this alphabet.

In many situations, for example inside computers, it is desirable to both the six-bit primary data alphabet and the six-bit FIELDATA supervisory code alphabet with implicit differentiation between them similar to the implicit differentiation between data and instructions in the computer. However, other situations arise where it is desirable to provide an explicit identifying tag to specify which alphabet is being used.

A basic tagging method has been adopted for use on interconnecting cables employed for joining equipment modules. A seventh or tag bit is added to each six-bit symbol: a binary "one" if the symbol is primary data, and a binary "zero" if the symbol is from the FIELDATA supervisory alphabet. In the interconnecting cables an eighth bit in the form of an odd parity bit is also added to provide error protective redundancy. This basic eight-bit form creates the appearance of an eight-bit code. It has widespread use, but cases do exist where other alphabet tagging techniques and other redundancy is preferable. For example, serious complications would arise if this basic eight-bit form were used for the actual punching of FIELDATA information on paper tape. This occurs because control difficulties occur with a paper tape punch-reader system when primary data symbols are allowed to use either the blank tape condition (no channels punched) or the deleted tape condition (all channels punched). Since the use of the basic eight-bit form inevitably results in one or the other of these symbols being a primary data symbol depending upon whether a hole is interpreted as a binay "zero" or as a binary "one," a slightly different tagging and parity scheme must be adopted. This, of course, results in another eight-bit form which could be interpreted as an eight-bit code. Other tagging and redundancy schemes could lead to other apparent codes. Thus, there is no such thing as a *unique* eight-bit FIELDATA code, although it may be convenient to think of the basic eight-bit form as an eight-bit code.

In some situations transmission errors may create important reasons for using other tagging and error protective redundancy schemes. Errors which cause loss or change in supervisory information such as dialing information, message headings, start and end of message indications, and so forth, may completely disrupt the proper functioning of a communications system. Thus they may require protective redundancy many times more powerful than the simple parity used in the basic eight-bit form. However, compared to these secondary data, primary data may be capable of tolerating considerably higher error rates. For example, if the data are English text the inherent redundancy of the language may permit significant corruption without loss of intelligibility. Numerical data may consist of successive observations of a physical phenomenon in such a form that inconsistent data may be deleted and ignored, or they may be protected by numerical checks similar to those used by accounting systems to detect bookkeeping errors. In a situation where error rates were severe it might not be desirable to apply as powerful error control to these less demanding primary data as to secondary data; thus one might desire to use methods of differentiating between primary and secondary data which are more resistive to corruption by errors than the simple tags used in the basic eight-bit form together with different error control schemes for primary and secondary data.

This kind of differentiation illustrates a fundamental assumption about error control which is part of the FIELDATA concepts. Specific error control requirements should be determined by the nature of the data and their use. As mentioned above there may be cases where primary data can tolerate frequent errors with little loss of usefulness, but there are other cases, such as the transmission of computer programs, where very low error rates are required. In some cases if errors above the desired maximum rate occur and are detected, the erroneous information may be deleted without significant harm; in other cases they must be corrected. In some cases where correction is required it may be deferred and handled by a service message; in other cases it must be corrected before the data are released, and so forth.

Notice that all these requirements are determined by the use of the data, and that these demands remain the same regardless of the transmission path and types of transmission equipment through which the data may be required to flow. However, the occurrence of errors is anything but independent of transmission factors. Although errors do occur in input-output devices and embolic equipment, by far the most variable and difficult to control errors normally occur in the transmission portion of a data link. These errors are often quite variable in frequency and interrelated in occurrence. They are quite strongly dependent upon the nature of the propagation medium and the kinds of disturbances to which it is subject. For example, an HF radio link subject to severe fading and multipath disturbances could hardly be expected to have the same error problems as a wire and cable link subject to intracable crosstalk and impulse-type switching noise. Furthermore, for a given propagation medium and kind of noise and disturbances, the frequency and interrelationships of errors are strongly dependent upon the characteristics of the transmission transducers used. For example, if amplitude modulation is used one would expect different errors than if frequency shift keying were used; if sequential transmission of short bauds on a single subcarrier is used one would expect different error problems than if parallel transmission of long bauds on multiple subcarriers is used; and if sampling or nonintegrating types of detection are used one would expect different error problems than if full integrating detection schemes were used.

The number, variability, and difficulty of measurement and analysis of the various factors which contribute to the frequency and interrelationships of transmission errors or particular circuits is staggering. At the present time the state of the art is such that only crude estimates of frequency of error can be made for typical equipments when exposed to disturbances other than Gaussian noise, and that practically nothing can be estimated in advance about the interrelationships of errors under practical conditions of impulse noise, crosstalk, propagation variations, etc. This is particularly unfortunate because the effectiveness of the various digital error control schemes available is strongly dependent upon the interrelationships of errors. For example, a simple parity check is capable of detecting single errors but not double errors. If errors occur randomly, double errors will seldom occur and this very simple check will be quite powerful. Thus if the bit error rate is 10^{-4}, a simple parity check will reduce the undetected error rate to 10^{-8}. On the other hand, if errors tend to be clustered a parity check will be rather ineffective. Thus if the conditional probability of a second error immediately following the first is 0.5 and the bit error rate is 10^{-4}, then a parity check will reduce the undetected error rate to only 0.5×10^{-4}. Given knowledge of the interrelations, checks can be designed which give high protection with a minimum amount of checking equipment. Unfortunately this knowledge is usually unavailable.

If the most important sources of errors are in a data communications link, is it proper to incorporate the major error control features of the link into the transmission transducers? The FIELDATA concepts answer this question with a resounding NO! Why? The key reason is that while the *occurrence* of errors and the raw error rate and characteristics are determined primarily by transmission factors, the error *requirements* are determined by the use of the data. The means and techniques of error control appropriate to a particular situation obviously depend upon the *interaction* of these factors. However, it is a fundamental modularity principle of FIELDATA that the characteristics of transmission transducers should as nearly as possible be independent of the details of user input-output characteristics and data employment.

If one were to incorporate the error control features into the transmission transducers and one desired to provide p classes of controlled error service to users with q modulator/demodulator assemblies, then one would require p times q types of complete transmission transducers. The obvious answer is to separate modularly, making the error control module an item of embolic equipment. This allows one advantage of similarities in requirements and raw error characteristics among the different situations to reduce the variety of equipment to be constructed.

In view of the present difficulties in predetermining the specific error characteristics of transmission transducers prior to construction and test, it also permits construction of new transmission transducers and their use with existing error control embolic equipments until the specific error characteristics of the transducer can be measured and new error control embolic equipment designed if necessary to meet user requirements with the measured transmission error characteristics.

In addition to these practical advantages of placing error control responsibilities in embolic equipment modules rather than in transmission transducer modules, there are conceptual advantages associated with maintaining the simplest possible information flow patterns and division of activities among the three basic kinds of assemblies.

In general transmission, transducers pay no attention to the information content of the digital information they convert to modulated transmission form, neither knowing nor caring whether the data are primary or secondary, whether they are redundant or irredundant, or what code or codes they use. In contrast to this, embolic equipments normally act as information processing devices. Thus, in supervising a transmission link embolic supervisory equipments act on sensory information received from transmission transducers and in-out transducers and generate, process, and interpret secondary supervisory information to control the over-all operation of the communications link. The error control problem is exactly parallel. Acting on information about user requirements from the in-out transducer side, and information and sensory information about transmission errors from the transmission transducer side, error control equipment is required to generate, process, and interpret error control information using it to control (often via supervisory operations) the overall operation of the communications link in such a way as to control its errors. Thus it is obvious that from the information processing viewpoint the performance of error control as an embolic function has a close parallel to other embolic functions and is distinctly different from the functions otherwise performed by transmission transducers.

Some of the FIELDATA equipments being developed in implementation of these concepts are listed in Table I.

The transmission transducers of the FIELDATA family are limited in number. However, the choice of the 75×2^n pattern of data rates permits widespread augmentation by minor modification of existing or developmental teletypewriter multiplexed transmission equipments. In addition, future expansion is simplified by the fact that future equipments will be able to utilize the same embolic and input-output equipments, and will thus be cheaper to develop than data transmission equipments which require development of embolic and/or input-output equipment as part of the same package. Expected future expansion will place greater emphasis on transducers for radio circuits.

TABLE I

Transmission Transducers		
AN/TSQ-32	600–1200 bit/second	Stelma Corp.
AN/TSQ-33	600–2400 bit/second	Collins Radio
AN/TSQ-35	19,200 bit/second	Bendix-Pacific
General Purpose Computers		
MOBIDIC		Sylvania
BASICPAC/LOGICPAC		Philco
INFORMER/DATA COORDINATOR		IBM
In-Out Transducers		
Electric Typewriter		Smith-Corona
Paper Tape Reader		Smith-Corona
Paper Tape Punch		Smith-Corona
High-Speed Printer		Anderson Nichols
Paper Tape Transport		Ampex Corp.
Magnetic Tape Transport		Ampex Corp.
Tacden		Aeronutronics Systems
Special Embolic Equipment		
CV-689	Cryptosecurity Adaptor	Collins Radio
CV-690	Control Equipment	Collins Radio
CV-691	Data Concentrator	Collins Radio

The AN/TSQ-32 is a transmission transducer capable of accepting data from a standard FIELDATA connection and of transmitting it serially as frequency-shift modulation of a single subcarrier over a standard voice channel. Transmission rates are 1200 bits/second (1500 words per minute) over good quality circuits, and 600 bits/second over poorer circuits.

The AN/TSQ-33 is a transmission transducer capable of accepting data from a standard FIELDATA connection and of transmitting it as 8 channels as synchronous phase quadrature modulation of four subcarriers over a standard voice channel. Transmission rates are 2400 bits/second (3000 words per minute) over good quality circuits, with 1200 and 600 bits/second available for use over poorer circuits. This equipment is essentially a militarized, miniaturized, FIELDATA compatible version of the Kineplex TE-206.

The AN/TSQ-35 is a transmission transducer capable of accepting data from a standard FIELDATA connection and of transmitting it by amplitude modulation of 8 subcarriers orthogonally spaced in frequency and time. The transmission baseband is the 48-kc band between 12 and 60 kc used for military and commercial cable and carrier circuits. Representative circuits are the Army spiral-four and associated AN/TCC-7, 8, and 11 equipments; and commercial types N and K carrier equipments. In addition to point-to-point full duplex operation, this equipment has special features for multiple station "common net" round-robin type operation.

In addition to these transmission transducers specifically designed for FIELDATA a wide variety of existing military and commercial teletypewriter transmission equipments can be used for FIELDATA transmission with only minor modification. Examples of such equipment are the AN/FGC-54 capable of transmission and diversity reception of FIELDATA information at 2400 bits/second over long-haul 3-kc radio circuits using 32 channels each operating at 75 bits/second. Another example is the AN/FGC-29 potentially capable of transmission and diversity reception FIELDATA information at 1200 bits/second using 16 channels each operating at 75 bits/second. Yet another example is the AN/TCC-30 potentially capable of transmitting 1200 bits/second using 16 channels operating at 75 bits/second.

The FIELDATA computers form the most complete and well-balanced portion of the FIELDATA family.

The FIELDATA computers may act as either input-output transducers or as embolic equipments for data transmission purposes, having the ability to accept, process, and emit either primary or secondary data. All are designed for direct operation with data transmission equipment. In their employment the MOBIDIC, which was the first machine to have its characteristics frozen, is the least capable of transmission of machine data; it has serious restrictions on its use of the supervisory code functions. The most flexible in its employment of data transmission will be the DATA COORDINATOR, a newer equipment which will have the capability of terminating a large number of data transmission circuits simultaneously and which will have a number of special capabilities and console positions to facilitate its use as a facilities coordination processor for an integrated communications/data processing system.

All the FIELDATA computers are general-purpose processors of modular design and great flexibility. Their relative computation speeds are shown on the bar chart. All are designed for field use with operation and maintenance simple enough for field personnel. The largest, MOBIDIC, mounts in a semitrailer van, while the others mount in shelters which can be carried on a truck. It is interesting to note that the minimum assembly which forms a fully operational stored program computer of the BASICPAC/LOGICPAC type or the INFORMER/DATA COORDINATOR type weighs in either case less than 150 pounds subdividable into 50-pound or smaller packages. However, these central processors are normally used for data processing purposes in vehicular assemblies which far exceed these weights because of auxiliary equipments such as multiple tape transports, special real-time input-output units, additional magnetic core memory modules, data transmission equipment, input-output converters, etc. For example, a vehicular BASICPAC would augment the central processor with four magnetic tape transports, a high-speed paper tape reader and punch, an AN/TSQ-33 transmission transducer, and other auxiliary equipment. Fig. 2 indicates the relative computational capabilities of the various FIELDATA processors.

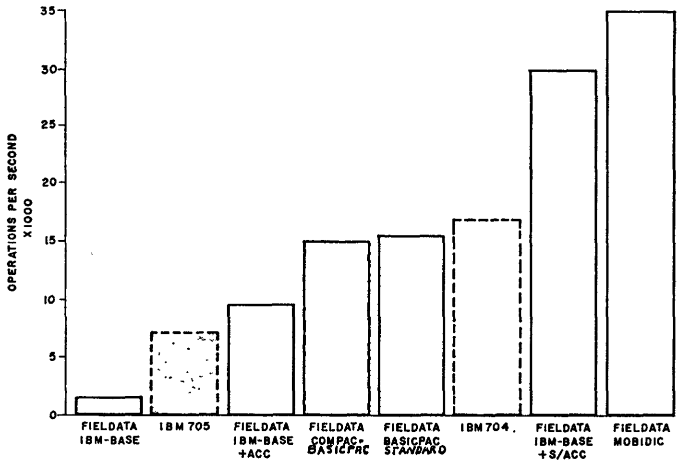

Fig. 2—Speeds of computation, FIELDATA processors.

The input-output transducers of the FIELDATA family serve double duty as computer input-output devices and as data transmission input-output devices. The group under current development constitutes a minimum group of general usage items, a number of which are in only partially militarized form. This minimum group will be augmented by future field teletypewriter equipments which will utilize FIELDATA code, and by advanced equipments now under study to provide specialized input-output capabilities. Since the items are mostly quite conventional, detailed descriptions are omitted here in order to save space.

The specialized embolic equipments in FIELDATA provide cryptographic security, interconnection of input-output and transmission transducers, and tie-in of FIELDATA circuits to existing teletypewriter circuits.

Three major items of special embolic equipment are being developed for FIELDATA. The CV-689 is a special cryptosecurity adaptor which permits an existing type of security equipment to be inserted just before the transmission transducer in any FIELDATA data transmission assembly, thus providing cryptographic security.

The CV-690 is a device which provides supervisory control, error control, and synchronizing buffer facilities for connecting paper tape or magnetic tape units to the AN/TSQ-32 or 33. Although future plans call for similar special militarized embolic equipments for other kinds of input-output equipment such as card equipment none is now under development. However, rather minor modifications of commercial Collins Kinecard equipment will permit nontactical employment of AN/TSQ-33 equipment for card transmission, and at least some versions of the MOBIDIC will include card equipment which, through the computer, can reach transmission facilities.

Although FIELDATA concepts make provision for a wide variety of error control and supervisory control systems only the particular system used in the CV-690 will actually be used initially except for computer-to-computer transmission, since other embolic devices using different error control or supervisory control schemes are now under development. It is expected that when experiments determine the actual frequency and interrelationship of errors for particular transmission transducers, more effective schemes will be devised. However, the very simple and easy to implement two-dimensional (interlaced) parity error detection scheme followed by request-back or rerun-type error correction used in the CV-690 is particularly easy to implement, and is expected to suffice for initial testing.

The CV-691 Data Concentrator is a device designed to bridge the gap between existing large-scale 60- and 100-wpm teletypewriter facilities and FIELDATA equipment. Although all FIELDATA processors have normal provision for a paper tape reader which accepts teletypewriter tape as well as one for FIELDATA tape, there exists a significant need, especially at locations where FIELDATA processors might not be available, to accept multiple channels of teletypewriter information and convert it into FIELDATA form to take advantage of FIELDATA transmission transducers and error control, permit recording on FIELDATA magnetic or paper tape, permit printing on FIELDATA high-speed printers, simplify entry into FIELDATA computers, etc. The CV-691 accepts up to 25 (or 50) teletypewriter inputs, stores the information in a buffer core memory (made up of the same memory planes as used in MOBIDIC), assembles it into message blocks, converts it into FIELDATA form, applies the same error and supervisory control as the CV-690, and emits the data in FIELDATA form at rates up to 2400 bits/second (3000 words per minute). The receive side performs the inverse functions.

It is expected that as more and more of the voice and other analog communications systems convert to pulse code modulation and other digital forms that additional types of FIELDATA embolic equipment will be required to perform the error control, supervisory functions, and buffering/synchronization necessary to tie input-output transducers to their digital bit streams.

The FIELDATA family is an attempt to create an integrated family of data transmission equipments to meet Army needs. Though lacking many of the features and equipments of an ideal family of data transmission equipments, it will make available in experimental quantities by the end of 1960 the first integrated family of equipments for experimental establishment of a truly integrated communications/data processing system. It will be the first system in which data processing and communications equipment both utilize the same input-output and storage devices, the same voltages, impedance levels, codes, and other common interconnection characteristics, and in which the equipments are so designed that in many cases the only way to determine whether a device is used for communications or data processing is to look at its specific application in the system.

Appendix I

FIELDATA Alphanumeric Code

A key step in achieving the required compatibility between the various elements of an automatic data system is the adoption of a common "language" for the storage and transmission of data throughout the system. The basic 6-bit alphanumeric code for use in this family shall consist of 2 indicator bits and 4 detail bits. The pattern of character assignment for the code is as follows with the 2 indicator bits determining the choice of column and the 4 detail bits determining choice of row in Table II.

Appendix II

FIELDATA Supervisory Code

The FIELDATA supervisory code is used for message headings, dialing, multiplex identification, supervisory control, and other activities associated with secondary data. This code is similar to the FIELDATA alphanumeric code used for primary data. It also consists of 2 indicator bits and 4 detail bits. The pattern of control assignment is as follows with the 2 indicator bits determining the choice of column and the 4 detail bits determining the choice of row in Table III. When it is not necessary to provide alphabetic supervisory information only the latter two columns are used. In this case when the basic 8-bit FIELDATA form is used, an OR of the first indicator bit and the tag bit will provide clocking for the 96 legitimate characters of the 8-bit form.

TABLE II

	00 (Upper and Lower Case)	01 (Upper and Lower Case)	10 Upper Case	11 Lower Case
0000	Master Space ≷	K	)	0
0001	Upper Case ʅ	L	—	1
0010	Lower Case ×	M	+	2
0011	Tab. ◇	N	<	3
0100	Car. Ret. <	O	=	4
0101	Space △	P	>	5
0110	A	Q	|	6
0111	B	R	$	7
1000	C	S	*	8
1001	D	T	(	9
1010	E	U	"	'
1011	F	V	:	;
1100	G	W	?	/
1101	H	X	!	.
1110	I	Y	,	Special □
1111	J	Z	Stop ⊕.	Back Space

TABLE III

	00	01	10	11
0000	BLANK/IDLE	k	Dial 0	Ready to Transmit
0001	Control Upper Case	l	Dial 1	Ready to Receive
0010	Control Lower Case	m	Dial 2	Not Ready to Receive
0011	Control Tab.	n	Dial 3	End of Blockette
0100	Control Carriage Ret.	o	Dial 4	End of Block
0101	Control Space	p	Dial 5	End of File
0110	a	q	Dial 6	End of Control Block
0111	b	r	Dial 7	Acknowledge Receipt
1000	c	s	Dial 8	Repeat Block
1001	d	t	Dial 9	Spare
1010	e	u	Start of Control Block	Interpret Sign
1011	f	v	Start of Block	Non-Interpret Sign
1100	g	w	Spare	Control Word Follows
1101	h	x	Spare	S.A.C.
1110	i	y	Spare	Special Character
1111	j	z	Spare	Delete