Computer Contribution

A Computer-Based Medical Record

Entry of Data From the History and Physical Examination by the Physician

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The Mayo Clinic has had preliminary experience with a computer-input system which employs video screen and light-pen and allows the physician to use ordinary English language for entry and retrieval of historical and physical-examination data. The system allows the clinician convenient, rapid, direct interaction with a computer-based, medical-information system. Use of this technique results in clinical records that are carefully formatted, complete and legible, and easily retrievable either on the video screen or as printed copy. These improved attributes of the clinical record should result in better patient care and facilitate retrieval of data for clinical research.

The belief that electronic data processing can be a powerful aid in clinical medicine is shared by a growing number of physicians interested in computer technology. However, a practical operational method for the recording, storage, and retrieval of a clinical history and physical findings by electronic means has yet to be fully developed. There are several reasons for the clinician's inability to take full advantage of the digital computer's potential. Among them are the problems of language and cost.

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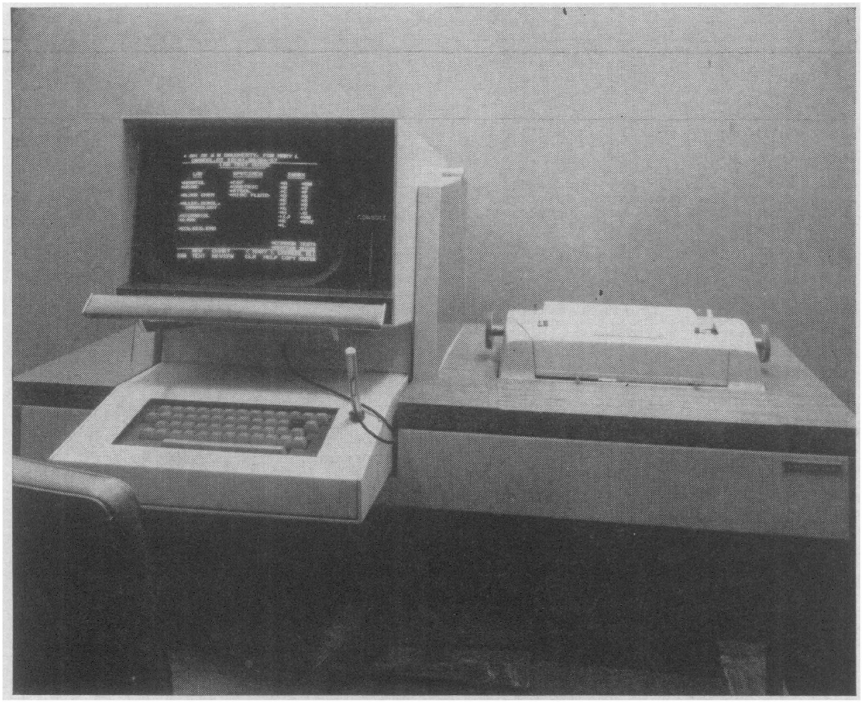
The language problem exists because communication with computers requires a very precise artificial language. Direct physician-computer communication can be accomplished easily only if the physicain does not have to learn a new specialized language. Our own experience indicates that it is highly unlikely that physicians engaged in clinical practice will routinely use the standard types of computer-input devices such as mark-sense forms, typewriters, or message-coded keyboards.

It is a waste of a large computer's capacity and speed if only one person at a time can use it in sequential fashion. The sharing of a high-speed computer by many people, each of whom feels that he alone is "on-line," is now technically feasible. The on-line time-sharing has reduced, but not completely eliminated, the cost problem; large computer systems with their peripheral equipment are still very expensive for routine clinical use.

The purpose of this communication is to describe a visual-display technique by means of which the physician can communicate directly with a time-shared, on-line computer and enter the history and physical findings, using natural language, into a computer-based medical record.

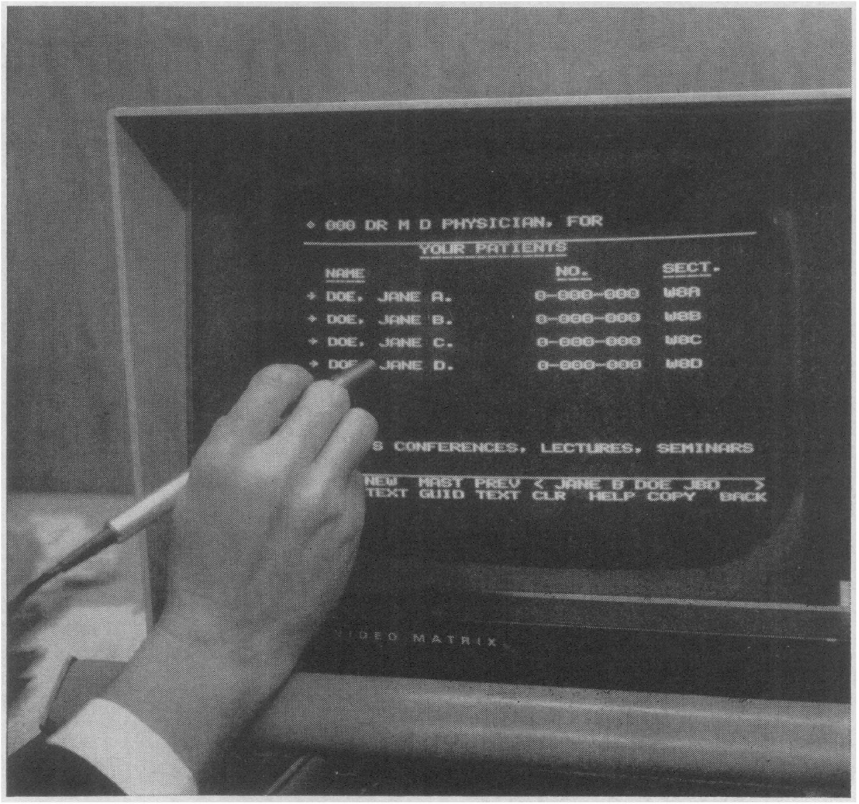
Methods and Equipment

The video matrix input-output station includes four integrated components: television screen, light-pen, keyboard, and printer (Fig 1). The video dis-



1. Video matrix input-output station. Four integrated components: video screen, light-pen, keyboard, and electric typewriter.

2. Video display terminal. In selecting items from screen, user can generate sentence or entire paragraph with one flick of selector switch on light-pen.

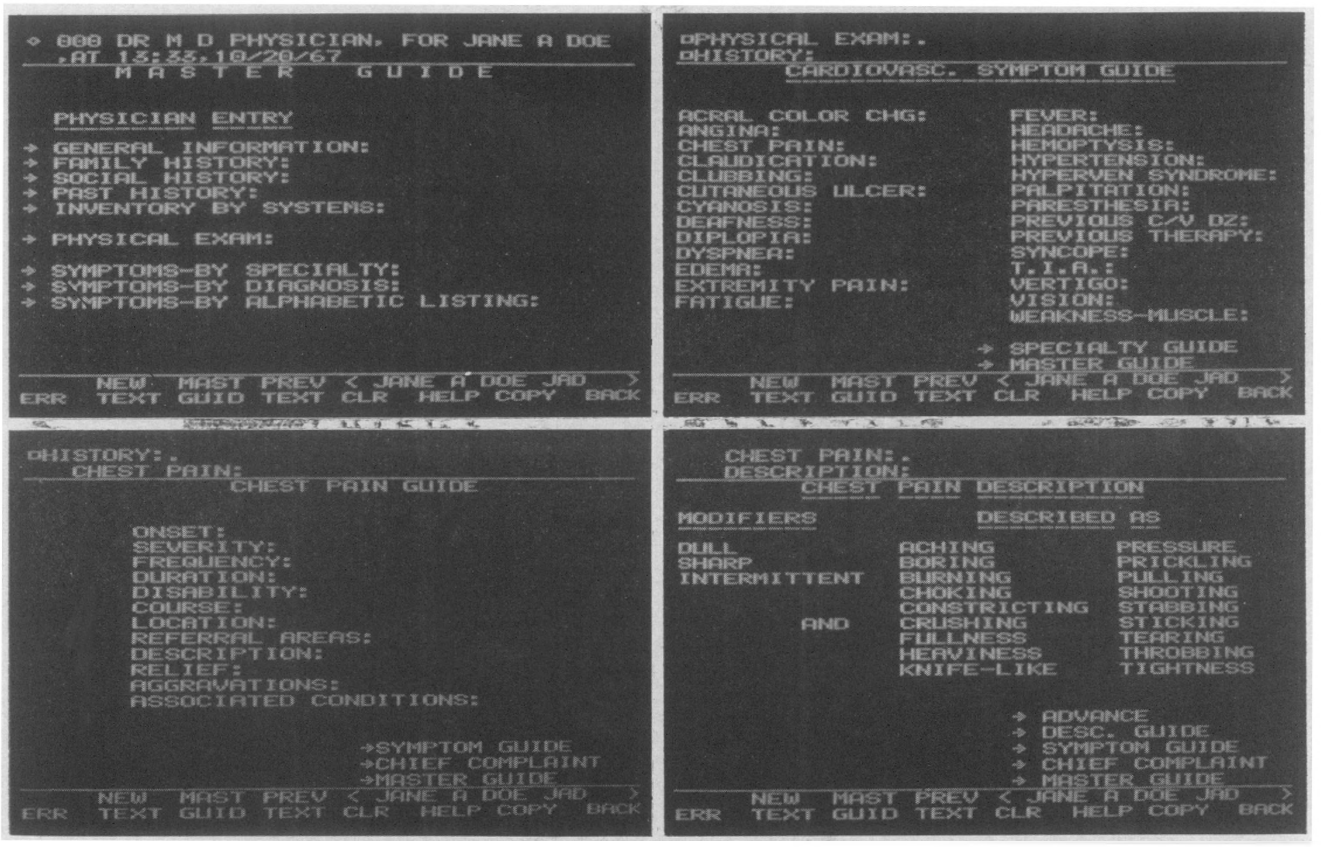


play terminal with a hand-held light-pen is the physician's input device (Fig 2). Message elements may be selected by the operator, with displays sequenced automatically in response to the selection so that there is convenient, rapid, and direct interaction with the computer. The same video terminal is used for call-up and display of the medical record stored in the computer. A typewriter is attached to the video terminal so that a printed copy of any portion of the medical record may be automatically typed if desired.

The word "video" denotes that a television tube is used in the system. The word "matrix" denotes that information is arrayed in horizontal rows and vertical columns so that each item in the array has a horizontal and vertical coordinate. Hence, the term "video matrix" refers to a horizontal-vertical display of information on a television screen. Each individual display is called a "matrix" (Fig 3). The video-matrix system consists of a complete set of related matrices, together with the hardware and computer programs required to use the matrices.

One of the principal reasons for using the video-matrix approach is that the interface problems between the user and the computer are solved as completely as possible. The information stored is in a computer-understandable form, yet is selected by the physician with his own language from the matrices displayed by the computer.

Although the objective of the video-matrix system is to eliminate the need for handwriting or typing of information, there will be occasions when the user cannot enter the exact message he desires using the video matrices and light-pen alone. At present, the keyboard is used to modify or add to the message generated with the light-pen. Eventually, we plan to develop a method for rapid dictation transcription to enter such data so that the physician will not have to use the typewriter keyboard. This dictated input



3. Sample history matrices as they appear on screen. *Top left,* Master guide for physician entry. *Top right,* Symptoms relating to cardiovascular disease that may be selected. *Bottom left,* Having selected "chest pain" from preceding matrix, physician is next presented with chest-pain guide to enter more information regarding symptom. *Bottom right,* Having selected "description" from preceding matrix, physician may enter detailed data about this aspect of pain.

will then be automatically merged with the preformatted display data entered by the video-screen light-pen system.

The computer used in our experimental work has a 16,000-word memory. Each word consists of 12 bits. The present mass-storage device is a fixed-head drum, which stores 1,500,000 characters. Response time from operator action to display update is less than 0.3 second. Data from any of the preformatted matrices stored in the drum may be entered by use of the light-pen, and unrestricted entry of narrative data is possible by use of the keyboard. The drum capacity of this demonstration system limits storage to two complete patient records in addition to the matrices.

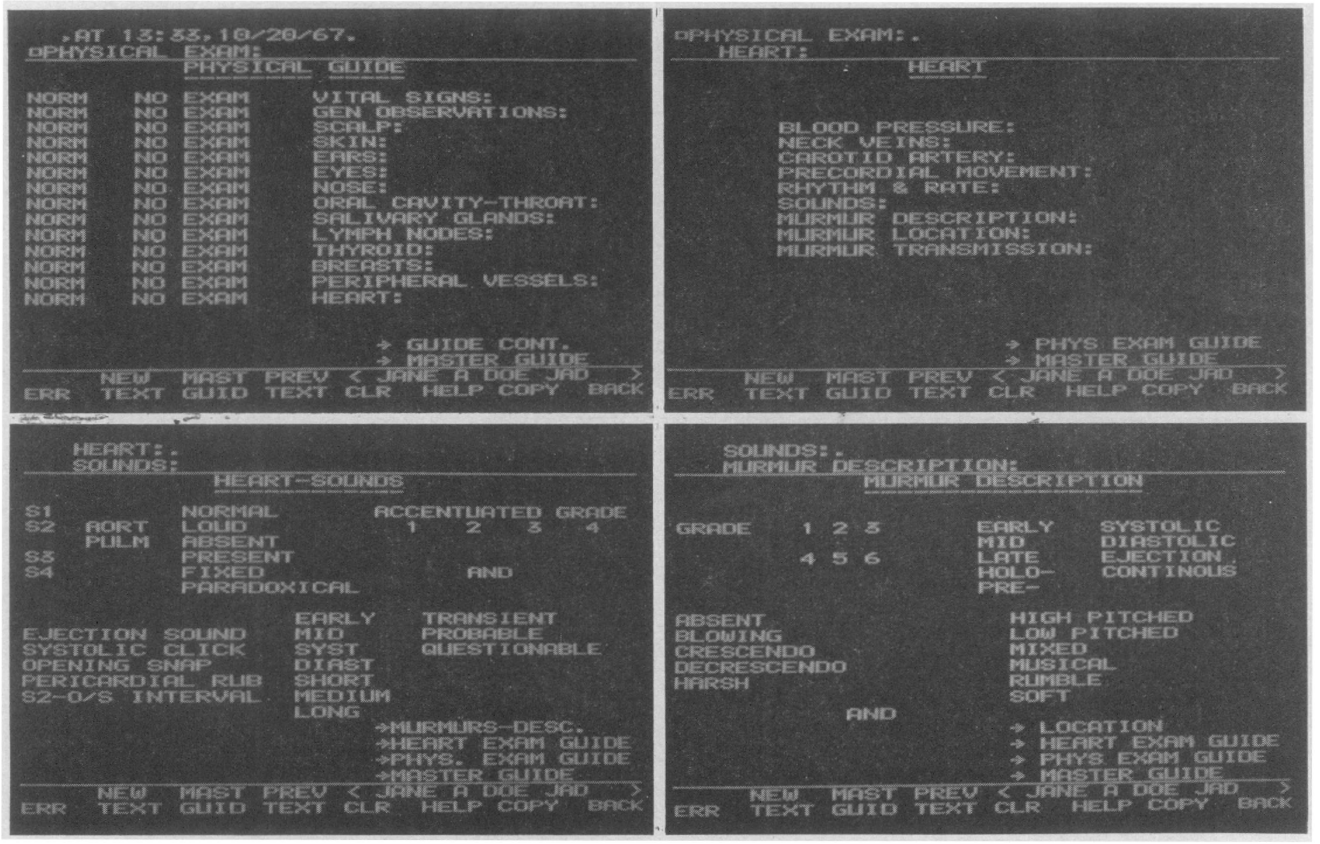
Results

During the first year of this project, the principal effort has been directed toward development of the hierarchical matrix structure, which allows direct entry of information in these areas: general information, family history, personal history, inventory by systems, history of cardiovascular symptoms, and general physical examination.

More than 600 matrices have been completed for these categories. Examples of some of these are shown in Fig 3 and 4, and sample physician entries are illustrated in Fig 5. The names of the physician and the patient are fictitious.

Eventually, formatted video display content will be prepared for physician use in entering historical data, data of physical examination, and progress and procedure notes for all areas of clinical medicine. At present, however, the programs available are designed to permit an internist to record physical findings from a general medical examination and to select historical data relating to cardiovascular and cerebrovascular disease. These findings are selected from comprehensive lists, systematically classified, and arranged in logical sequences on the television screen. Having selected and reviewed the history and physical findings, the physician can then enter them into a patient's record both as "hard copy" and for later retrieval from computer-controlled storage files.

In operation, the video screen initially displays general categories of information, starting with a master guide, which lists such items as personal history, family history, present illness, and physical examination findings. As a selection is made, succeeding displays first automatically narrow the scope and then sequence the selections from general



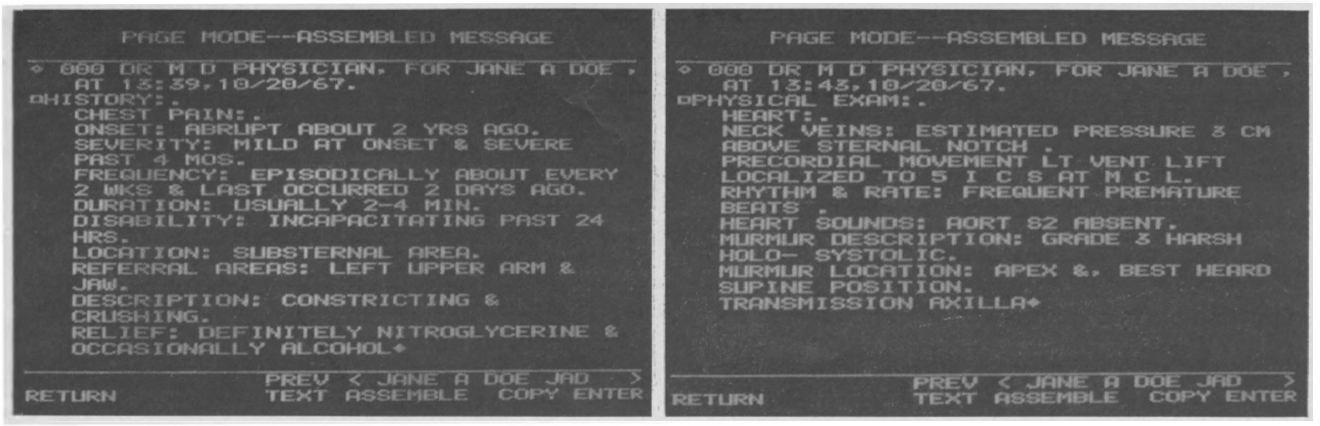
4. Sample physical-examination matrices as they appear on screen. *Top left,* Physician may indicate that result of any specific part of examination was normal ("norm") or that a particular portion of the body was not examined ("no exam"). *Top right,* Having selected "heart" from preceding matrix, physician is next presented with heart guide to enter pertinent findings. *Bottom left and right,* Having selected "sounds" or "murmurs" from heart guide, physician can enter detailed information about auscultatory examination.

to specific until the desired entry data are available. We have found that clinicians want very rapid response from the video system so that their thought processes are not interrupted. In general, the matrices are structured in a uniform manner so that a familiar hierarchy is offered to the physician for each patient. For example, in the entering of the chief complaint, data about the onset of the symptom are offered first. This matrix is followed by others dealing with location, description, severity, frequency, duration, course, aggravating or precipitating events, relieving factors, and associated conditions (Fig 3). Entry is facilitated by passive recognition of data presented on the screen instead of requiring active recall by the physician. At all times the physician has complete control and can override any automatic sequencing if desired.

Our initial experience with the system indicates that, with the use of present techniques, it is more difficult to format historical information in sufficient detail to satisfy the physician than to format entry of the relatively standardized physical findings. Preliminary testing of physician reaction to use of the video terminal for entry of historical and physical-examination data relating to cardiovascular disease suggests that internists will be willing to use such a system when it is fully developed. In this subjective acceptance-evaluation test, 32 internists were individually given a 45-minute demonstration of the video-matrix terminal, after which they entered the historical and physical findings. After using the video system, the test group was given a list of five statements and asked to indicate a response—agree, undecided, or disagree. Results of this test are tabulated in the Table. The subjective response was generally favorable.

Comment

The group at Tulane University[1] has long been interested in processing information from medical records. This is acquired on specially prepared self-encoding work sheets that are converted to machine-sensible form by manual keypunching; the information is read from cards onto magnetic tape and then merged into a master file from which it can be retrieved. Levy and associates[2] have described a system which has, perhaps, somewhat more latitude in that the physician expresses some of the data in his own words. However, special input forms, clerical transcription of some data, and sub-



5. Sample physician entries as they appear on screen. When physician selects "copy" with light-pen, typewritten copy is automatically generated by printer. *Left,* Details of portion of history regarding chest pain. *Right,* Details of portion of cardiac examination.

sequent keypunching of all data are necessary. Korein and associates[1] have reported a technique that allows narrative from medical summaries and reports to be dictated in a standardized sequence. A typist then uses a specialized typewriter to produce simultaneously a printed document and a punched paper tape, the latter suitable for computer input. Slack and associates[4] have devised a computer-based interviewing system for obtaining information from the physician regarding physical-examination findings. Questions concerning physical findings are presented on a cathode-ray tube, and responses are entered by the physician into the computer via typewriter keyboard. A legible and standardized summary of the physical findings is printed by a teletype machine connected to the computer.

In 1964 we[5] reported a method for storing and retrieving clinical and laboratory data on certain patients with hyperlipidemia, hypertension, or arteriosclerosis. These data were gathered by well-motivated physicians and entered on work sheets for manual keypunching and transfer to a magnetic-tape file. The chief benefit of the system to the participating physicians was the automatic generation of a standardized, printed clinical summary useful for subsequent patient visits and for correspondence with referring physicians. However, we found that busy clinicians were poor clerks, and soon lost patience with this type of data collection. In our institution the printed clinical summary did not provide benefits sufficient to compensate for the increased time and the inconvenience of filling out the work sheet; oversights, omissions, and errors appeared with increasing frequency. Despite the usefulness of the printed summary and the obvious potential advantages in clinical research, this particular method of data processing has now been abandoned.

The system for physician entry of historical and physical-examination data described in the present report should obviate some, if not all, of the previous problems encountered. There is a direct physician-computer interface in natural language with instantaneous retrieval. Avoided are the laborious and time-consuming encoding of work sheets and the errors inherent in the handling of clinical data by clerks and keypunch operators.

Response of Internists to Questionnaire After Demonstration and Use of Video-Matrix System

Questions	Response		
	Disagree	Undecided	Agree
1. Eventually, I would like to have a system with the general characteristics of the video display available for use in my section.	0	3	29
2. In my opinion, specialties other than mine at the clinic would be willing to use such a system.	1	6	25
3. I feel that the completeness of clinic records would be increased if the physician had ready access to history and physical displays such as those just tested.	0	0	32
4. In my opinion, it would be practical to enter the history of an average clinic patient on this sort of device.	0	5	27
5. In my opinion, it would be practical to enter physical examination data of a clinic patient on this sort of device.	1	5	26

Physicians appear willing to use this entry technique, though a few express skepticism as to whether it is completely practical or whether others will be willing to use it. All agree that the medical record would be more complete with the system (Table). Our preliminary observations indicate that physicians will be able to enter historical and physical-examination data at speeds comparable to normal handwriting. It remains to be determined whether routine use in actual clinical setting will offer more constraints than presently foreseen. Certainly, objective timing data of physician entries in a clinical setting will be necessary before a large-scale operational system can be recommended. In this connection, logging programs, which automatically record all operator activities, and the time intervals between them, have already been developed. If certain matrices or portions thereof are rarely used, modifications or complete revision of these formats can be quickly and easily accomplished. Direct en-

try of the physician's findings into a computer-based medical record with opportunity for rapid review on a video screen also has implications for objective assessment of quality and completeness of histories and physical examinations by interested third parties.

It should be emphasized that this system for physician entry of clinical data into a computer-based medical record is but one part of a comprehensive medical-information system currently under study at the Mayo Clinic. Other aspects of this medical-information system include the ordering, scheduling, and reporting of laboratory tests with the videomatrix system, as well as acquisition of information from the patient with adaptive computer-generated questionnaires. The method detailed in this report is not an attempt at automating diagnoses. The physician remains at the very core of this system; it is the physician's judgments, interpretations, and objective findings that are entered into the computer.

For the future it is not difficult to visualize computer-aided abstraction of this clinical data and partially automated generation of insurance reports, letters to referring physicians, and other correspondence relating to the patient's medical record. In the distant future, perhaps even this type of hard copy will become outmoded as medical centers and physicians learn to communicate directly with one another via a computer.

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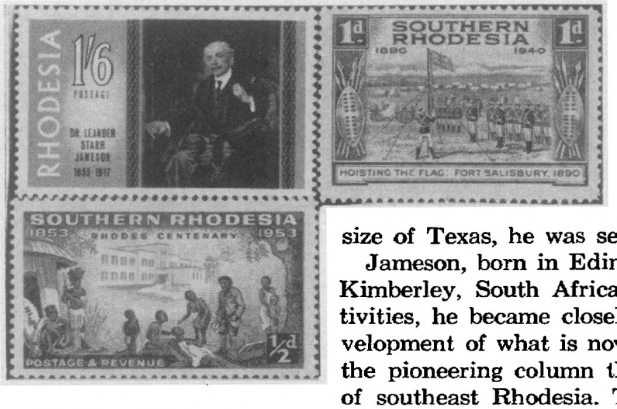

JAMESON, PHYSICIAN AND PIONEER.—Leander Starr Jameson (1853-1917), a Scot who received his medical training in Edinburgh and London, played a dual role in the history of South Africa. As a physician, he brought scientific medicine to a vast area. As a factor in the birth and early development of the Union of South Africa, an area nearly twice the size of Texas, he was second only to Cecil Rhodes.

Jameson, born in Edinburgh, took up the practice of medicine in Kimberley, South Africa, at the age of 25. In his professional activities, he became closely associated with Rhodes in the early development of what is now Rhodesia. Jameson in 1890 accompanied the pioneering column that entered Matabeleland, now a province of southeast Rhodesia. The following year, he was appointed administrator of Rhodesia.

He became a leader in the movement which eventually brought the country into the British empire. Trouble developed at Johannesburg in 1895 between the Boer government and the Uitlanders (foreigners). On the order of Rhodes, Jameson led a military force to support the Uitlanders. The intention was to place the Dutch states, then experiencing a gold rush, under British rule. The campaign ended in disaster and his surrender. He was handed over to the British authorities who sentenced him to 15 months' imprisonment.

Jameson resumed his political activity in the Cape of Good Hope and was elected to the legislative assembly in 1900. Four years later, he became premier for a four-year term. He was a member of the 1910 national convention that drafted the constitution of the Union of South Africa as a self-governing dominion within the British empire. He was made a privy councillor and given a baronetcy in 1911.

The Rhodesian Ministry of Posts in 1967 issued a postage stamp bearing Jameson's portrait. A hospital, physician, and natives, and the hoisting of the British flag at Fort Salisbury (1890) are shown on earlier Southern Rhodesian Stamps. Mirt, J.A., "Medical Pathfinders on Postage Stamps."