Specialized personnel at Bell Telephone Laboratories are studying the human factors in modern telephony—man's communication needs, abilities and limitations.

J. E. Karlin

Human Factors Engineering and Modern

Effective communications engineering requires some basic knowledge about the telephone user's properties, namely, his communication needs, abilities, and limitations. The user's needs help determine what new systems should be considered and his abilities and limitations help dictate how the system should be built. The study of these user communication properties is the subject of human factors engineering and research.

In the early days of telephony, the important needs like better intelligibility and faster service were obvious and the demands of the simple equipment on the user's abilities were slight. Therefore, the human factors research was relatively straightforward and uncomplicated. In modern communications, both the needs and the technological possibilities for satisfying them are multiplying at a rapid rate. This diversity, coupled with increasing competition, cost, and demands on the user's abilities due to more complex equipment, has made it necessary to devise methods for a more profound understanding and for better measurement of man's communication properties. As a result, the number of specialized personnel at Bell Laboratories studying telephone man-machine problems has increased rapidly over the past decade. Human factors specialists are working in several research, development and engineering departments, as well as in groups studying military problems.

How can the user's future communications needs be foreseen? The methods available are still highly qualitative and rudimentary from a measurement viewpoint, yet they have yielded some worth-while results. One method is, simply, to look for any items of dissatisfaction at the points where man is coupled to the machine in the present telephone system. This method has led in various departments to such developments as lighter weight handsets, TOUCH-TONE Calling sets and automatic dialers (RECORD, *October, 1961*). Second, ideas come from studying trends in world conditions. Data transmission and satellite communication are two outstanding results of this method.

After the qualitative methods have suggested a number of ideas for potentially worthwhile services, the idea is evaluated in terms of its future utility to the user. As pointed out in an earlier article (RECORD, *May,* 1954), forecasting the utility of a new service without actual experience with the service is fraught with danger. For example, in one recent experiment, the utility of a message storage device at the Laboratories was shown to have been badly over-estimated by armchair experts. With this device, a user was able to dial a number and record a message in his own voice to be played back to a designated telephone at a designated time. It was assumed that this service would be useful for "busy" and "don't

Laboratories members and customers tested these dial-in-handsets. Both preferred the rectilinear model (foreground).

n Communications

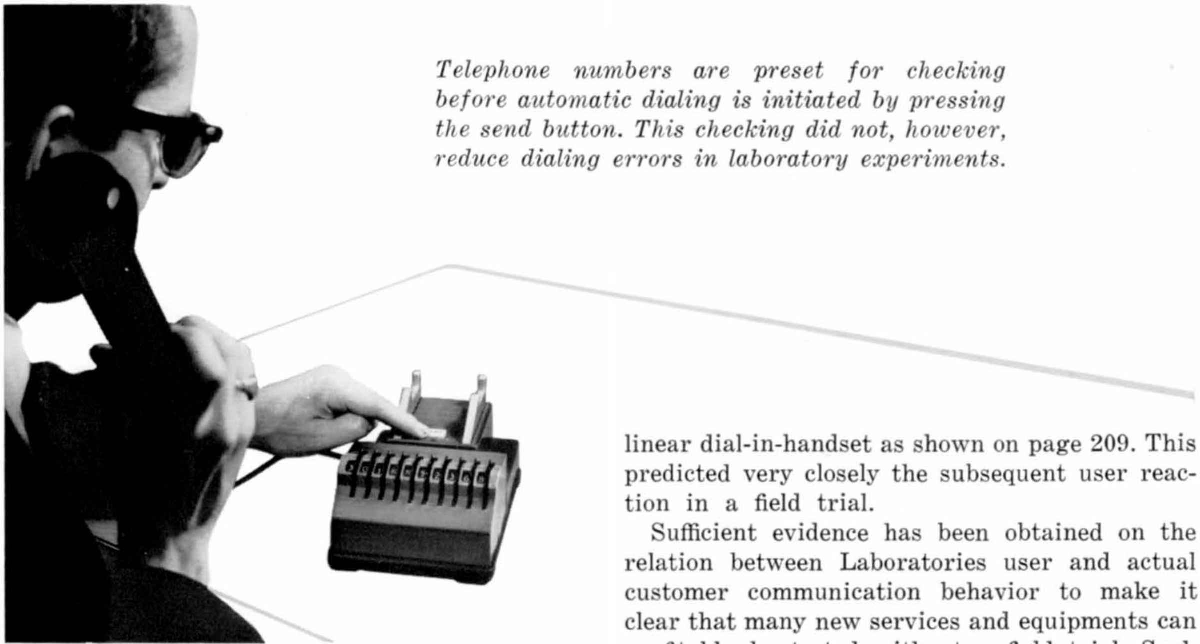
answer" conditions, or for sending the same message to a number of telephones. The results contradicted all the expectations. When the novelty of the service wore off, people used the service less and less. (The experiment also showed the importance of choosing the right sample of users —the project director and his staff required a much longer time for their interest in the service to disappear.) Overlooked in developing the device was the importance of the assurance that the message had been delivered.

In the same way, user interest in a preset dialer such as the one shown on page 210 was also shown to have been over-estimated. The experiment showed that people spent more time setting up the number to be called than dialing it with a conventional rotary dial. They also made just as many errors—in spite of the fact that they could check the number after it was set up.

The importance of appraising projected services through actual use led to the development of Sibyl, a general-purpose machine for simulating new telephone systems and recording data on user reaction under normal operating conditions (RECORD, *November*, 1958). Sibyl has considerable programming flexibility, eliminating the necessity of building expensive equipment to simulate each new system. At the present time, Sibyl is being used to allow some Laboratories personnel to conduct normal telephone calls from their desks over a simulated satellite communication path. Round-trip transmission time over the 90,000 odd miles in a stationary satellite system is about half a second. Echoes become very noticeable with such delays, consequently, suppressors are essential. Since echo suppressors tend to make it difficult for a listener to interrupt, it is necessary to test for the best suppressor arrangement. If tests were made in a test room, using planned conversations, the results would be highly variable. The tests made with Sibyl provide the necessary realism to obtain more accurate information. Much has already been learned about the type of user reaction to be expected with future satellite transmission systems.

Such methods of measuring utility, while not very precise, are useful because the information required about a new service sometimes need be only very general. However, on occasion, it is important to determine more precisely which of two services the user prefers and by how much. The variability permissible in such measurements is considerably less.

Research on a general approach to this problem led to the development of the *isopreference method,* which is still in the exploratory stage but appears promising. It has been used, for example, to map contour lines of equal preference for voice transmission circuits having different speech and noise levels. All the transmission con-



Telephone numbers are preset for checking before automatic dialing is initiated by pressing the send button. This checking did not, however, reduce dialing errors in laboratory experiments.

ditions on any one line of the graph at the top of page 211 are, on the average, equal in preference for a group of listeners and all the conditions on any one line are preferred to those on a lower numbered line. The numbers on two lines can be used to predict the percentage of listeners preferring one condition to another. The contours also show how noise and voice level can be traded off against each other for engineering or economic reasons. This kind of overview will become increasingly important in engineering as the over-all communication network becomes more complex and the requirements more exacting.

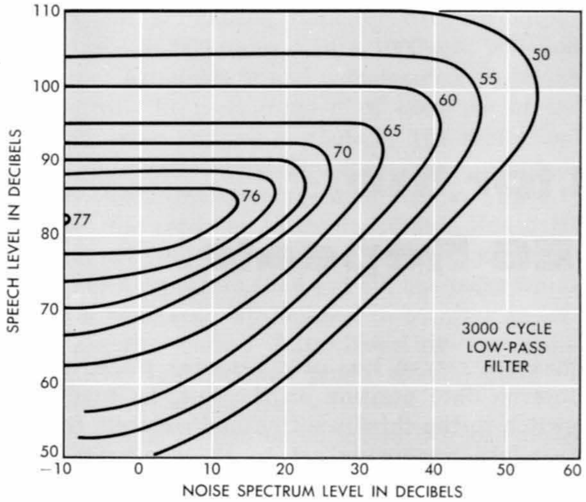
A principal objective of human factors laboratory experiments is the study of communication behavior under controlled conditions. To what extent do these apparently artificial conditions and limited nature of the Laboratories user samples impair our ability to predict user behavior in the field? Over a wide range of telephone equipment and services the impairment is surprisingly small. For example, Laboratories studies years ago showed a user preference for lightweight telephones in line with the continuing trend in the field over the subsequent fifteen years. Laboratory experiments also showed a gain in user accuracy and speed for all-number dialing over letter-number dialing; this has been substantiated in field operation. Experimental results showed that TOUCH-TONE calling is about twice as fast as, but no more accurate than rotary dialing; field trials confirmed both findings. Laboratories users showed a preference, both for appearance and usage, for a rectilinear rather than curvilinear dial-in-handset as shown on page 209. This predicted very closely the subsequent user reaction in a field trial.

Sufficient evidence has been obtained on the relation between Laboratories user and actual customer communication behavior to make it clear that many new services and equipments can profitably be tested without a field trial. Such tests, especially in the exploratory development stages, can economically help "debug" and evaluate the utility, appearance and convenience of new equipment and service. The resulting design then has a higher acceptance probability and can be used with more validity in later product and market trials.

There are some problems with customer telephone behavior which cannot be studied effectively in the laboratory. One problem is the heavy and expensive use of the Information Operator. In this case, a study was made in the field and data were collected under normal operating conditions. Analysis showed some unexpected and interesting results: in two different central offices, for example, about 10% of individual users were responsible for 50% of the calls to Information, as shown on page 211. One institution was requesting an average of 200 numbers a day; one customer requested the same number seven times in three weeks. Studies are now under way in an effort to explore reasons and devise necessary corrective action.

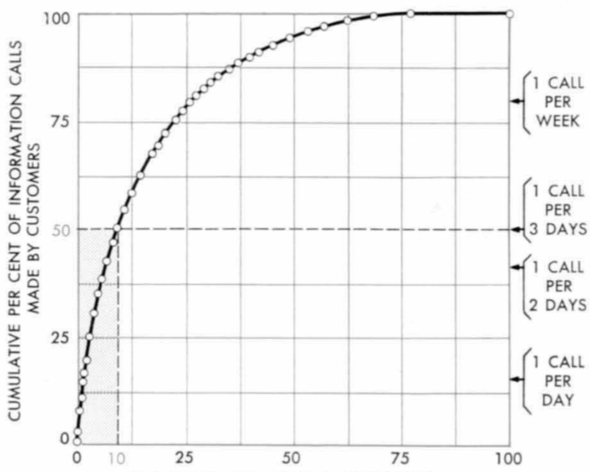
Human Factors and Maintenance

This article has related principally to the *design* of new equipment for customer use. However, the *maintenance* of existing plant equipment and human factors related to maintenance personnel are receiving more and more attention. Studies to date have shown both the seriousness of neglecting the human factor in designing for maintainability and the benefits to be gained from such studies (RECORD, *April*, 1962).



Isopreference contours show which transmission conditions are equally acceptable to listener and the number who prefer one condition to another.

The design of new communication systems is becoming increasingly dependent on a sophisticated knowledge of customer communication properties. Research has led to improved methods for understanding and measuring these properties, but the need for improvement continues as customers become part of an increasingly complex communication machine. With the advent of world-wide dialing, the compatibility of procedures and equipment used by customers in different countries becomes an additional problem. International human factors engineering meetings have already been organized to consider this problem.



A small proportion of users make a disproportionate number of calls to Telephone Information. Data was taken over a 106 day period.

Mercury Tracking System Aids Carpenter Flight

Navy Lieut. Commander M. Scott Carpenter, the second American spaceman to orbit the earth three times, was hurled into space from Cape Canaveral, Florida on May 24, by an Atlas booster rocket. Commander Carpenter's flight, three months on the heels of Marine Corps Colonel John H. Glenn, Jr.'s epic three-orbital trip was, like Glenn's, a National Aeronautics and Space Administration Project Mercury achievement. Western Electric led the industrial team which engineered and built the 18-station worldwide tracking network and provided the communciation with the astronaut through the 140,000 miles of special circuits. Bell Laboratories headed major portions of the Mercury program, including design and installation of the operations control room at Canaveral. Men from Long Lines and most of the associated Bell companies took active part in the project.

The astronaut's capsule dropped into the sea about 125 miles north of Puerto Rico, 200 miles down range from the expected recovery area. Carpenter blew off the escape hatch of the capsule and climbed into his raft. He was joined by two para-rescue men from a C-54 aircraft, who found him in good condition, and waited to be picked up by helicopters.

The 18 stations that comprise the Tracking and Ground Instrumentation System (TAGIS) are connected to the Goddard Space Flight Center in Greenbelt, Md. All types of transmission media are used to provide teletypewriter communication for every station and voice communication for all but six.

From the moment a Mercury spacecraft goes into orbit and recedes from the radar view at Cape Canaveral the successive remote sites of the worldwide network pick up and monitor its operation and position. During the orbital passes, each site receives information from the spacecraft and from the astronaut. These data are transmitted to Goddard Space Flight Center where they are processed by computers and then sent to the Control Center at Cape Canaveral. In this way, a continuous flow of information to and from the Control Center is maintained throughout the entire mission.

The tasks performed by the Laboratories for Project Mercury fall into four categories: equipment design and procurement, equipment engineering, development of operational procedures, and evaluation of the Mercury Range stations.