UNATTENDED DIAL TELEPHONE EXCHANGES
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UNATTENDED DIAL TELEPHONE EXCHANGES

INTRODUCTION

General

Telephone service since the installation of the first equipment has been continuously improving in scope, distance, speed, and dependability. Automatic or dial operation introduced a degree of efficiency and a speed of service unknown before that time. Although it was in the small unattended branch exchanges that automatic switching first found successful application, only in the last few years has dial equipment been generally adapted to the many conditions and problems that are found in small towns and rural communities.

There are several reasons for the increase in the number of unattended dial telephone exchanges (18)*. The ever-increasing use of the automobile has had a decided influence on the movement of families from the metropolitan centers of population to the outlying areas of our large cities and towns. This movement has precipitated the building of good roads and led to the formation of new shopping and social centers.

*The numbers in parenthesis throughout the paper refer to references in the bibliography.
As a natural result of these activities there has been the demand for adequate public utilities. Without power, water, gas, transportation and communication facilities, this community expansion would have been seriously retarded if not altogether blocked. The rural districts and small towns which are near the larger industrial centers have undergone this change and, in many cases, have demanded utility services on a par with those of the city proper.

Today this trend is not confined to those communities in proximity to the larger centers. People travel more widely, seeing and using services with which they were unfamiliar years ago. The utility of power, water, transportation and communications at first astonished them, but now they are demanding these services in their own homes. The farmer who has his radio and power-driven farm machinery is not going to be satisfied with oil lamps or with telephone service that is not thoroughly modern.

**Specific Problem**

The need of improved telephone service in small towns and rural communities brings up the question of manual versus dial operation. The problem has not always been easily solved (23). The principal problem which the telephone operating company has to face when considering
replacement of inadequate or obsolete equipment is the same problem faced by the manufacturer who is considering the introduction of machine equipment to replace manual labor. The fact that the machine equipment will considerably reduce the cost of the article he is producing must be definitely proved before he dares adopt it. In the case of the telephone company it is generally necessary to reduce the overall operating cost, the item which often puts small exchange telephone service "in the red." In fact, at one time, a feeling developed that the problems surrounding the operation of rural lines and small offices were such that this service never could be made to pay.

It has been more difficult to "prove in" dial equipment in small towns than in the large metropolitan centers. The reason is twofold: labor cost in the small town is less than in the city, and the simplicity of completing a telephone call in the small exchange compared to the complicity in the large multi-office exchange means that more than one operator often handles the same call in the latter case. The decision usually rested upon which one, dial or manual, granting that they both give a satisfactory grade of service, was the more economical.

However, today the picture has changed with the specialized development of different types of dial equipment to fit the outside plant conditions and the traffic characteristics of any size of exchange or rural line
development. Accordingly, when a program of modernization is planned for an exchange, there are usually few arguments in favor of manual operation. One of these few, however, often seems of major importance to the public involved. They are sure that it will be most inconvenient to lose the personal contact of a local operator who keeps track of the affairs and whereabouts of the individuals of the community. Also, in some cases a revision in magneto service rates, which have been in existence for years, is necessary before new equipment can be installed. This does not mean that rates must be higher under dial operation. It does mean that in those exchanges which have grown to a size where higher rates normally apply, it is desirable to put the exchange on the correct rate schedule at the time of the equipment conversion. An interesting phase of this situation has been the referring of the question directly to the public by the telephone company (15).

"The company outlined the advantages of automatic operation to the public in these small towns, emphasizing such points as accurate connections, better transmission, instant service both day and night, and selective ringing on party lines.

"Having the matter clearly presented to them, the public in practically every one of these communities made known their preference for the new system through resolutions passed by their boards of aldermen, Chambers of Commerce, etc.
Because of the unprejudiced and straightforward manner of presentation, there was a thorough understanding of the issue, and practically no opposition was encountered to the whole plan of conversion as originally conceived."

Even where this plan has not been followed for one reason or another, general satisfaction and approval have resulted from the use of dial equipment, from the isolated farmer to the business man in town.

The adaptation of improved telephone equipment to the smaller towns and rural communities, whether near the larger operating centers or more or less isolated from them, has been greatly facilitated by the development and production of the step-by-step type of community dial exchange unit. How one of these offices appears to the layman was described in the "World's Work" by W. P. Helm:

"When one enters one sees only columns of odd machinery, like metal filing cases, that rise in tiers from the floor to the ceiling. Busy little discs run over the surface of those tiers, darting about at high speed, while here and there a light flashes on and snaps off. One hears a purring made up of many rapid click-clickclicks as the metal discs come in sudden, gentle contact with other metal. Once a day perhaps, an inspector drops in to see if everything moves smoothly. He stays a few minutes, closes the door behind him, and goes away. Through this deserted little building there filters night and day the entire telephone conversation of the little

*Ref. No. 15, page 80.
city. The metal panels and discs make the connections and do all the work."*

For the small dial offices step-by-step operation was found exceptionally well fitted to combine low operating cost with a high grade of service twenty-four hours a day.

It is with the development, application, and operation of such unattended dial telephone exchanges that this paper deals.

*Ref. 17, page 562.
HISTORY

Everyone is aware of the dramatic beginning of the telephone—of the experimental work by Alexander Graham Bell and his associate, Thomas A. Watson, which led to the invention of the instrument that first "talked" on March 10, 1876. The public was slow to realize the usefulness of the device. The first commercial telephones were put out in May, 1877 (14). Telephones were used in pairs, one on each end of a single circuit, until the first commercial telephone switchboard was installed at New Haven, Conn., in January, 1878. The early switchboards, operated by boys, provided for the connection of the desired telephone lines by throwing switches. The idea of making these connections automatically was conceived and patents taken out (1879) by The Connollys and McTighe only two years after the first manual switchboard installation (21).

It was in the smallest unattended branch exchanges that automatic machine switching first found successful application about 1880, the local connections being established by an operator at a distance (10). The attempts to solve the larger problem of completing connections between an unlimited number of subscribers arrived slowly, and the real development came after the invention, by Strowger in 1899, of a switch which introduced the two-
coordinate motion across a half-cylindrical bank of contacts, the extent of the vertical and horizontal motions being determined by impulses under the control of the calling subscriber.

A great disadvantage in the early machine switching systems was the use of additional wires for the switching operations. The first Strowger system used five line wires, the impulses for the two motions being separated and generated by individual keys. A large type of this switch in which there were ten rows, each having a hundred studs, was used at an exchange in the United States in 1892 (10). This type of switch, though cumbersome, was a great advance on the mechanical commutators which were used unsuccessfully in attempts to solve the switching problem.

In 1895 Strowger produced a form of switch which is essentially the same as the "step-by-step" dial switch now in use. In the six years which followed his invention of the first two-coordinate switch, Strowger had experienced considerable difficulty in devising a satisfactory method of holding and insulating the bank contacts. The fiber strips, as used in the modern switch, proved more sturdy with far better insulating properties than did the plaster of Paris which was used at one time.
In 1896 W. P. Thomson produced a telephone dial for controlling the switching impulses having projecting pins which reduced the number of wires to the exchange from five to only three. However, it was not until 1912 that circuits were developed with the dialing impulses generated by opening the loop while current is flowing. This made it possible to dial with only a two-wire line—the circuit over which speech is ordinarily transmitted.

Considerable difficulty was encountered in designing a switch which would accommodate accurate selection among 1000 lines, and the alternative scheme of tandem switches as now employed in offices with more than one hundred lines was incorporated in an exchange in 1897. In the first designs the automatic hunting from the first selector to the final selector (connector) required an additional train of impulses, but this was later overcome and automatic hunting for a free outlet established.

The exchanges installed in the United States in the early years of this century are noteworthy for introducing improved circuits and types of apparatus. Although minor improvements have been added from time to time, step-by-step machine switching telephone service was in principle, then, as it is today.
DEVELOPMENT

Although it was in the small unattended branch exchanges that automatic switching first reached a degree of success many telephone companies over a period of years considered dial operation for small exchanges more or less of an experiment. And it is true that much experimental work was carried on in this branch of dial service to continually improve the equipment and adapt it to the various conditions found in small communities.

Some of the early installations of this type employed push buttons on the instruments for ringing (5). This is perhaps the simplest method of arranging code-ringing on automatic multi-party lines but it has its limitations and restrictions, and is not used on the modern installations. A great many schemes and features were tried out on a variety of circuit arrangements; some were incorporated in later models, but many were dropped as being unsatisfactory or impractical.

The very early unattended dial exchanges were relatively simple with few auxiliary circuits. Later installations were the result of research which tried to make these dial units as fool-proof as possible. As a result automatic switchboards about 1920 to 1923 were often unnecessarily complicated. This does not mean that
they were troublesome or difficult to maintain, but they had so many protective features and were so elaborately complete that the first cost was kept unnecessarily high.

During the following decade small exchange automatic equipment became more practical, compact, and standardized by types from the standpoint of exchange size or equipment function. The present standards represent a vast improvement over those of ten years ago, and although the equipment has been simplified, the service, due to continuous development, has improved. The early designers viewpoint was to insure against any possible chance for failure, but a medium has been reached between an unnecessarily elaborate design which is too costly, and low-priced equipment which is not fully safeguarded against failure.

Ten years ago practically all village central offices were manually operated, but the expense of providing first class twenty-four hour manual service has tended to favor the introduction of dial service at a constantly increasing rate. In this state, for example, there were no unattended dial exchanges prior to December, 1935. Today there are thirty, and the number is steadily increasing. Inexpensive housing with little heat, and low operating charges tend to offset the higher first cost of dial equipment. For the smaller exchanges
the central office building in which such an installation is housed today may be smaller than a one-car garage.

Several types of dial equipment employing only relays have been developed for small towns and rural communities, but they are not used as extensively as the step-by-step type of switching equipment. For small offices of various sizes and condition of plant the latter type of operation has been found best fitted to combine low operating cost with a high grade of service. This equipment is of such a nature as to afford a uniform grade of service twenty-four hours a day without the constant attention of a maintenance man.

A simple, compact arrangement of equipment is standard, with small frames to carry the switching equipment and power plant. These units are shipped from the factory as completely wired as possible and the work of connecting them is simple. A small distributing frame provides a flexible link in the circuit for connecting any line with any desired terminal of the switching equipment. Additional small units mounted on swinging gates hinged to the main frame or located in a common cabinet are required for two-way trunks, coin box lines, and for other special line equipment.

The alarm circuits available with most community dial offices are somewhat unusual. It is this
equipment that discovers irregularities or circuit failures and transmits the alarms to the master office where the maintenance headquarters are located. All alarm conditions are classified mechanically into two groups: those requiring immediate attention, and those of a minor nature which may be rectified at some more convenient time.

The power equipment to operate a small dial office consists of a small rectifier and storage batteries, with the charging circuit automatically controlled. Whenever a call is initiated the charging is automatically started and continues until the high-voltage relay cuts it off at a predetermined value. With such a method the storage battery is maintained in a fully-charged condition at all times without manual regulation or special attention.
APPLICATION

As mentioned in the introduction the problem of small office operation has been considered for a long time, but impetus has been given to this study in recent years by new developments, technical and economic. There are many factors which enter into the furnishing of a satisfactory grade of telephone service, some embrace the outside plant, some involve the dial office or control office equipment, while others concern traffic operating arrangements.

The Outside Plant Problem

In any consideration of the problem of engineering dial equipment that is to serve rural lines, one of the first questions which must be settled involves the number of telephones to be connected to a line. Poor transmission and subscriber complaints frequently result when there are too many stations per line. A series of surveys of rural subscribers and an investigation of calling rates per station and per line indicate that, in most cases, the maximum number of rural subscribers on any one line should be limited to eight (11). In practice, rural lines owned by the telephone company are usually limited to ten. To prepare rural lines for dial
conversion it is sometimes possible to work toward building and rehabilitating for a maximum of eight or ten stations per line, but this necessitates a fairly accurate estimate of future station development. Exceptions to this practice may be warranted especially with existing lines, but, in general, the objective mentioned seems reasonable if improved service is the desired end.

One of the special problems in connection with the installation of community dial offices is that of service company lines. A service company is understood to be an organization which has built its own outside plant, has either purchased or leased its station apparatus, but depends upon some other company for handling its traffic. These small local companies are privately owned because it is usually economically unsound for the switching company to build and maintain long rural lines. This usually means that the company which does the switching has very little control over the type of construction used in the outside plant and practically none over the maintenance methods employed and effort expended. More often than not when these conditions exist the result is that many of these lines are in such a state of disrepair that satisfactory service cannot be rendered over them. This may react, to a certain extent, upon the telephone company and its service in general, for customers calling the stations on these service lines, not realizing the
conditions existing, are prone to blame the company doing the switching.

An example of the threefold nature of the problem that often actually exists on rural lines in the small exchanges is seen from the diagram, Figure 1 (a). This represents a mutually-owned "switched" line of single wire, grounded construction, consisting of varying lengths of numbers 10, 12, and 14 iron wire. This line was run partly on poles with the occasional use of an insulator. For the most part, however, the line was looped around fence posts, hooked over branches of trees or nailed to their trunks, and in one place the tree had actually grown around the wire. Of the many high resistance joints, the swinging loops, though noisy in a wind, usually were better conductors than the rusty twists. The 19 subscribers located along the line and on its ramifications, as shown by the crosses in Figure 1, operated a weird assortment of privately-owned instruments, most of which could easily be classed as antiques.

This "farmer line" problem often must be solved in small exchanges before conversion to dial operation is practical. In most cases it has been worked out satisfactorily, with the switching company offering all reasonable assistance to the service companies in an effort to improve the over-all grade of service rendered,
thus making it possible to operate the lines on a dial basis.

Some types of community dial exchange equipment are designed to serve poorly insulated lines with as many as twenty parties per line (see "Description of Equipment" section following) without necessitating costly reconstruction. However, in the interests of better transmission and a reduction of noise, insulators are usually added on the farmer lines, and the lines restored to fairly good order without incurring unusual expense. In some cases each privately owned telephone instrument is converted for dial operation by the addition of a dial and a condenser and the removal of the generator crank. Usually it is more satisfactory, both for the telephone (switching) company and the farmer, to replace the "antique" with a more modern type of dial instrument. The instrument conversion or replacement is usually done by the telephone company at a nominal charge to the owner. In this manner a "ticklish" problem is successfully solved, the switched lines converted to dial operation, and the good-will and patronage of the service subscribers retained.

A few manual exchanges serve farmer lines, the characteristics of which do not readily permit their conversion to dial operation. This may be due to the length,
to the construction, or to the number of stations on the line, but is often due to the fact that the type of community dial exchange equipment being installed (usually dictated by the size of the exchange) is not arranged to handle lines with more than a given number of stations—ten, or in some cases, twenty. The problem of caring for these lines is usually solved in one of four ways:

1. The lines are divided by stringing additional wire to the central office exchange boundary so that the number of stations on any one line does not exceed the maximum.

2. The lines are manually operated from the master office (practical only when the distance is short).

3. Auxiliary equipment is provided to increase the number of stations per line that can be served. This feature is not available for all types of community dial equipment, but in any case it materially increases the first cost.

4. A single position of manual switchboard is retained to handle these lines. (When this is done the dial exchange is not an unattended exchange, however.)

In a few magneto exchanges a large percentage of the lines offer obstacles to conversion to regular dial operation (where the customers magneto telephones are converted to or replaced by dial equipped instruments). For such cases a type of equipment was developed which is known as Remote Control Exchange, (RCX), equipment with which the switching is accomplished by a
dial under the control of an operator in some nearby telephone control center. The customers retain their magneto instruments and operate them in the same manner as under full manual operation. This type of equipment has several inherent and service weaknesses, however, and is seldom recommended since the development of the improved operating range of community dial equipment and long line adapter circuits.

**Equipment Arrangements**

Community dial offices necessitate that manual equipment be available at the control centers (master offices) in order to handle the assistance calls and the toll calls from the unattended exchanges. The fact that manual equipment is necessary at the master office does not mean that local service at that exchange must be handled on a manual basis. The local service arrangement at the master office varies with the size of the office, the calling rate, the amount of toll and assistance traffic, and operating expense factors.

Various trunking arrangements are possible for handling the assistance and toll calls from more than one community dial exchange over a common trunk group. In fact, almost every exchange group seems to present problems unique to that particular installation. The com-
Community dial exchange program in Oregon has included, in addition to single office one and two-way trunk groups, single tandem, Figure 2, double tandem, Figure 3, and parallel tandem, Figure 4, trunking from the master office, as well as direct interexchange dialing, Figure 5. Community dial equipment is very flexible in this respect, the principle limitations being the number of switch levels available for trunking, and the possibility that the operation at the master office may become too complicated to be practical.

The single tandem trunking arrangement, Figure 2, provides a method for the master office operators to reach Office B by dialing through Office A over a common trunk group. Each step-by-step switch shown on the diagram represents several switches with common wiring. All of Office B subscriber telephone numbers have an extra digit, "8", as an initial directing digit to eliminate the necessity of requiring the operators to dial more than the listed number to reach either exchange. As shown on the diagram the step-by-step operator's switches at Office A, incoming connectors, have the first seven levels used for dialing Office A subscribers, the eighth level is associated with trunk circuit equipment for dialing Office B subscribers, and the ninth and tenth levels are grounded. The ninth level of the local connec-
tors is used for trunking to reverting call switches, and the tenth level for trunking to the master office operators. The local connector eighth level is grounded; Office A subscribers must place calls for Office B with an operator since a toll charge is involved. The incoming rotary secondary switches at Office A make any one of the master office trunks available to any one of the trunks from Office B.

The double tandem trunking diagram, Figure 3, illustrates a method for reaching subscribers in any one of three community dial exchanges over a common group of trunks to the master office. The operators dial only the listed number to reach subscribers at Office A, prefix the listed number with "0" to reach subscribers at Office B, and prefix the listed number with "00" to reach subscribers in Office C. The rotary secondary switches are arranged so that the subscribers in all three exchanges reach a master office operator by dialing the single digit "0".

The parallel tandem trunking arrangement, Figure 4, makes it possible to reach either Office B or Office C over a common master office trunk group by dialing a single directing digit, "0" or "9", respectively. The operation of the interexchange dialing trunking arrangement, Figure 5, is explained in detail in the "Method of Operation" section.
Two-way circuits are used as community dial exchange master office trunks unless the trunk group is large and the distance is not great to the master office. Where the trunks are available or are relatively inexpensive to add, incoming dial switches and repeater circuits may be the determining factors from the cost standpoint. On this basis two groups of one-way trunks are more economical, and in addition are more efficient from an operating viewpoint. For example, a single group of 25 two-way trunks would require 25 incoming selector switches and two-way repeater circuits on each end, or a total of 50. Two separate groups of one-way trunks would require about 15 trunks in each direction or a total of 30 trunks. However, incoming selector switches with associated one-way repeater circuits would be required only on the terminating end of each group of 15 or a total of 30. This is a saving of 20 switches and repeaters, and in addition the one-way repeaters are less complicated and less expensive than the two-way repeaters.

**Housing of Equipment**

General development of the unattended dial telephone exchange in rural districts or small communities dates from the period just after the World War although, as previously indicated, a limited number of
exchanges of various types had been installed much earlier. One of the advantages claimed for this equipment at that time was its adaptability to almost any type of housing rather than the elaborate or expensive facilities that were sometimes used with early systems.

All that was actually required was that reasonable precautions be established to ensure the equipment against damage by the elements, and that the apparatus be suitably located and arranged for proper supervision and maintenance. With these relatively simple basic requirements, there naturally was little to restrict the extent to which local conditions or needs were satisfied.

Each small dial system of the Strowger type consists essentially of an automatic switchboard comprising one or more unit sections housed in a "dust-proof" cabinet, a main distributing frame, a storage battery, and a power board. Because of the sectional type of construction, this equipment can be readily installed in almost any shape of room space, and many installations have been made in rented quarters, stores, rooms of private homes, hallways of office buildings, and lodge rooms (6).

Later, isolated small central office buildings were erected of frame, concrete and frame, or brick and frame construction which were designed to include ventilation, heating, etc., where required. Fireproof or semi-
fireproof construction is recommended wherever the cost permits. Hollow building tile has also been used extensively, and in the western part of the United States stucco on metal lath, using either wood or metal studding is often preferred. Concrete floors are usually covered with battleship linoleum or coated with "granolithic" or other good cement paint.

In 1934 a steel construction company* was commissioned to design a frameless steel building that would be especially well suited for housing unattended dial equipment (22). The first such building was constructed at North Washington, Pennsylvania. It was designed to contain an ultimate of 200 lines of equipment, with dimensions ten feet wide, sixteen feet long, and ten feet high. The sectional box-type construction provides a strong insulated building which when protected with suitable rust resisting compounds and covered with porcelain-enamelled sheet steel, joined with aluminum clipstrips, is attractive and durable.

Unattended exchanges are in successful operation in all sorts of climates and housed in all sorts of structures, but under a given set of conditions it seems reasonable to expect a certain type of building may be more desirable than another.

*Insulated Steel Construction Co., Middleton, Ohio
Where a special building is to be constructed the size, of course, depends upon the amount of switching and associated equipment to be housed. Aside from the initial equipment to be installed, consideration should be given to the ultimate requirements of the building based on the anticipated growth for a fifteen or twenty-year period. In those cases where it is not evident which course to follow a cost study is usually made which takes into consideration all the factors involved in long term building investment to determine whether it will prove more economical to provide the ultimate building at the beginning than to plan an addition for some future time.

Traffic Data

Since telephone service (or traffic, that is, the flow of telephone calls) is the primary thing that a telephone company has for sale it is important to know exactly how much traffic is being carried, not only by the office as a whole but also by certain groups of switches or trunks.

A telephone exchange may be carefully engineered to give excellent service when first installed, but unless the traffic in the various switch or trunk groups is carefully checked from time to time and rearrangements or additions made to meet changing load conditions, good service
will not be maintained. There are a number of factors which may change the traffic characteristics of an office such as abnormal growth, regrading of service, changes in rates or boundaries, increased toll traffic, or increased calling rates due to changing economic or social conditions. It is usually possible by a carefully planned assignment program and systematic switch counts or register readings to prevent service troubles due to trunking and at the same time to detect overloads in sufficient time to provide additional equipment (7).

Working out the equipment or trunk requirements for dial operation to insure satisfactory service is an entirely different problem than in a manual office. With a manual switchboard the number of operators and operators' positions depends almost entirely on the number of calls and the methods used to dispose of them, since the operator's work time is used principally in putting up and taking down connections. During the subscriber conversation period the operator is free to handle other calls. With dial equipment the holding time or length of conversation must also be taken into consideration. When a call is made the dial switches and the trunking equipment used in setting up the connection are held until the calling party hangs up, so that both the number of calls and the holding time must be taken into consideration in calculating the trunking and the switching equipment required.
The amount of equipment installed is that quantity which will give satisfactory service to the customers and at the same time make possible economical operation. A balance is sought between adequate switching and trunking equipment to handle the traffic during the normal peak periods and at the same time keep the investment as low as is consistent with good service.

Since calling rates per line and holding times for different classes of service vary so widely it is common practice in engineering dial equipment to reduce all calls to calls of common units of 100 seconds known as "equivalent 100 second calls" or "unit calls." For example a group of lines originating an average of six calls per line with an average holding time of 85 seconds, would originate \( \frac{6 \times 85}{100} \) or 5.1 equivalent 100-second calls per line. A number of tables have been worked out by the telephone engineers which indicate the theoretical capacity of various trunk groups in terms of equivalent 100-second calls. The different tables are based on the probability of encountering a delay condition a certain number of times in a given number of calls, e.g. one, three, or seven times in one hundred calls, etc.

In the small unattended dial exchanges with less than one hundred lines the problem of balancing the traffic by classes of service among the equipment groups does not exist since there would be but one "hundred" group.
In the step-by-step system, lines (or stations in a terminal-per-station office) are naturally arranged in groups of 100 since the switches are constructed with 10 levels and 10 terminals on each level (10 x 10 = 100). However, since many unattended dial offices have from one to two thousand terminals the problem of balancing the traffic among dial equipment groups is considered in this paper.

The first step in determining how to efficiently direct telephone traffic through dial equipment is the segregation of the subscriber lines according to their class of service, which, in turn, usually groups them with respect to their calling rate and holding time. Business lines, in general, will have a much higher calling rate and a shorter holding time than will residence lines, although the number of stations on multi-party residence lines will influence the traffic values considerably. By assigning approximately the same number of lines of each class to each group of line-finder switches (outgoing call balance) and to each hundred group of connector switches (incoming call balance), the traffic in each group can be kept fairly uniform. Often many refinements are considered if traffic conditions warrant it, such as assigning large business subscribers, in the same line of business, into different groups so as to avoid simultaneous peak traffic conditions, and arranging the trunks of a private branch
exchange subscriber in more than one line finder group to insure an outgoing path if all of the line finders in a certain group are busy.

If the dial equipment is working close to its capacity, the traffic in the trunk groups is checked at periodic intervals. At community dial exchanges all-trunks-busy or overflow traffic registers provide valuable information of extreme conditions. The switch count, which is a supplemental method employed when possible, is a simple and efficient method of checking dial traffic to obtain information not provided by registers. By this method the number of switches in use in each group are counted once a minute (or less frequently) during the busy hour or hours. With Strowger equipment the switches in use are readily noted by the wiper shaft being out of the normal position. The number of trunks in use at each counting interval is listed, and at the end of the hour the total and average for the hour are summarized and the maximum number of trunks in use at any one time noted.

When traffic (peg count) registers are installed to count the number of calls, they are read at the beginning and end of the switch count. The importance of having adequate traffic register equipment was often underestimated on early community dial equipment, but most types of equipment now available make provision for the necessary registers.
The figures obtained from these traffic counts are used in a number of ways for several different purposes (7):

1. The average and maximum load for the various groups are compared.

2. The average and maximum for each group are also compared to the previous readings, preferably for a year or more to determine the trend of traffic growth.

3. The time of the peak load on different classes of trunks is indicated (when the busy hour occurs).

4. If the switch counts are taken at one-minute intervals, the total at the end of an hour indicates directly (indirectly if other than one-minute intervals) the call-minutes the trunks in that group were in use during the hour. Dividing this total by the number of calls (from the peg count readings) the average holding time is obtained.
DESCRIPTION OF EQUIPMENT

General

Since the inauguration of the dial office considerable time and effort have been expended by telephone manufacturing organizations in developing and marketing comparatively inexpensive automatic switchboards of the community dial exchange type designed for use, not only in the smaller communities and rural districts, but also in towns of fair size. These efforts have met with considerable success as indicated by the large number of these community dial units of various types now in use throughout the country.

In meeting the needs of these smaller exchanges many different sets of conditions have been encountered. In fact, it appears that small community service requirements, especially since under dial operation these exchanges are unattended, are sometimes more complex than those of larger cities. However, there is equipment available today for the satisfactory and economical application on practically any set of conditions that may arise. A few representative types will be described in this paper.

The most extensively used type of small exchange dial switchboard is the common battery, line switch-connector system. In this case the magneto telephones are replaced by standard automatic common battery instruments
and the connector switches are of the automatic code ringing type. Service is usually rendered on a terminal-per-line common battery basis.

**Equipment Units for Less Than Twenty Lines**

The smallest unit of this type is known as the 36A3 CDX* which has been designed to serve exchanges with a maximum of nine lines having any number of stations up to ten per line. The "lock" or "compensated" pulsing employed insures dependable operation even though line resistance is as high as 1000 ohms, and the insulation is reduced to 5000 ohms (between either or both conductors and ground) (1).

As code signaling is almost invariably used on the existing magneto lines, this form of signaling is retained in this community dial unit, five stations being rung over each side of the line to ground. Dial tone, busy tone, and audible ringing tone are provided just as in the large automatic systems.

While the equipment unit provides all the features required for modern telephone service, it is not burdened with unessential refinements as were some of the

*The term CDX, indicating community dial exchange, is used commercially as a convenient abbreviation; in this paper it is associated with code numbers that are commonly used to indicate the type and size of the various equipment units.
early installations. This makes the equipment easy to maintain and reduces the cost per line. Much of this economy in equipment is secured by making the best use of the equipment provided. For example, the equipment used in making a reverting call is the same as is used in completing regular calls between lines. On reverting calls this equipment is held only while the connection is being completed—it is released as soon as the called party answers, and is then ready to handle another call. In the same manner, a link (connecting circuit) which is seized by a "permanent" line or held busy by an unanswered call or by a party failing to replace his receiver, is automatically released from the line, by means of an automatic timing mechanism, after a period of two to four minutes, and is then available for another call. The faulty line is "locked out"—prevented from seizing another link—until the trouble is cleared.

Physically these dial switchboard units are small and compact, requiring very little space. They may even be mounted outdoors on telephone poles, if desired, so that there is no expense for an exchange building.

To make possible this compactness, together with reliable operation and lowest possible cost, the switching equipment is made up of twenty-five-point rotary switches and associated relays instead of the step-by-step type of
switches. The systems are of the "line-finder" type, each connecting "link" consisting of three rotary switches—a finder which automatically finds the calling line, a connector which selects the line number dialed by the calling party, and a code selector which selects the code ringing signal and places it on the proper side of the line. The ringing codes are generated by another rotary switch operating as a code interrupter. Ringing is automatic and intermittent, ringing current being generated by a vibrating converter and its transformer. The relays associated with these switches are provided with twin contacts, and heavy contact pressures assure reliable operation of the equipment.

These community dial exchanges provide for trunks to connecting offices. Any of these trunks may be carried through an intermediate automatic "tandem" exchange, if necessary. The trunks are two-way and terminate on regular subscriber line equipments.

The 36A3 CDX is designed to operate on 48 volts supplied by a battery and charger or a battery eliminator (the latter can be used only when the commercial power is very reliable). The equipment is designed, however, to assure dependable operation through the line limits previously mentioned with a voltage variation from 42 to 56 volts. The unit is assembled on a steel framework welded into a rigid unit, and provided with a sheet steel cover
with sponge-rubber gaskets to protect the equipment from
dust. Radio interference suppressors are provided at all
vital points which are most likely to cause radio distur-
ances. These suppressors, together with close-fitting
grounded metal cover of the switchboard, are ordinarily all
that is required to prevent the telephone plant from caus-
ing radio interference.

The type 36A1 CDX is a unit similar to the type
36A3 CDX but is designed specifically to meet the needs of
the large number of exchanges that fall in the range of
approximately 60 to 100 stations. The nominal capacity of
the switchboard is 19 subscriber lines (with a maximum of
ten stations per line), four links, and three trunks. A
maximum of eight ground return lines may be equipped--the
remainder must be metallic. On this community dial unit
every possible consideration has also been given to the
provision of modern standard services and operating
practices.

Units for Twenty to One-Hundred-Line Exchanges

To meet the needs for a type of dial equipment
which would serve the medium sized exchange where the out-
side plant does not include grounded lines, the type 32A32
CDX was developed and has been used extensively with very
satisfactory results.
The 32A32 CDX is a complete self-contained and inexpensive automatic switchboard having rotary line finders and Strowger connectors, and using dial-equipped, common battery telephones. It provides high grade service in any area, the requirements of which are not expected to exceed 90 lines, and where the outside plant is full metallic (loop resistance not to exceed 1000 ohms) with not more than 10 stations per line.

The unit is extremely flexible. Its line capacity may be installed by 10-line steps, and finder-connector switches may be added, one at a time. Equipment may be installed initially for 20 or 30 lines, with an ultimate for 50 lines in the basic unit, and later it may be further expanded to a maximum of 90 lines by adding a second unit without displacing any of the original equipment and at no disproportionate cost. The number of simultaneous local conversations are limited to seven for each of the two units.

The local service of the 32A32 CDX is comparable with that furnished by any standard Strowger dial-type exchange. Three digit numbers are used for both straight-line and party-line calls, with dial and busy tones, automatic ringing and instantaneous ring cut-off. Calls between stations on the same line are made automatically by dialing 3-digit reverting-call numbers.
Toll calls may be handled over a single group of trunks to a supervisory exchange, either manual or automatic. The equipment may also serve as a switching point for toll lines centering there. Subscriber-to-subscriber dialing between the community dial exchange and other automatic exchanges can be provided by the use of suitable office prefixes. Incoming connectors are recommended for terminating trunks for toll or subscriber-to-subscriber calls if traffic warrants; otherwise the trunks are terminated on line circuits.

The more important equipment and operating features of the 32A32 CDX are briefly as follows:

(1) Permanent line lock-out: This is an optional feature whereby any line is automatically disconnected should the line circuit become permanently closed, and is restored to normal when the permanent condition is cleared.

(2) Duplicate equipment: Dial and busy tone generators, ringing converters, and ringing interrupters are all furnished in duplicate, and are switched in and out of service by dialing special numbers from a supervisory exchange or other point.

(3) Call Distribution: Each successive call, from the same or different lines, is routed to a different finder-connector switch group.
(4) Automatic trunk hunting: Consecutive number service is possible on all connector levels.

(5) Pay Stations: Any line may be equipped for postpayment dial coinbox operation and class of service tone.

(6) Remote Supervision: The condition of the community dial equipment may be ascertained at any time from the supervisory exchange (master office) or other point, by dialing a special supervisory test number. Distinctive tones are provided to indicate various conditions.

(7) Automatic alarm sender: An optional equipment which transmits alarms to the supervisory exchange over a master office trunk which is seized and held momentarily for the purpose. The cause of the alarm may be determined by dialing the supervisory test number.

(8) Remote Testing: When a trunk terminates on regular line equipment, the finder-connector switches can be tested from a supervisory exchange by making successive calls, as these are automatically distributed to the various switches.

(9) By installing suitable repeaters, through-dialing to other automatic exchanges can be provided, simplex dialing is possible, phantom-composited
trunks may be used, toll operation can be given full answering supervision, and positive, fraudproof indication can be secured on calls originating at paystations.

(10) The standard type 32A32 CDX is designed for code ringing and provides 10-party signaling, 5 over each side of the line to earth. The unit may, however, be arranged for harmonic ringing, giving full-selective 10-party service by means of 5 frequencies over each side of the line to earth.

There are exchanges of the size for which the type 32A32 CDX was designed that have plant characteristics that are beyond the scope of the equipment described above. To meet the demands for a type of dial equipment which incorporates certain special features in operating range and scope of services the type 32A44 CDX was developed. Before the introduction of this type the usual community dial unit required that all lines be full metallic and that the number of parties served by one line be limited to a maximum of ten parties. In many communities the cost of bringing the existing outside plant up to these specifications in order that conversion to dial operation could be made was considerable--enough in some cases to block the conversion program.
The type 32A44 CDX is a full-automatic switchboard designed to serve small towns and rural communities in which the condition of the telephone plant imposes unusually severe restrictions on the operation of the switching equipment. Its operating range and scope of service are unusually large.

This community dial unit will serve long and poorly maintained ground-return lines with as many as 20 telephones per line. The stations served may include any combination of central-battery and local-battery telephones on ground-return or metallic lines. Otherwise, this unit is very similar to the type 32A32 CDX.

An explanation of the more important unique operating features of the type 32A44 CDX is as follows:

(1) Twenty-party lines: Each subscriber line, whatever its capacity, terminates in a set of three relays. Fifty-line rotary-type finders and 100-point Strowger connector switches complete the connections. The first 50 line circuits are wired to connector terminals 10-59, and selected by dialing the connector terminal followed by one digit to select the ringing code. Each connector terminal may serve ten parties.

When any line is to serve more than ten parties, a jumper is run from its connector terminal on one of these lower five levels to another terminal on one of
the upper levels. A set of springs is arranged to operate on any or all of the upper levels, and provide a choice of ten other ringing codes. The last ten parties on 20-party lines are thus served through the upper levels of the connectors.

This arrangement applies to both metallic and ground-return lines with bridged ringing. If divided ringing is desired on metallic lines, any two connector terminals may be tied together with a reversed jumper, to serve one line.

(2) Reverting calls: Reverting calls are established by dialing the directory number of the wanted station. Since the calling party thus dials his own line the connector finds the line engaged and returns the busy signal. When the calling party hangs up the connector seizes and rings the line, continuing until the receiver of one of the telephones is lifted to trip the ring and release the connector for other traffic. The line relay supplies the necessary transmitting battery and the lock-out relay marks the line busy to any incoming call.

**Equipment Units for More Than One Hundred Lines**

For those exchanges that are eligible for unattended dial operation but have too large a telephone de-
velopment to be served by the community dial exchange types already described, the types 35E97 and 355A dial equipments* have been designed. Since these two types of equipment have the same theoretical capacity and practically the same operating features, the following description of the 355A CDX applies to the 35E97 CDX equipment with a few exceptions as noted.

The type 355A CDX uses the step-by-step switching equipment—line finders, selectors, and connectors—and is intended for use in community dial offices, in general, from 100 to 1500 lines or more in the ultimate.

Provision has been made in this type of equipment for handling the various classes of service commonly required in community dial areas, and, in addition to the traffic features usually necessary, optional facilities are also available for a number of features for which there is a limited, but in some cases, definite demand. On the other hand, in the interest of economy, certain refinements used in other types of community dial offices have not been provided in this office. These simplifications result in some limitation in the field of use, but, in general, the equipment has been designed for use in all

*Type 35E97 is produced by the Automatic Electric Co., Chicago, Ill. Type 355A is produced by the Western Electric Co., Chicago, Ill.
offices in the size range previously indicated except those with extremely heavy traffic, those requiring frequent trunking rearrangements, or those with a considerable number of poorly insulated or high resistance lines.

The switch equipment for the type 355A CDX is mounted on universal frames of the single-sided type, 9 feet high (optional, 7 feet high). The more commonly used trunk and miscellaneous equipments such as alarm and timing apparatus are jack-mounted on shelves on the switch frames. The equipment for some of the more complicated and infrequently used circuits is mounted on relay racks. Unit power plants with tube-type rectifiers are used for the smaller offices. For larger installations where greater power plant capacity is required, diverter pole generators are used. The ringing machines are of the rotary, battery operated type equipped with shaft-driven interrupters.

The switching plan used with this type of office is a conventional step-by-step arrangement using line finders, one or two stages of selectors, depending upon the number of lines to be served, and connectors for completing calls from one line to another within the office. First or second selectors can be equipped with trunks to other offices for outgoing calls, while incoming calls from other offices enter the switch train through incoming selectors associated with the trunks involved.
Reverting calls are in some cases completed by connectors and in other cases by separate reverting call switches depending upon the type of connectors used. If the size of the exchange warrants refinements in service, provision may be made for toll and service code trains and such miscellaneous switches as test distributors, test connectors, verification switches, and coin control switches.

Two line finder circuits are available, a 100-point finder and a 200-point finder, but the latter is used in most type 355A unattended dial exchange installations. The number of "points" or terminals indicates the number of lines served by the line finder. But since more than one line of the group of 200, for example, may be calling out at one time a number of line finders (up to 20 per shelf) are provided having access to the same 200 lines. The number of line finders in each group depends upon the calling rate and the holding time of the lines being served.

The subscriber line circuit has a two-step relay which serves as a combined line and cut-off relay and operates over subscriber loops of 1,000 ohms (885 ohms conductor loop). The circuit is provided with two options, one without the line lockout feature and the other with this feature, the latter requiring an additional relay.
The 200-point line finder circuit uses only two relays, one or the other operating to cut through to the upper or lower line bank, as necessary, when the calling line is found. The lines on each unit are arranged in two groups of 100, one group being associated with half of the terminals in each of the upper and lower banks and the other group with the remaining terminals. With the same division each group is associated with a control circuit. The line banks are reversed between the two shelves of a unit and each control circuit has access to those finders in which its associated group of lines appears in the lower half of the bank. The control circuit starts idle finders in rotation by means of an allotting selector and consequently each successive call or attempt will normally be served by a different finder. As a result of the bank reversal and subgrouping arrangement a finder will not take more than five vertical steps to find the calling line excepting during periods of heavy traffic or under trouble conditions. If all of the line finders associated with a control circuit are busy or if a trouble condition occurs in the control circuit the associated lines are automatically transferred to the other control circuit which then serves all 200 lines until the condition causing the transfer clears. Under this condition a finder may, of course, be required to take as many as 10
vertical steps to find the calling line.

A number of different types of connectors are available for either a terminal-per-line or a terminal-per-station basis. Hunting connectors for serving PBX (private branch exchange) trunk groups or auxiliary line service are of the rotary hunting type (maximum of ten trunks). Four, five, and ten-code connectors are designed for serving a maximum of eight, ten, and twenty parties per line, respectively. All connectors are arranged for calling party control, i.e., the connection is held up until the calling party hangs up his receiver. The type 35E97 CDX connectors may be arranged to permit delayed ringing operation so that a line can be held by the operator by not immediately dialing the last digit. The 355A CDX local connectors differ in this respect that this feature is not included. However, if a separate toll train of switches is provided the delayed ringing feature is available.

Coinbox circuits can be either prepay or postpay. Auxiliary line circuits are available for improving the range which are used on lines with high resistance loops or low resistance leaks. Two types are available for use with this equipment, one for operation with lines having conductor loops of less than 1000 ohms and insulation resistance more than 5000 ohms, and the other for lines with conductor loops between 1000 and 2000 ohms with insu-
lation resistance higher than 10,000 ohms.

A complete audible and visual alarm system is included as a part of each 355A CDX installation. The power supervisory circuit is arranged so that whenever an unstandard condition occurs in the automatic equipment an alarm signal is established.

Alarm signals appearing in the dial office itself for the benefit of the maintenance man, indicate "permanent" switch (line) conditions, fuse failures, ringing machine failure, high and low voltage, all line finders busy, line finder control blocked, etc. An alarm sender circuit is available on an optional basis which transmits alarm signals to an operator over a master office trunk for each irregularity that might occur for all types of alarms recorded by the alarm facilities. The operator knows that an alarm condition exists by the distinctive lamp signal (flashing) or by a distinctive audible signal upon answering the trunk. To determine the nature of the trouble an alarm checking terminal is dialed. Code signals or the absence of any tone indicates the type of alarm condition in the dial office.

The duplicate ringing machine and tone generating equipments are associated with connector terminals so that either set may be placed in operation by simply dialing ringing machine transfer numbers from the master
office. However, the 355A CDX equipment is also arranged for automatic transfer of the ringing machines upon failure of the output.

Intercepting service (whereby the calling customer is connected with an operator if he dials the wrong number—a number which has not been assigned, a changed number, or a disconnected number, etc.) is not generally given in unattended dial offices except in some of the larger installations reasonably close to the master office. Where the equipment is of the terminal-per-station type and separate intercepting trunks are available the problem is easily solved by directly connecting the terminals involved to the trunk circuits to the master office. Where the dial equipment is of the terminal-per-line type it is a much more complicated proposition to intercept calls to one station of several on a party line. Recently equipment has been developed which is known as detector type intercepting equipment which automatically brings in a signal over a master office trunk (or separate intercepting trunk) when it intercepts a call to a particular station on a working party line. This involves recognition by the intercepting circuit of the ringing code corresponding to the intercepted station.

The identifying of the calls for a particular party is accomplished by cross-connecting an intercepting trunk to the line. This trunk circuit has a ring-up
relay connected to the same side of the line as the ringer at the intercepted station. When ringing current is applied to the line the ring-up relay is also supplied with ringing current corresponding to the code of the station which is to have intercepting service. If, during a complete ringing cycle, the ringing current received from the line corresponds at all times with the code ringing current connected to the ring-up relay the latter does not operate and the call is accepted as being for the intercepted station. If the current fails to match during any part of the ringing cycle the ring-up relay operates and the call is not intercepted.

When intercepting equipment is not included vacant connector terminals are ordinarily left open so that the calling subscriber receives neither the ringing signal nor a busy signal. As an exception, if a non-working station on a working party line is dialed, the audible ringing signal is heard and the call results in an apparent "don't answer."

Traffic registers are available to record the number of originating calls, the number of over-flow calls, the number of all-trunks-busy conditions, and the number of terminating calls.
METHOD OF OPERATION

General

The methods of operation of most unattended automatic telephone offices of the community dial type are very similar whether small or large. The latter type may have a few features that are due to, or more practical with, more extensive equipment. This may make the operation a little more involved, but it is fundamentally the same even though the equipment may function on a different principle, i.e., relay, rotary switch, or step-by-step.

To avoid undue repetition the method of operation of one representative type of equipment is included in this paper. This equipment* is recommended for use in exchanges requiring from 100 to 1500 connector terminals (an equivalent number of lines, if a terminal-per-line arrangement, or stations, if a terminal-per-station arrangement) although it can, and has been, used in exchanges with 2000 terminals or even more. The equipment arrangements referred to in the following explanation are the same as shown on the diagram, Figure 5, of two community dial exchange installations, A and B, located less

*Automatic Electric Co. Type 35E97 Community Dial Exchange Equipment
than three miles apart. Free switching is given between the two exchanges for all flat rate stations with equipment arrangements whereby the interexchange calls are dialed and completed through the equipment similarly to the dialing and completion of calls within either exchange.

**Equipment Arrangements**

At office A one-way free switching trunks are associated with the third switching level of the flat rate first selectors (see Figure 5). These trunks terminate on incoming selectors at office B. At this office one-way free switching trunks are associated with the second level of the flat rate first selectors, and terminate on incoming selectors at A. Both flat rate and coinbox first selectors at A are arranged to drop back when the digit "2" is dialed thereby making this digit ineffective. By a similar arrangement the digit "3" is absorbed, on the first selectors at B. The numeral "2" is used as a prefix for all A office number assignments and the numeral "3" for all B office assignments. With this arrangement when the calling and called stations are in the same exchange the dialing of the first digit will be ineffective, and when the stations are not in the same exchange the dialing of the first digit from flat rate stations will route the call to the other exchange.
The giving of free service between the two exchanges does not apply to the coinbox stations. At A the third level of the coinbox first selectors is tied to the "O" level and at B the second level of the coinbox first selectors is similarly tied to the "O" level. Attempting to place a call from a coinbox station in one exchange to a station in the other exchange by dialing the called number instead of the operator thereby results in the call being routed to the master office where it is handled on a toll basis.

The drop back feature is associated with the second level of the master office incoming selectors at office A and the third level of the master office incoming selectors at office B, so that it is possible to follow the practice of dialing all of the digits of the assigned numbers in completing calls from the master office to the two exchanges.

One group of connectors in each exchange is of the rotary trunk-hunting type, thereby permitting the assignment of private branch exchange and associated line groups.

At the master office multiple jacks on the switchboard are used for the termination of the two groups of master office trunks from the community dial units. Associated line lamp signals appear before these positions
that are used for combined outward toll (outgoing calls as differentiated from incoming toll calls) and "operator" assistance work. The switchboard cord circuits are of a type so that either cord of a cord pair may be used in the CDX trunk multiple with switchhook supervision (cord lamp lighting when the CDX subscriber hangs up his receiver).

All subscriber assignments consist of five-digit numbers. The first digit is used for exchange selection, the second for hundred group selection, the third and fourth for line terminal selection within the hundred group (the third selects the called level of the ten levels on the connector switch bank and the fourth selects the called terminal of the ten contacts or terminals on the level), and the fifth for determining the ringing code and the proper side of the line for signaling.

The usual dial, busy signal, and audible ringing signal tones are provided. The ringing plan is arranged to be full selective for two-party service, semi-selective for four-party service, and divided code ringing for ten-party service. The digits used for selecting the ringing codes (last digit of the subscriber's telephone number) are as follows:
<table>
<thead>
<tr>
<th>Digit Dialed</th>
<th>Code Ring</th>
<th>Side of Line</th>
<th>Class of Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 long</td>
<td>Ring</td>
<td>Ind., 2, 4 &amp; 10-party</td>
</tr>
<tr>
<td>2</td>
<td>2 short</td>
<td>Ring</td>
<td>4 &amp; 10-party</td>
</tr>
<tr>
<td>3</td>
<td>3 short</td>
<td>Ring</td>
<td>10-party</td>
</tr>
<tr>
<td>4</td>
<td>4 short</td>
<td>Ring</td>
<td>10-party</td>
</tr>
<tr>
<td>5</td>
<td>1 long &amp; 1 short</td>
<td>Ring</td>
<td>10-party</td>
</tr>
<tr>
<td>6</td>
<td>1 long</td>
<td>Tip</td>
<td>2, 4 &amp; 10-party</td>
</tr>
<tr>
<td>7</td>
<td>2 short</td>
<td>Tip</td>
<td>4 &amp; 10-party</td>
</tr>
<tr>
<td>8</td>
<td>3 short</td>
<td>Tip</td>
<td>10-party</td>
</tr>
<tr>
<td>9</td>
<td>4 short</td>
<td>Tip</td>
<td>10-party</td>
</tr>
<tr>
<td>0</td>
<td>1 long &amp; 1 short</td>
<td>Tip</td>
<td>10-party</td>
</tr>
</tbody>
</table>

Coinbox stations are of the dial multi-coin postpayment type—the coin is deposited only after the called party has been reached. They are equipped so that when calling another station the answer of the called station splits the connection and transmits the dial tone to the calling party. The deposit of a coin clears the line for conversation. Calls to the master office do not require the deposit of a coin. The operator recognizes that a coinbox station is calling by a momentary identifying tone. The coinbox stations are assigned to specific terminal numbers so that they may readily be recognized by operators, a feature especially necessary on incoming collect calls.

When centralized "operator" service (known as single-channel operation) is employed for the community dial exchange, and Long Distance, assistance calls, etc., are handled by a common group of operators, the sub-
subscribers have few codes to remember. The master office trunks are associated with the zero level of the local selectors, and the code "0" (Operator) is dialed to reach an operator at the master office.

The only other code employed at the exchange, 9--, is used by party-line subscribers for reverting calls (calling other subscribers on their own line)--see "Customer Operation" section following. The reverting call switches are associated with the ninth level of the first selectors.

The detector type of intercepting equipment has been included (it is an optional feature) at both exchanges A and B with separate intercepting trunks. When a call is intercepted for any reason the operator answers the intercepting trunk, asks the calling party for the number he has dialed, refers to the intercepting records and gives the report as indicated.

Customer Operation

To call a station served from either community dial office except a station on his own line, the subscriber is instructed to listen for the dial tone and then dial the listed number. The usual audible signals—that is, dial tone, ringing signal, and busy signal—are re-
ceived. In case a vacant terminal, a disconnected or changed number, or a terminal affected by a directory error is dialed, the call will be intercepted as explained in the preceding section. To make a reverting call requires the dialing of a three-digit code consisting of the digit "9" followed by the last digit of the calling party's telephone number and then the last digit of the called party's telephone number. Immediately after dialing is completed, the calling party hangs up his receiver. On hanging up, the calling party, if the called party's telephone is on the same side of the line, hears the code ring of the called station; if the called party's telephone is on the opposite side of the line, the calling party hears his own code ring. When the ringing stops the called party knows that the called party has answered and removes his receiver and starts conversation. The mechanism restores to normal when both receivers are hung up. If the called party does not answer, the calling party removes and replaces his receiver to stop the ringing and restore the equipment to normal.

Under the single-channel method of operation the subscriber is instructed to dial "Operator" to obtain assistance in securing any station, to place a long distance call, to reach Information, Repair Service, the Telephone Company Business Office and Time Service.
Master Office Operation

The master office toll switchboard is equipped so that the position dials can be associated with either cord for completing calls over the dial trunks.

From an equipment viewpoint (see diagram, Figure 5) it would be possible to omit the dialing of the first digit of the assigned numbers in completing calls from the master office to the two exchanges. The reason for this is that, in dialing, the initial digit is used by the customers for exchange selection, but the operators accomplish this by selecting the proper group of outgoing dial trunks at the switchboard. However, in order to avoid possible operating difficulties resulting when the operators must remember which community dial exchanges require the omission of the first digit and which do not, it was found desirable to follow a uniform practice and dial all digits of the assigned numbers.

Calls from A and B Office stations light the multiple line lamp signals associated with the multiple jacks used for termination of the master office trunks. Switchhook supervision is received on the cord supervisory lamp.* Calls from coinbox lines are recognized by the

*At those master offices where the cord circuits are not of the type whereby cord lamp supervision will not be received on both cords of the cord pairs, an additional lamp for supervisory purposes is associated with the multiple. This method is known as lamp-in-multiple supervision.
momentary tone which is received on answer of a master office trunk signal and can be checked by replugging.

On an assistance call the operator gives such assistance as is feasible, but does not complete a local connection for the calling customer (this would use two master office trunks for a local community dial exchange call) until she has made an effort to have the subscriber dial the number himself. Where the calling party indicates that he has experienced difficulty in attempting to secure a number the operator attempts to establish the connection.

To establish a connection to a line and hold it without ringing the desired station (a practice followed in the completion of toll calls when the called station is found to be busy), the operator sets up the connection in the regular manner but omits the last digit in dialing the number. Ringing is then started as required by dialing the last digit.
The problem of conversion to community dial exchanges resolves itself into three major considerations: the economics of manual versus dial operation, the personnel adjustment involved, and the improved service rendered.

The question of operating small magneto exchanges at a profit, intimately connected as it is with conversion to more modern methods of operation, is a problem of no small concern to many an operating company (2). This problem is often a difficult one to solve because the contributing factors are interwoven, as it were, in a vicious circle.

In the first place, the magneto exchange switchboard and local battery telephones stand for a certain grade of service, limit rates, and often hinder expansion; because of this situation revenues are limited. To this is added the operating expense, itself dependent upon the number of hours of service given daily and thereby reflecting directly on the value of the service. Further ramifications of this problem are the condition of the outside plant, the grounded lines, the poor transmission, and last, but not a minor consideration, the independently-owned "farmer" lines.

On the other hand the limited revenue prohibits expansion, cramps improvement, and often does little more
than contribute to maintenance of steadily-declining plant. It is inevitable that the manual operators' wages be given serious consideration for in the small exchanges this item constitutes a large part of all operating expenses, and it is almost entirely eliminated when converting to full dial operation.

It has been known for years that under the generally prevailing low rates—and due to the nature of this rural development being scattered, making the plant cost per station high—the profit from the rural station has been very small. Community dial equipment has changed the picture so that instead of being a money-losing proposition most small exchanges can be made to pay. Those that cannot be operated at a profit can, at least, be operated with considerably smaller loss (see Appendix). Engineering and installation methods must be made as economical as possible in the smaller telephone offices where, because of relatively few lines, a small extra cost increases quite appreciably the investment per line.

The ideal office for a small community is one which contains only the equipment required for the existing number of lines, and provides economically for growth. As the number of telephones increases community dial equipment is provided in such amounts that it is possible to install the extra equipment necessary to keep the cost per station as low as is consistent with satisfactory service.
Experience has shown that community dial equipment is not difficult or expensive to maintain. Most maintenance men who can successfully maintain a common battery manual office can maintain modern automatic equipment after a brief course of supervised instruction.

In their own exchanges, under their own jurisdiction, and subject to their own peculiar conditions of operation, public relations, and financial set up, many telephone companies have apparently proved to their own satisfaction from actual experience that there is a successful and profitable method of giving small communities modern telephone service, (15).

To conclude a paper on the unattended dial telephone office without mentioning the personnel problem of manual operators involved in a conversion program, would be to omit an important angle on this subject. Under the sponsorship of the U. S. Department of Labor a report was made in 1933 on the subject "The Change from Manual to Dial Operation in the Telephone Industry" (3). Since this is a thorough investigation of the effects on women operators of this change, the following excerpts from the report are quoted as an unbiased reference on a phase of industry that is of paramount importance, not only from the standpoint of business economies, but also its effect upon human relationships and public goodwill:
"The telephone industry is like other great industries in that it is constantly improving its equipment and installing the latest and best designs invented in its engineering and laboratory departments.

"The technological change to the dial operating of the telephone probably is better known to the men and women of the United States than any other recent technical change, and there has been much discussion as to the numbers of women displaced by the dial and some interest as to how they fared.

"In the telephone industry, where every effort is made to mitigate the hardship to the workers of technological change and improvement, there is practically no unemployment except in the case of temporary employees, who know when they are taken on that the job probably will last only until the change to dial is made. The long-time planning in this instance shows that much can be done to prevent general dislocation where new and labor-saving equipment is introduced."

It has been said that community dial service has proved to be quicker, more uniform, more accurate, and more pleasing to use. In the opinion of some the impersonality of automatic service is a virtue, rather than a disadvantage, and the idea that subscribers want personal service in their local telephone calls is entirely imaginary.*

The introduction and development of the dial system is in line with industrial and social progress. It is the general trend coincident with growing business and industrial activities, as well as in expanding person-

*Arthur O. Black, General Manager, Peoples Tel. Corp, Butler, Pa.
al relationships, to expect faster methods of communication with less risk of error, and the utilization of all practical mechanical and electrical devices for effecting improvements. Without community dial operation it would have been increasingly difficult to meet the needs of business and residence subscribers in towns and rural communities. At these points manual operation at best is often difficult to maintain on a level comparable to the service rendered in the larger centers. In an attempt to insure continued improvements where the conversion to dial has not taken place, there have often been substantial increases in cost for a service which falls continually farther behind the possibilities of the dial system.

There is another phase of the subject of the unattended dial office which is steadily increasing in importance. The last decade has witnessed the evolution of the small dial exchange from a position of relative isolation to one of being a necessary link in the country's growing toll system (19). This type of exchange has tended to simplify the technical and service problems of the comprehensive toll development plan, by eliminating the handling of toll calls at such points, and by its easy adaptability to the growing practice of dialing toll calls instead of switching them manually. The dialing of toll calls promises to be a factor of growing importance;
there are many advantages from the viewpoint of service and economy due to the greater time efficiency of toll trunks.

If the assumption is correct that the small dial office should not be regarded as an isolated collection of stations, but as an important part of a nation-wide telephone network, then we must also take the position that the equipment and methods adopted for the small exchange must be of such a nature as to be capable of fitting in with the whole toll system.

As mentioned before, there must be uniformly high standards of transmission, economical plant, well maintained, efficient central office equipment, and low operating cost. It has been with the solution of the last two points by means of community dial equipment that this paper has dealt.
DIAGRAMS
FIG. 1 LAYOUT OF SINGLE WIRE GROUNDED LINE WITH 19 PARTIES
**Fig. 2** Single Tandem Community Dial Trunking Diagram

*The initial digit of Office B numbers ("B") is absorbed on local calls.*
FIG. 3  DOUBLE TANDEM COMMUNITY DIAL TRUNKING DIAGRAM
FIG. 4 PARALLEL TANDEM COMMUNITY DIAL TRUNKING DIAGRAM
FIG. 5  COMMUNITY DIAL INTEREXCHANGE DIALING TRUNKING DIAGRAM

OFFICE A 365397 CDX

OFFICE B 365397 CDX

* TO REVERTING SEL.
* FALLS BACK
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APPENDIX

This appendix presents a concrete example of the cost of operation of a telephone exchange on a community dial basis compared to the cost of the same exchange on a manual basis. Although these cost figures apply to a particular exchange* (population 420 urban, 1800 rural) they are representative of most small towns which have the same exchange characteristics, considerable rural telephone development, and approximately 73 lines and 210 stations. In larger or smaller exchanges with similar features the savings under dial operation vary with the location, traffic conditions, and the development.

The principal items of dial equipment employed in this step-by-step office that vary with the size and the traffic characteristics of the exchange are as follows:

- Subscriber line circuits: 76
- Coinbox adapter circuits: 4
- Finder-connector links: 13
- Incoming connectors: 3
- Line lock-out circuits: 76
- Two-way master office trunk circuits: 3
- Traffic registers: 5

The cost of converting the manual exchange to community dial operation was divided among the following items:

*The name of the exchange is withheld for commercial reasons.
Land (real estate) $ 200
Building (cement floor and foundation, frame construction, Fir-tex insulation) 800
Central office dial equipment 7,000
Subscriber station dial equipment 1,000
Outside plant (line improvements, etc.) 600
Control equipment-master office 1,600

Total (new money) $11,200

Annual Cost - Manual Operation Basis

Operators wages 2,075
Plant maintenance 900
Commercial expense (wages) 168
General Traffic Supervision 178
Rent of quarters 156
House service (heat, light, water, etc.) 108
Misc. central office expense (postage, etc.) 7

Total $3,592

Annual Cost - Community Dial Basis

Plant maintenance $1,100
General Traffic Supervision 178
Taxes 20
Interest on investment (7% x 11,200) 784
Electric Power 36

Total $2,118

Annual Savings under Community Dial Operation $1,474

In the above comparison the "Interest on investment" item does not appear under manual operation because the first cost of the single position magneto switchboard, which was twenty to thirty years old, has long since been cared for; the switchboard had no practical salvage value at the time of conversion to dial operation.
It may be noted that the annual savings, $1,474, represents a return of 13.2% on the new money invested. Or, if the total annual savings were used to retire the sum invested, $11,200, it would take less than seven years (assuming that the interest would decrease as the principal decreased) for the dial equipment to pay for itself.