Bell Laboratories engineers consider even the most precise laboratory tests to be only tentative indications of reliability in a new telephone. In carefully planned field trials, they study the performance of a new instrument under the rigors of its ultimate environment and test its appeal to the customer as well.

R. Black, Jr.

Field Testing An Experimental Telephone

Before new telephone apparatus is placed in service it must survive the crucible of rigorous testing. Often, a program of both laboratory tests and field trials is conducted before the apparatus is approved. Many tests made at the "drawing board" are a basis for accurately predicting its reliability and for judging the performance of myriad other factors prerequisite to its use in the Bell System. But because telephone apparatus is designed as a functioning component of a vast communications system, final proof of its reliability waits on evidence of its performance there.

During a field trial of customer equipment—a new telephone, for example—a whole community, or some large segment of it, becomes in effect a laboratory. In this instance, the field trial is a study of the very important design criteria in the field of human factors, as well as a judgment on the efficacy of the instrument in a functioning system. Literally, we want to know how the customer reacts to the new telephone and, figuratively speaking, how it reacts to him. For these reasons, the same kind of creative thought is expended on planning a field trial as on the laboratory development of new apparatus.

If the trial is to be fully effective, precise control must be exercised over all its phases. This begins with the advance planning. The community chosen for the trial must be a representative cross section of the ultimate market in grades of telephone service and in environmental conditions. It may be necessary to design ancillary equipment, exclusively for the trial, to adapt the new apparatus to the existing central office without interruptions to regular service. Also, procedures must be formulated to train plant people and customers in the use of the new apparatus. The data to be gathered and the test procedures for its gathering are planned in detail; this may necessitate the formulation of new test arrangements. All these problems faced Bell Laboratories engineers in a recent field trial of the tone-ringer telephone. In following that trial, this article will tell the story of how some of these problems were solved.

The tone-ringer telephone (RECORD, *February*, 1957), designed to operate with the relatively low line current of the experimental Electronic Central Office, looks like the modern 500 set except for a louvered section in its side. Actually, it is a considerable departure from the bell-

equipped instrument. The most obvious change is implicit in its name—the tone ringer replaces the bell. This sounding method requires much less power than is needed to ring a bell; a transistor amplifier in the new instrument responds to a ringing tone of approximately one volt. A second transistor amplifier, in the transmitting branch of the set, permits operation on low values of talking current. Solid state devices—transistors and diodes—and other new devices such as ferrite coils were used extensively in the design.

Evaluation tests at the Laboratories predicted high reliability for the new telephone. What still had to be determined was: (1) its transmission quality in an actual operating environment, (2) the reliability of certain new components, (3) its general maintenance requirements, (4) the adequacy of its lightning protection devices and, of utmost importance, (5) if customers would benefit from the new set's transmission quality and if their speed in answering a tone-ringing telephone compared favorably with that for a bell-equipped instrument. Only a field test would yield the answers to these questions. The town of Crystal Lake, Illinois, was chosen for the purpose.

Author shown with the tone-ringer telephone and a standard 500 set. Both casings have been removed to show difference in circuit components.

A number of factors were instrumental in the choice: the town's many classes of customers—farmers, professional people, local merchants, housewives, commuters; its various grades of telephone service, from private business to eight-party rural lines; and its several types of outside plant construction, including cable and open wire. Finally, the area's annual temperature range is from below zero to over 100 degrees and it experiences a full range of weather phenomena.

Special Trial Equipment

It is frequently prerequisite to a field trial either that special apparatus be installed to make the new equipment compatible with the existing central office or that special operating procedures be adopted. The last procedure is undesirable because it engenders additional training problems and because the most successful trials are conducted under normal operating conditions. The low-current nature of the tone-ringer telephone would have necessitated considerable revision in operating practices at the Crystal Lake manual office. To preclude this, Laboratories engineers devised special line circuits which made the low-current lines compatible with the manual office. Six bays of these circuits, transistorized tone-ringing generators (see photograph on page 17), a complete set of standby generators, and a special power supply composed the array of special central-office equipment.

Another problem indigenous to the low-current sets involved the outside plant. Plant operation with these low-current sets required a minimum outside-plant leakage resistance exceeding that required by the normal office, so cables containing the low-current lines were put under gas pressure and careful attention was given to tree trimming on the open-wire sections of these lines.

As a final preliminary to the actual trial, local installers were trained in the special handling of the new telephone. A school was established and a training manual was prepared which consisted of provisional installation and maintenance practices formulated at Bell Laboratories. Local central-office personnel also attended the school. This program led to effective coordination between the two groups of personnel when the lines used in the trial were converted to low-current operation.

More than 300 customers in the Crystal Lake office were selected as subjects for the test. Prior

to the conversion to low-current tone-ringing operation on the trial lines, at least one station on each trial line was visited. During this visit, transmission measurements were made from the station. These measurements included transmitting from the station to the central office, receiving, sidetone path loss at the station, line loss and received noise. These transmission measurements were made with a test arrangement devised for this trial. The equipment used consisted of a sound source, receiver coupler and indicating meter, and a noise measuring set.

Confirmation of Laboratory Tests

Similar transmission measurements were made at these same stations on every line after conversion to low-current operation. The improved transmission, which was predicted by prior laboratory measurements, was confirmed by the actual plant transmission measurements. The received noise on the new sets, which have no station ground, was so low that it was measurable at only a few stations.

To obtain comparative data a group of control lines was selected. The plant facilities supporting these lines were similar to those on the trial lines, though the telephone sets on the control lines were conventional.

To determine the stability of sets over a given time span, measurements of customer talking volume were made at intervals during the course of the trial on both trial lines and control lines. The distributions of these volume measurements at the start of the trial and about one year later indicated the good transmission stability of the new sets, as well as the old.

The speed of customer answering on both the trial lines and the control lines was recorded during the course of the trial. Customers with tone ringers answered their calls in approximately the same time as customers on the control lines with conventional bells. The percentage of incoming calls with "don't answer" varies with the season of the year. But in general, the percentage of "don't answer" calls on the trial lines and the control lines was the same.

Special routine measurements of several types were made in the Crystal Lake office during the course of the trial. All low-current lines were terminated in a jack field and line-leakage measurements were made from a special test desk during wet weather. Periodic measurements were made of current drains on all idle low-current lines. This idle-line current results from line-leakage and tone-ringer components bridged on the line. Abnormal current drains indicated a change in line or station conditions and often foretold a trouble report. Periodic checks were made of the frequencies, wave shapes and output levels of the tone generators. These tone generators met the design objectives for stability over the wide range of operating temperatures in the office.

The same testing arrangement used for field transmission measurements was used in the office to measure all low-current sets on an artificial line, prior to installation and after removal from

F. L. Crutchfield with special testing arrangements used in Crystal Lake trial. Mr. Crutchfield reads meter on control panel. Other components of the equipment are the sweep oscillator, rear; and the transmission measuring set, right.

service, either because of reported trouble or at the termination of the trial for customers who had used the sets for the trial period of one year.

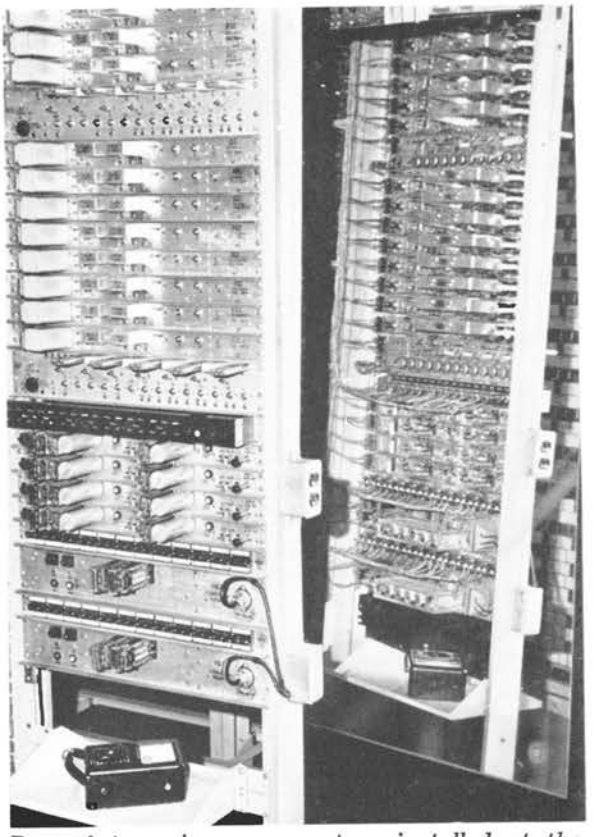
The photograph on page 16 shows the testing arrangement in use in the office. Tone-ringer output was also measured in the office with a specially constructed anechoic chamber (a chamber without echos). Some of these measurements were used to verify trouble reports. Units measured after a year of trouble-free service indicated that the low-current sets had stable transmission characteristics and stable tone-ringer output.

During the course of the trial, many of the low-current trial lines were subject to lightning surges as evidenced by the scoring of the carbon blocks and some blown fuses. The exploratory silicon-diode protector used in this trial in conjunction with the regular carbon-block station protector did an adequate protection job.

Resistance unbalance measurements were made on the trial lines and on the control lines after about a year of low-current operation. The amount of resistance unbalance on the low-current lines was approximately the same as on the control lines which indicates that low-current operation in an exchange plant with unsoldered pigtail joints introduces no new hazards.

A primary source of data in any station field trial is the line card, which is normally kept in the test center and reflects such factors as in-and-out movements, equipment changes, customer and employee trouble reports and located troubles. The line cards for the trial stations which are normally kept at a distant test center, were transferred to the Crystal Lake office where they were kept up to date. All trouble reports on these lines came into this office and all testing and dispatching on the low-current trial lines was handled from this office by assigned personnel. This arrangement made it readily possible to determine the required maintenance rate for the trial and control stations for any period of time.

In the early stages of the trial, after a little over half of the low-current sets had been installed, the station trouble rate was much higher than expected. These trouble reports were mostly "Bell Does Not Ring" or "Bell Does Not Ring Loud." Further installation was stopped and an analysis of the troubles was made. Two types of components—mylar foil capacitor and diodes—were not performing as expected. Design changes were made and installation of the new sets resumed. The trouble rate was appreciably reduced and the trial on all redesigned sets was continued for one year to prove the reliability of the low-current set and its components.



Bay of tone-ringer generators installed at the Crystal Lake central office. A mirror, tilted slightly, has been used to show the rear of the frame.

To show how customers in Crystal Lake reacted to the low-current tone-ringer set we will note briefly some of the information gained through interviews. Customers noticed the improvement in transmission and the quieter circuits; they liked the tone ringer; in fact most of them preferred the tone ringer to the bell. The reason given for this preference included: it was "less irritating," "more pleasant" or "kinder to the ears." Several said they had impaired hearing and could hear the tone ringer better than the bell. It took most customers about a week to become accustomed to the tone ringer. A few thought the tone ringer was not loud enough but agreed that they could hear it throughout the house and often in the yard. In general, interviews confirmed that the tone-ringer sets used in the Crystal Lake trial did an effective job of alerting customers to their incoming calls.

The reliability and effectiveness of the tone-ringer set at Crystal Lake was so well affirmed that it is now being used in the field trial of another important Laboratories development—the electronic central office in Morris, Illinois.