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Keyset Selection of Telephone Numbers

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Summary *A system for keyset selection of telephone numbers has been developed for the private automatic branch exchange system type UB 49. It makes use of the earth connection present at each extension for the purpose of transfer and call-back. Transfer of the code information of a digit is completed in about twenty milliseconds. The keyset has been so designed that it will fit in place of the standard telephone dial and can be connected to the same terminals.*

Introduction

Speed in setting-up of telephone connections is assuming an ever increasing importance in the development of modern automatic telephone systems. Economical operation of such systems is favourably affected by high-speed switching. The time needed to set up a connection between two subscribers may be divided into two periods: one from the time the caller lifts his receiver until he has finished dialling the wanted number, and the second from that moment until the bell rings at the called party's station. In common control systems which often defer switching until a certain minimum number, or even all, of the digits have been dialled by the subscriber, it is extremely important to reduce the second period to an absolute minimum, not only for the convenience of the caller, but also because it reduces the holding time of the common control equipment.

In automatic telephone systems developed by N.V. Philips Telecommunicatie Industrie this has been achieved by the use of their type U 45 A high speed uniselector, which has now been in use for a period of six years. The high speed of this selector has also reduced the first part of the total setting-up time by minimising the time elapsing between the moment the caller lifts his receiver and the moment he obtains dialling tone.

A substantial part of this first period is, however, taken up by the actual dialling of the wanted number. The dialling of a four-digit number takes an average of seven seconds, which is seven per cent of the average holding time of a call. It is a much larger percentage, however, of the holding time of the common control equipment, which is of the order of ten to fifteen seconds. There is,

therefore, much to be gained by reducing the time needed by the subscriber to transmit the wanted number.

When the conventional dial is replaced by a push-button keyset, the sending-in time of a four-digit number is reduced from an average of seven to an average of two seconds, the saving being proportionally greater for a greater number of digits. This substantial reduction in the holding time of the common controls obviously entails a considerable reduction in the number of these circuits required to handle a given amount of traffic.

Apart from the material gains which can be achieved through keyset selection, practical experience has shown that subscribers have a distinct preference for this method of number selection. A further advantage is obtained in the field of station maintenance. It is known from statistical evidence that ten to fifteen per cent of all subscriber complaints are due to faulty adjustment of the telephone dial, which must be kept within fairly narrow speed limits. The mechanical design of a keyset as described in the present article is so much simpler that the need for maintenance may be expected to be considerably less than for the conventional dial.

The system of keysending as described here was developed for the PABX system type UB 49. In this system all telephone sets are provided with an earthing button for the purpose of call-back and transfer. In the design of the keysending circuits, use is made of the presence of this earth connection. The keying circuits will function with line loops of up to 2500 ohms. A keysending system for which an earth connection is not required at the subscriber's station will be described in a future article.

Electrical design

In the design of the electrical circuits the following requirements had to be met:

a Only the two line wires and an earth connection are available at the subscribers set for signalling purposes.

b It had been determined experimentally that the minimum time during which even a very fast keyer can keep the key contacts closed is forty milliseconds. The system had therefore to be so designed that the transfer of keying information to the register could be completed within forty milliseconds.

c In order to obtain a simple mechanical design of the keyset it was desirable that the keying code should not require more than two contacts to be closed for each key.

d The keying code should leave room for sending one or two special extra signals besides the ten numerical digits.

Condition *a* was met by choosing the basic circuit of Fig.1. During each keying operation the line wires a and b are first connected to relays *A* and *B* in the register and immediately afterwards, by the transfer of the *w*-contacts, to relays *C* and *D*. Since *A* and *B* are connected to a negative potential and *C* and *D* to a positive potential, it is possible, by earthing any combination of points *A*, *B*, *C* and *D* in the subscribers set via one of the rectifiers G_1 to G_4, to energize any combination of the relays *A* to *D*. In principle, a maximum of fifteen different signal codes are possible. Type S 50 high-speed relays [1] are used for *A*, *B*, *C* and *D*. They enable the transmission of any code combination to the register to be completed in twenty milliseconds, so that condition *b* is amply fulfilled.

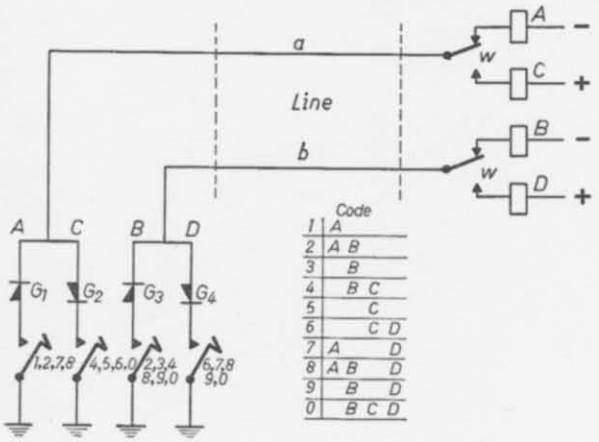

Fig. 1. Simplified keying circuit, showing register code.

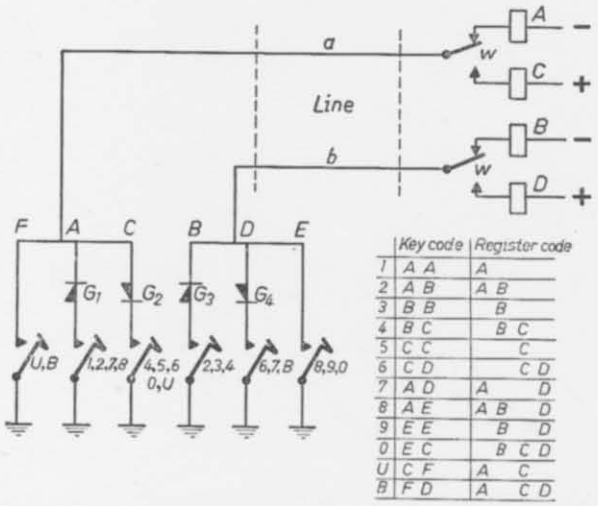

Fig. 2. Actual keying circuit, as adapted to the requirement that no more than two contacts need ever be closed simultaneously.

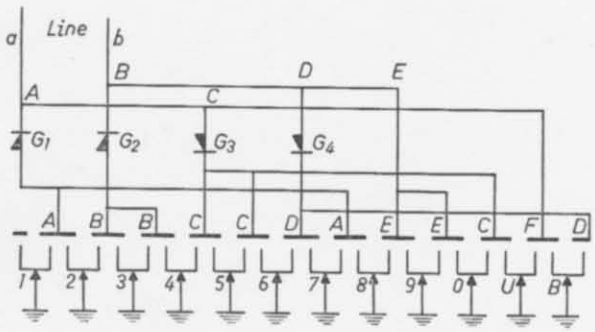

Fig. 3. Wiring diagram of keyset contacts.

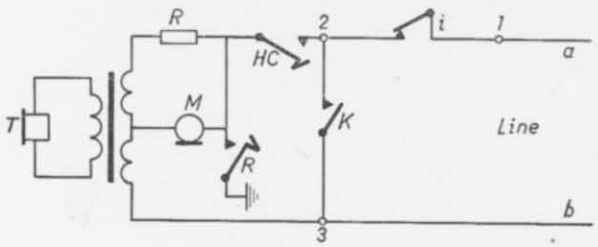

Fig. 4. Circuit diagram of dial telephone set.

The code used for digit registration in the register [2] is also shown in Fig. 1 and it will be noted that condition *c* would not be fulfilled by this circuit, since digits 8 and 0 would require three contacts to be closed simultaneously. Since, however, earthing points *B* and *D* simultaneously via rectifiers G_3 and G_4 respectively is equivalent to earthing the *b*-wire directly, this difficulty can be overcome by providing connection *E*, shown in Fig. 2. It will be seen that the line code never requires more than two contacts to be closed at any one time and that it produces the register code of Fig. 1. By providing connection *F*, similar to *E*, two more codes, designated as *U* and *B*, became available, neither of which requires the simultaneous closure of more than two contacts. The wiring diagram of Fig. 3 also shows, in a schematical way, the mechanical arrangement of the contacts and explains the occurrence of such line codes as *AA*, *BB*, *CC* and *EE*.

Comparison of Fig. 4, which shows the diagram of a normal dial telephone set with impulse contact *i*, dial off-normal contact *k* and earthing button *R* for call-back and transfer, with Fig. 5, which represents the circuit of a keysending

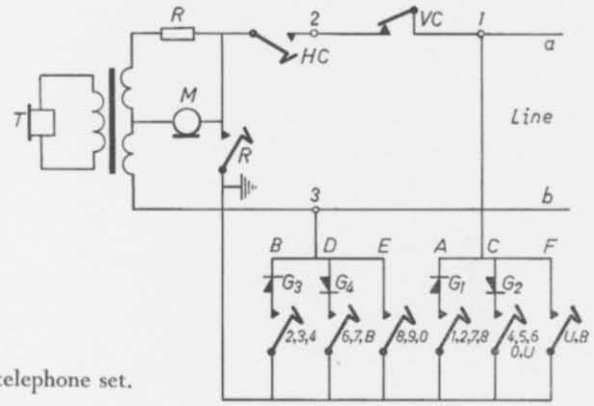

Fig. 5. Circuit diagram of keysending telephone set.

telephone set, shows that the keyset can be wired to the same points which are otherwise used for the dial. It will be noted that the impulse contact *i* of Fig. 4 is replaced by the line break contact *vc* in Fig. 5. This contact *vc* is operated each time a digit key is depressed and the opening of this contact serves as a signal to the register that registration of a key signal is required.

When a subscriber lifts his receiver, the circuit of Fig. 6 between the subscriber's set and the register is established. Contact *bc* operates as soon as the register comes into circuit and remains operated until the register has completed its operation. Upon closure of *bc* relays *W* and *L* operate in succession. Relay *L*, once operated, will hold via its secondary winding and the line loop. Relay *V* will operate in series with *L* and cause relay *W* to release. The sending of digits may now begin.

Each time a digit key is depressed, the code contacts will close before the common line contact *vc* opens. Resistances R_1 and R_2 are provided to prevent

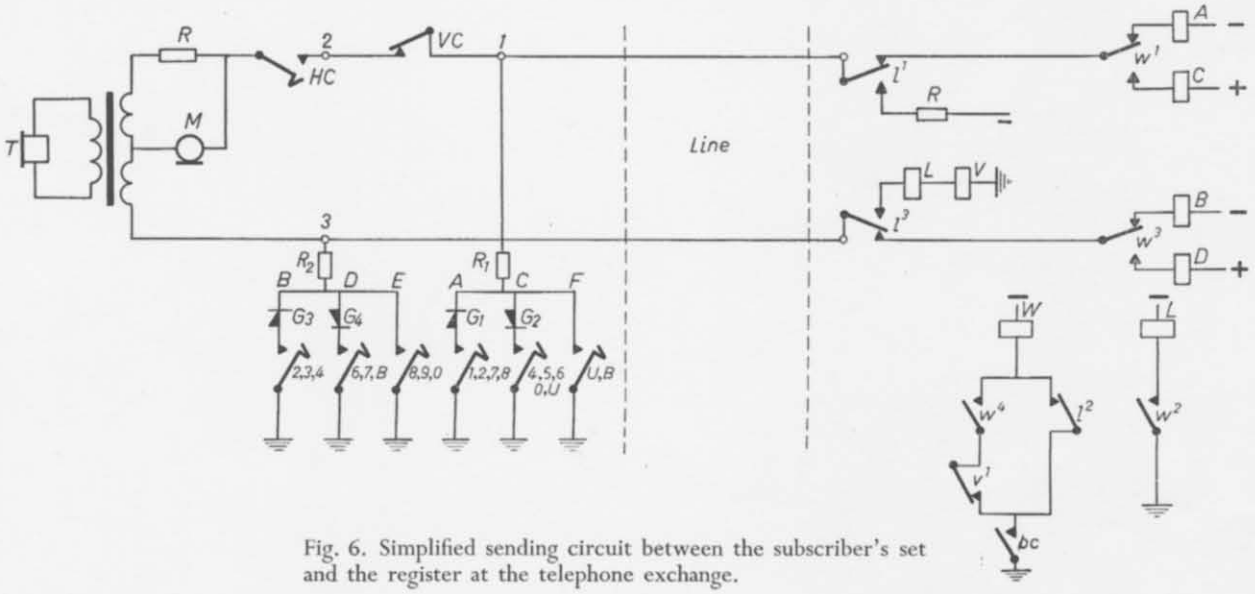

Fig. 6. Simplified sending circuit between the subscriber's set and the register at the telephone exchange.

Fig. 7. Keysending telephone set.

relays *L* and *V* from being short-circuited by a code contact. When contact *vc* opens, relays *L* and *V* will release within ten milliseconds and connect relays *A* and *B* to the line. After the release of relay *L* relay *W* will operate once more, again within ten milliseconds, and connect relays *C* and *D* to the line. Since relays *A*, *B*, *C* and *D* have an operate time of one millisecond, any code combination can be signalled to the register in about twenty milliseconds. The operation of any of these four high-speed relays is registered in a set of auxiliary relays. Relays *C* and *D* are also disconnected from the line after another ten milliseconds because relay *L* reoperates after *W*. Relay *V* cannot operate again, however, until contact *vc* in the telephone set has closed as a signal that the subscriber has released his digit key. When this happens, relay *V* reoperates and disconnects relay *W*, which, when released, restores the original condition.

No separate positive battery is required for the operation of relays *C* and *D*. The energy required for these relays is so small that it can be provided by a capacitor, which is normally connected to the exchange battery, but whose connections are momentarily reversed when *C* & *D* are connected to the line.

The above description applies to the operation of the register circuitry for the case of a keysending telephone set. It is worth noting that the register is so designed that it will accept dial pulses from a dial set and key pulses from a keysending set. In the former case relay *V* of Fig. 6 will act as an impulse relay. This feature will, of course, only be used when a mixed type of operation is adopted.

Mechanical design

As was already shown in the preceding paragraph, the electrical keying code is so designed that a uniform number of two contacts are closed for each digit, although in the case of digit 1 only one of these two contacts is actually utilized. This arrangement made it possible to use a simple and uniform design for the keyset. Further requirements which had to met by the mechanical design were:

a It should be possible to mount the keyset assembly in place of the standard telephone dial.

b The mechanical arrangement must prevent two adjacent keys from being depressed simultaneously.

In order to meet condition *a* the keys were mounted on a circular disk of the same dimensions as a standard dial (see Fig. 7). Keys 1 to 0 were arranged in the same sequence as the finger-holes on a dial and the space between keys 1 and 0 was used for the two extra keys *U* and *B*, so that the 12 keys were evenly distributed along the circumference of the disk.

In order to meet condition *b* the arrangement shown diagrammatically in Fig. 8 was adopted. Each of the press buttons of the keyset acts on a little plunger which terminates in a conical point. Below these conical points is mounted a disk of the form shown in Fig. 9, which can rotate in a plane parallel to the top surface of the keyset assembly. With all keys in their normal position the point of each key is just clear of the edge of one of the vanes of the disk, as shown in Fig. 8a. When a single key is depressed, the conical end of the plunger will slide along the edge of a vane and cause the disk to rotate (see Fig. 8c). As a result the two adjacent plungers are blocked and depression of the corresponding keys is impossible. If two keys are depressed simultaneously, as shown in Fig. 8b, the two respective plungers tend to rotate the disk in opposite directions and the two keys become blocked before they have been able to operate their electrical contacts.

The contact mechanism is shown in Fig. 10. In Fig. 10*a* a press button key is shown in the rest position. Washer *D* rests on bracket *A* and carries spring *C*,

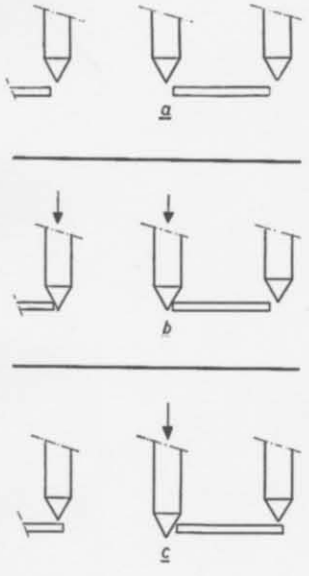

Fig. 8.
Interlocking of press-button keys.
a = all keys and interlocking disk in normal position.
b = two keys are depressed simultaneously; rotation of disk is prevented and keys cannot be fully depressed.
c = one key only is depressed; the interlocking disk has rotated, blocking the adjacent keys.

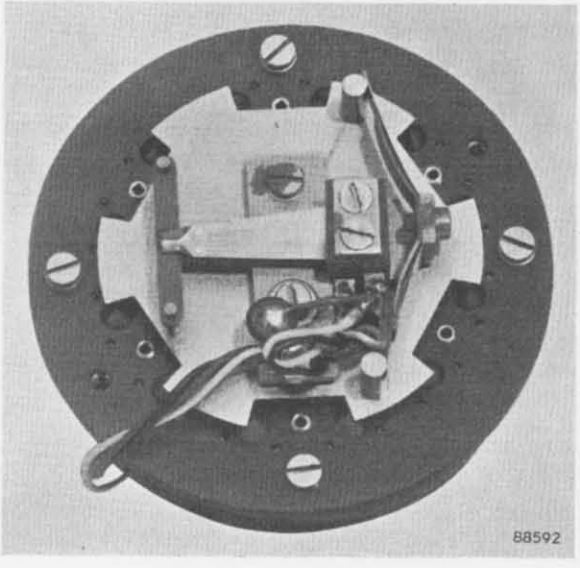

Fig. 9.
Keyset mounting plate seen from below. The interlocking disk with its vanes and the conical ends of the key plungers can be clearly seen. The spring set in the centre is the start contact VC of Fig. 5.

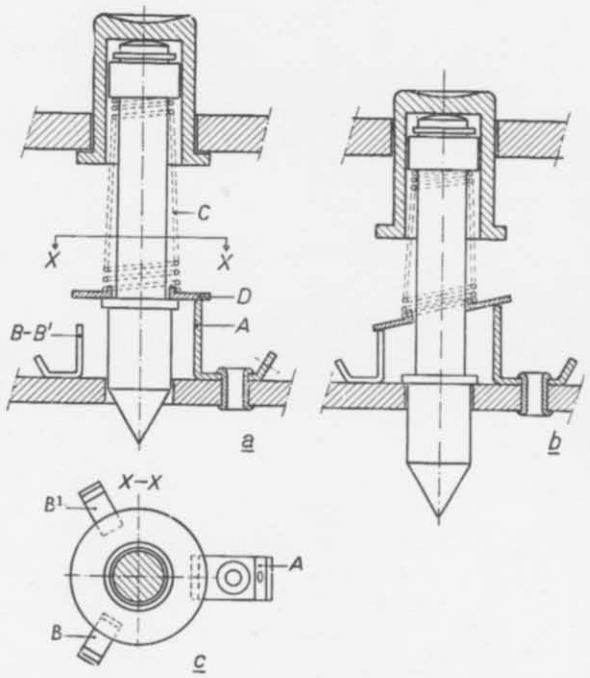

Fig. 10. Diagram of contact mechanism. *a* = key plunger in unoperated position; *b* = key plunger operated; *c* = horizontal projection of lower part of *a*, showing position of contact brackets.

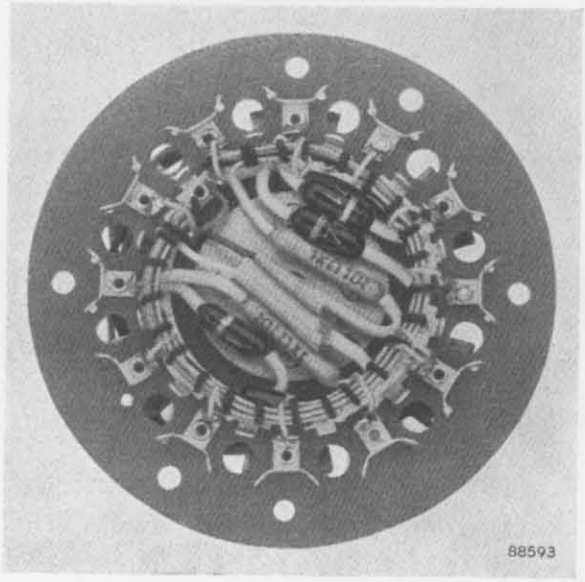

Fig. 11. Top view of keyset mounting plate, showing contact brackets and arrangement of wiring.

which presses the plunger with its press button upwards. When the button and plunger are pressed down, as in Fig. 10*b*, washer *D* cants until it rests on the two brackets *B* and *B'* which can be seen separately in the horizontal projection of Fig. 10*c*. When *D* rests on *A*, *B* and *B'*, the movement of the plunger continues until it is arrested because it butts against the lower mounting plate. The conical point of the plunger has then pushed one of the vanes of the plate of Fig. 9 aside. Bracket *A* provides the ground connection in the diagram of Fig. 3 and *B* and B^1 correspond with the two code contacts. The length of spring *C* is such that it has a very flat characteristic and as a result no adjustment of this spring is required

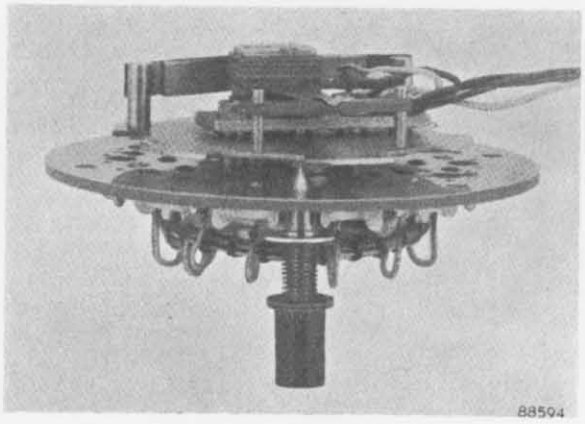

Fig. 12. Side view of keyset mounting plate. One key plunger and the interlocking disk are shown in the unoperated position. The operating spring of the start contact vc rests in a hollow in a cross-piece of insulating material mounted on the interlocking disk.

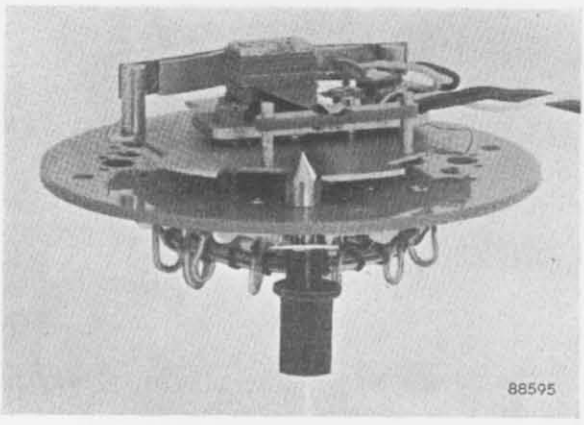

Fig. 13. Same view as Fig. 12, but with the key plunger operated. The interlocking disk has been pushed aside and the operating spring of the start contact vc has been forced out of the hollow in the insulating cross-piece.

after assembly in order to obtain sufficient contact pressure. Since brackets A of all keys are connected electrically, they are combined into one circular stamping as shown in Fig. 11. Bracket *B* of one key is always connected electrically with bracket B^1 of the adjacent key and the two brackets have therefore been combined into one stamping which is also visible in Fig. 11. Washer *D* and the contact points of brackets *A*, *B* & B^1 are silver plated in order to give good electrical contact.

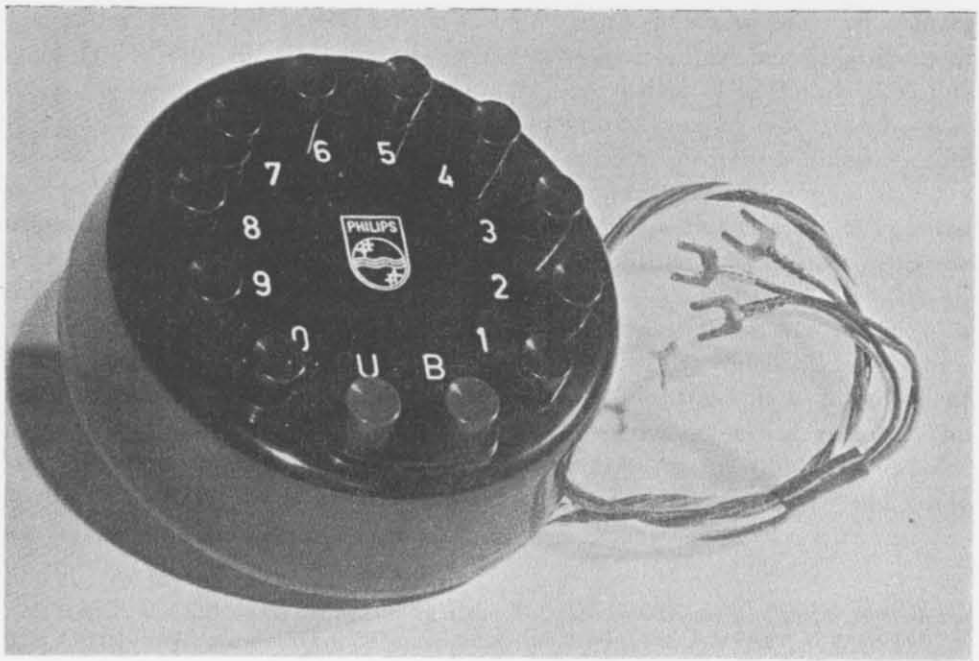

Fig. 14. The completely assembled keyset unit, ready for mounting in a subscriber's set.

The spring set visible in the centre of Fig. 9 corresponds to the start contact *vc* of Fig. 5. The end of the upper spring rests in a hollow in a cross-piece of insulating material which is attached to the vaned disk. The hollow is visible in Fig.12. When the disk rotates either clockwise or counter-clockwise because one of the buttons has been depressed, the cross-piece moves sideways, the spring is forced out of the hollow (see Fig.13) and contact *vc* opens.

Inspection of Figs.12 and 13 shows that the entire keyset mechanism is mounted on a single plate, with the blocking disk of Fig.9 and the start contact *vc* on one side and the contact mechanism, resistances R_1 and R_2, and rectifiers G_1 to G_4 on the other side. When this plate is completely assembled and wired, it is placed inside the cover together with the press buttons, which fit loosely into holes in the cover. Because these buttons are separate parts, it was convenient to make buttons *U* and *B* a different colour from the numerical buttons. The loose fit of the buttons obviates the risk of their becoming stuck in the holes in the cover. Fig.14 shows the keyset unit completely assembled and ready for mounting in the telephone set.

Literature
1 J. M. Unk, A new high-speed uniselector for automatic telephony. *Comm. News* **XII**, 69–99, 1952.
2 B. H. Geels, Private automatic branch exchange system UB 49. *Comm. News* **XIV**, 2–19, 1954.