Coin-disposal mechanisms for pay telephones have always presented interesting challenges to Bell Laboratories designers. A new slow-release coin relay, now being manufactured, lowers the minimum operating voltage from 60 to 50 volts and handles twenty instead of eleven coins.

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A New Coin-Disposal Mechanism For Pay Telephones

When a customer uses a coin telephone he activates an important unit known as the "coin-disposal" mechanism. It consists of a hopper to accept coins, devices to collect or return them, and various electrical and mechanical controls.

Briefly, this is what happens when a customer places a coin call: He inserts a coin or coins in a slot, from which they pass into a device that rejects slugs and then drop into the hopper — a vertical, cylindrical tube. As it enters the hopper, a coin passes over a small "finger" or trigger which causes a signal to be sent to the central office. If the call is manually controlled, this signal brings in the telephone operator, who asks for the number. If the call is to be dialed, the signal causes the automatic equipment to return dial tone.

At the bottom of the hopper a coin comes to rest on a type of "trap door," and under this is a vertically oriented vane. Later, when the operator or the automatic equipment knows the correct disposition of the coins, a signal is sent from the office to the telephone. This signal will be of either positive or negative polarity—one polarity causes the vane to deflect in one direction, and the other causes the vane to deflect in the opposite direction. The trap door opens and, depending on the position of the vane, the coin or coins fall into the cashbox or into the refund receptacle.

The present coin-disposal mechanism was introduced in 1912. Over the years, as with most Bell System apparatus, it has gone through many modifications and improvements. But again like many telephone items, a number of factors sometimes combine in such a way that a major revision or a completely new design is called for. In the case of the coin-disposal mechanism, one of the chief factors was the incorporation into the coin telephone of certain transmission components of the 500-type telephone set. These provide speech transmission beyond the capability of existing coin-disposal units. In particular, the improved efficiency of these components offered the possibility of using coin telephones over higher-resistance loops — which result from the use of smaller gauge, less expensive wire, or from the placing of coin telephones at greater distances from the central office.

There were a number of other important considerations for a new design, however. The central-office signal which operates the mechanism should be of a certain duration, but there is always a possibility of this signal being too short to operate the mechanism properly. It was very desirable, therefore, to ease this requirement with a design that would insure operation even with a very brief signal. Further, with the increased use of coin telephones for long-distance calls, the hopper needed a larger coin capacity. In addition, many details of the electrical and mechanical functions were capable of improvement as insurance against sticking of coins or jamming and excessive wear of the trap and vane.

Another electrical requirement was that the coil of the relay which operates the mechanism should have a high impedance to voice frequencies. By this means the amount of "ground noise" reaching the telephone set is held to an acceptable value. The use of the G-type handset with its more efficient receiver has made an increase in this impedance desirable. Finally, a new design had to be interchangeable in existing coin telephones.

The new slow-release coin relay (*see drawing on page 433*), was designed to meet these requirements. It is basically a nonpolar relay with a polarized preselector mechanism. The principal element in the preselector is a nylon card, which is moved in a vertical plane by a lever attached to the armature. Molded into the card is a small permanent alnico magnet whose ends are located in close proximity to two magnetic flux leads extending from the upper end of the electromagnet.

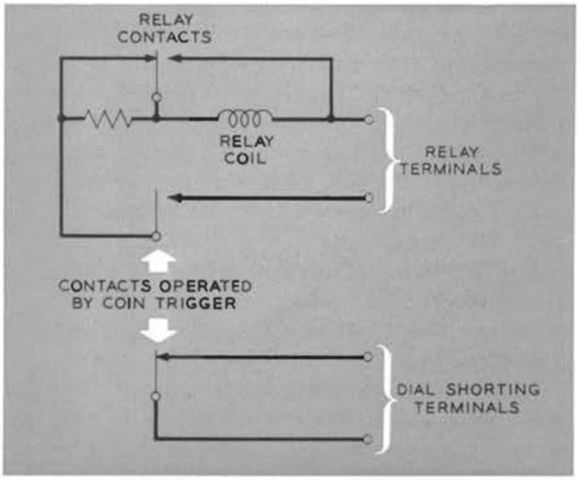
This mechanism operates as follows: When the electromagnet energizes the two flux leads with a "North" polarity, they respectively repel and attract the "North" and "South" ends of the permanent magnet embedded in the selector card. The resulting torque tilts the selector card as the main armature starts to move it downward, so that it can engage one side of a nylon cam. The cam thus turns the hopper vane to the "collect" position.

The opposite direction of current flow through the electromagnet polarizes the two flux leads "South," thereby tilting the selector card in the other direction and causing the vane to turn to the "refund" position. In this manner, the polarity of the voltage sent out by the central office determines whether the coins waiting on the trap are to be collected or refunded. In other words, the nylon card responds to polarity, even though the armature of the relay always acts in the same direction regardless of the polarity of the energizing pulse. This type of action eliminates the problem of controlling and balancing large differential forces — a problem which has made the older type of coin relay difficult to adjust.

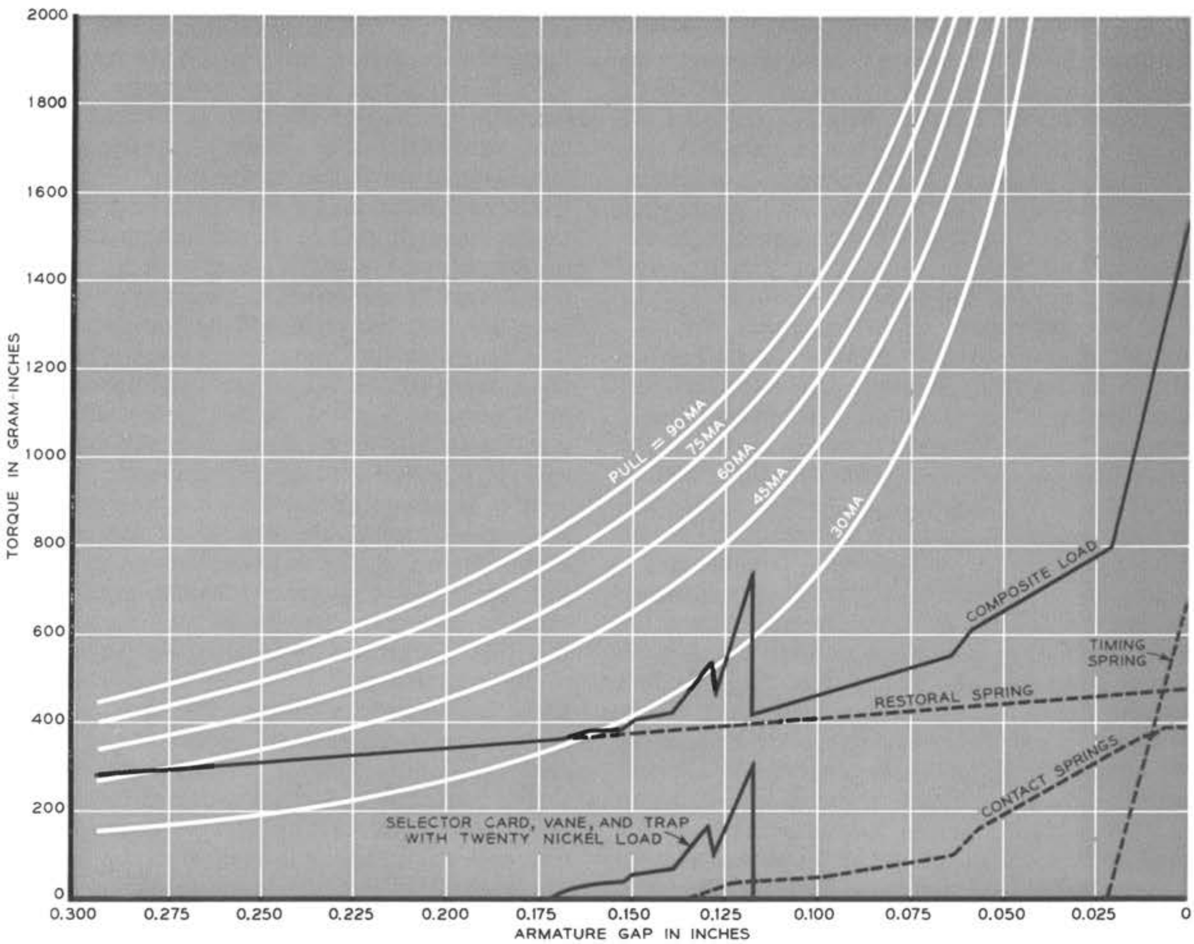
The card also controls the motion of the trap. After the vane has turned part way from its vertical rest position, the card engages a small tab attached to the trap-support arm, moves it from under the nylon trap, and permits the trap to fall open. In the last part of the armature stroke, the complete opening of the trap is insured by the final drive of this arm against a cam surface projecting from the bottom of the trap.

All mechanical load forces have been matched to the magnetic pull curve of the armature (*see the graph on page 432*) so that as much work as possible can be performed by the relay with assurance that the operation will be completed after it is once started. Except for a small amount of pivot friction, the initial resisting force (*left-hand portion of graph*) is due to the adjustable restoral spring, which determines the minimum operating voltage. Since the magnetic pull increases inversely as the square of the armature air gap — whereas the change of the restoral spring force is linear and relatively small during the stroke — excess force becomes available to perform other functions as the gap closes. First, the light mechanical load caused by the rotation of the vane is undertaken. Then the trap support lever is rotated to release the trap. Contact springs are operated near the end of the stroke. Last of all, the load of an adjustable release timing spring is picked up. None of these extra loads is great enough to stop the armature motion once the initial pull overcomes the force of the restoral spring.

One disadvantage of the older mechanism is that its "holding time" depends directly on the duration of the pulse sent out from the central office. In the case of manual operation at the central



Schematic circuit drawing to show position of the resistor substituted for the coil of the relay. This resistor extends the life of the limiting lamp at the central office and maintains needed supervisory functions while the relay is operated.



The measured pull and load characteristics of the new coin-disposal unit (read from left to right).

office, it is possible for an operator to produce such a short pulse that some coins will fail to pass through the trap and vane area and may jam in the mechanism as it restores to normal. Even automatic exchanges produce a small percentage of pulses which are below the 0.3-second minimum design limit. The new coin relay circumvents this problem with contacts which short circuit the coil on the electromagnet as the armature nears the end of its "operate" stroke. After the winding is short circuited, the collapsing magnetic field tends to maintain current flow through these contacts. Since the magnetic gaps are of large area and very short length when the armature is in the operated position, the magnetic pull is sufficient to hold the armature until the current fades to a small fraction of the minimum operate current. The point on the current-time decay curve at which the armature is released can be adjusted by the release timing spring. Normally this is set at 0.60 second for reasons we will now consider.

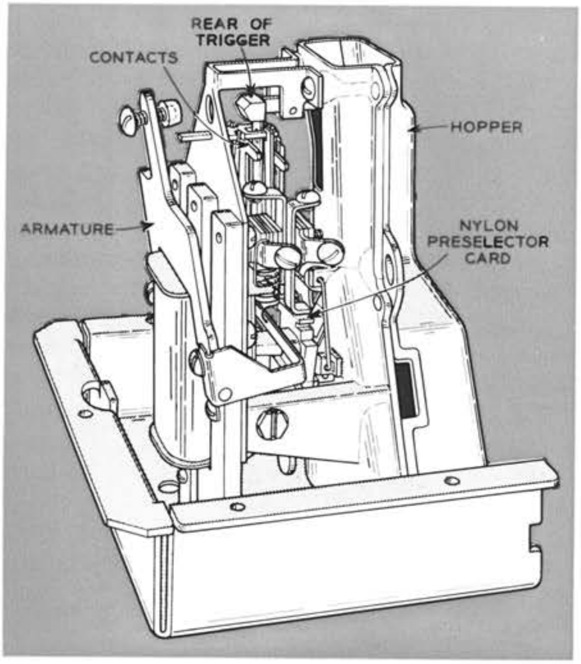
High-speed photographs show that a full load of assorted coins will fall clear of the trap and vane in 0.2 second. A 0.40-second margin must be available to allow for variations due to manufacturing tolerances, temperature changes, changes in the properties of the magnetic material in the armature and core, and operation of a coin pilot lamp at the central office. On the other hand, it is important that the release time should not be too long, because in some types of automatic exchanges the equipment sends out a check pulse 0.8 second after the actuating pulse, to verify that the relay has operated and reset itself. This check will be satisfied if the ground contacts at the mechanism unit are open when this pulse arrives. If not, the central office equipment takes steps to clear the difficulty.

Placing a short circuit on the relay coil will cause large current surges to flow through a series current-limiting lamp at the central office when the loop has a low resistance. Since the life of the lamp is greatly reduced by such treatment, it is desirable to avoid this condition. Also, supervisory functions must be maintained while the relay is operated. Hence, by using a set of contacts on the coin relay, a resistor *(see circuit drawing, page 431)* is substituted for the coil just before the short circuit contacts are closed.

The shorted-winding method of obtaining slow release also obviates the need of voltage-release requirements. As the relay is held operated by the short circuit on the winding, the trigger resets itself, and during the release stroke the ground contacts open before the short is removed. This is an important feature, because voltage may exist between line and ground under certain conditions of earth potential and circuit voltage following the coin pulse sent from the central office.

The first requirement of the redesign is met by the new relay because the operate voltage can now be set at 50 volts instead of 60; this permits operation on loops having about 550 ohms, or 50 per cent more resistance, yet the present nonoperate value of 40 volts — imposed to meet circuit and earth potential conditions — can still be maintained. The spread between the operate and nonoperate voltages can readily be held to these narrower limits. This is true because the pull on the armature is proportional to the square of the current and inversely proportional to the square of the gap; also, the greater work capacity makes frictional effects of less relative importance. We expect that the new units will be much simpler to adjust originally at the factory and will require much less adjustment in the field as they age and wear.

W. D. Goodale, Jr. dropping a coin in the hopper of the new coin-disposal mechanism. This unit takes twenty instead of the previous eleven coins.



This drawing presents the major components of the new coin-disposal mechanism. These include: coin relay armature, hopper, and nylon card.

Other requirements for the operation of the trap and vane are met by the design of the selector mechanism. Also, the new relay can handle a load of twenty coins instead of eleven, and the relay will operate on pulses which are approximately half the length required for the older mechanism. In addition the impedance of the relay coil has been increased substantially.

Finally, new materials and manufacturing processes in the design have reduced costs and repair. For instance, the switch is card-actuated to permit closer control of its operation, and it requires few adjustments during manufacture. The hopper is a zinc alloy diecasting rather than a part formed from flat stock. This provides more economical parts having closer dimensional tolerances. In combination with molded nylon traps, vanes and the parts of the preselector mechanism, we expect less trouble from manufacturing variations and changes caused by wear.

Performance data indicate that laboratory models on trial at the Buffalo, New York, airport for more than two years are very reliable and that trouble-free life expectancy should be many times that of the old unit. It is expected that the new unit, which is completely interchangeable with the old, will result in improved performance and important savings for the Bell System.