PHONOCARD® – a pay phone operated by prepaid cards

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The product division "Telephony" of Landis & Gyr has developed a telephone operated by prepaid cards which is currently undergoing trials in various countries. After a reminder of the specific conditions which had to be complied with in this particular application of the optical coding technique, this development is described and the functioning of this new equipment and the experience gained by putting it into service for public use are discussed.

1. Introduction

The outstanding development of telecommunications is characterized, particularly in recent years, by spectacular advances in the data transmission field. Telephone networks constitute an ideal tool, of remarkable efficacity, capable of facilitating the arrival of the "cashless society" which is made possible only by an extensive infrastructure, capable of rapidly transmitting vast amounts of numerical data. In this context, why should not such an evolution also take place in the very particular sector of coin operated public telephones? In point of fact, the use of a card instead of coins offers definite advantages for the user and thus constitutes a new service.

2. Prepayment and postpayment

When speaking of card operated telephones, two fundamentally different modes of operation have to be distinguished: *prepayment* and *postpayment*.

The prepayment mode is that currently used for coin operated telephones: the money has to be introduced by the user before it is possible for the connection to be made or, at least a minimum amount must be inserted, it being possible to add further coins later, to allow the call to be prolonged. In all cases, the money to be collected corresponds to the subsequent period of the call, which is thus always paid for in advance. If the money is replaced by a value-bearing card, while retaining the same method of operation, then the card should be referred to as a "debit" card. Such a card must be purchased in advance. The credit which it carries is reduced progressively as it is used, until it has been completely exhausted. The process is completely analogous to that which has become daily practice in the transport systems of many cities, where the public transport undertakings sell multi-trip bus and tram tickets which have to be cancelled, that is to say progressively consumed as successive trips are taken. These multi-trip tickets are in fact nothing else but "debit" cards, used instead of money in the automatic ticket machines.

In the postpayment mode, on the other hand, the service is paid for afterwards (on the basis of an account or record). If the operation is carried out by means of a card, then it is a credit card in the true sense of the term. This has no intrinsic value; it merely allows the holder access to the facility which is accorded to him and is characterized by a number of an account in which the operation is entered. The postpayment system for telephone use is historically the oldest, since it has already been used for a long time in various countries, in particular in the USA und the UK. This service at present necessitates going through an operator who notes the account number indicated by the caller, verifies it and allows the call to be made, noting its characteristics (date, time, number called, duration, tariff). On the other hand, it allows the card holder to use any ordinary public telephone.

Making the procedure completely automatic would necessitate:
- automatic reading of the card in the telephone equipment,
- transmission of the account number to the central office responsible for accounting,
- the obligation for the user to dial a secret code number in order to check his identity by comparison with the account number,
- the recording by the central office of all information relating to the call to permit subsequent accounting.

3. Advantages of the card operated telephone

Whatever the system used, the two modes, "prepayment" and "postpayment" share the common advantage of completely freeing the user from the constraints inherent in the use of coins: no need to make sure of having a reserve of bulky and heavy coins, no insertion difficulties, disappearance of problems in making costly international calls, no frustration when the credit runs out, account always exact (to the nearest unit of account), in short, a high degree of convenience is offered to the telephone user. Now, it is well known that a considerable increase in revenue can arise from increased convenience and, in the last analysis, a higher utilization factor for the equipment is to the benefit of both the Administrations and the user.

The disappearance of coins also constitutes an advantage for the

Telephone Administration, which is freed from all the tasks associated with handling them: emptying of cash boxes, sorting and counting of receipts, coin handling (making up into rolls), operations which although not spectacular are nevertheless costly. Because of the fact that the card operated telephone contains no monetary values, the risks of its being broken into and of vandalism are considerably reduced. All this results in important saving in the operating costs of the equipment.

The "prepayment" mode has the additional advantage for the Administration of constituting a source of financing, since by the sale of cards in advance the receipt of large sums takes place well before the corresponding service is provided. The interest on this capital will largely cover the costs of card distribution. Moreover, most Administrations already have excellent sales networks consisting of the post offices, which are quite capable of ensuring this service in the same way as they handle stamp sales.

The comparison with postage stamps is of interest in more ways than one. These too are a form of prepayment system. Their unit value is similar to that of telephone "units of account" and their level of security and production cost which are both relatively high because of the techniques used (copper-plate printing for example) can be compared with what is required for a telephone "debit" card.

4. Objectives

The product division Telephony of Landis & Gyr has many years of experience in the field of pay phones. The idea of developing a card-operated telephone based on the prepayment principle is the natural extension of a continuous process of organic development, the expansion of the product range with the aim of making possible a new service which the Telephone Administrations, our traditional clients in several countries, may feel desirable to offer the users of public telephones. The prepaid card is effectively a generalized form of telephone tokens which were once very familiar and are still used in certain countries. Instead of steadily collecting coins in the course of the call, the proposed telephone erases value units "stored" or "memorized" on a card, regarded as an information carrier. In other respects, that is to say connection to the telephone line, reception and counting of the call charge pulses, display of the remaining credit, accounting (subtraction of the credit "consumed" from the credit "introduced") and cutting off of the call if all the credit should be used up, the card-operated telephone functions exactly like a coin-operated telephone and is made up of the same components.

A first series of mock-ups, using a magnetic card reader available on the market, has been built in order to put the idea into concrete form and show the behaviour of the public. On the basis of the positive reactions to these trials, is has been decided to proceed further with the project.

The crucial problem which arose immediately was the choice of the right technology for storage of the information representing the value on the card.

Magnetic technology is well known and technically irreproachable. However, it has one essential property: the information stored on the magnetic track is, by its very nature, volatile. Once read, it can be erased and replaced by fresh information and the read-erase-write cycle can be repeated many times. Consequently, magnetic technology enables rechargeable cards to be made which can have their value restored by insertion in a suitable charging device. This apparent advantage in fact represents a serious risk since fraudulent treatment of the cards enables values to be "created" by recharging them. Moreover, at present it is relatively easy to copy onto a suitable magnetic base the information on a valid fully "charged" card and thus obtain a duplicate card or, still more serious, reproduce it ad infinitum. And those indulging in this eminently remunerative activity are not likely to have any difficulty in obtaing the raw material.

A "debit" card is a form of money, often referred to as "electronic money". The higher the value involved, the greater the temptation for criminals. Thus, in a prepayment system, the security of the card reader, its resistance to forgery whether by imitation or by modification of the coded information, and the verification of the authenticity are of prime importance. To use the magnetic technique in such a case is to make the manufacture of forged monetary values accessible to every handyman in every household.

It follows from these considerations that the choice must be for non-rechargeable processes, in which the information representing the value is physically destroyed on erasure. "Regeneration" of the original structure must be impossible or, since technically speaking nothing is impossible, must at least necessitate means (knowledge, equipment) such that the cost of the operation is prohibitive in relation to the benefit which could be derived from it.

Erasing must be "clean" in that it must not leave residues (dust, chips, debris, "confetti" resulting from punching) in the equipment which would necessitate periodically emptying it or cleaning it, the aim being to reduce such operations to a minimum.

The reduction in the value of the card in the course of the transaction (in this case, a telephone call) must be continuous, that is to say that the physical state of the information on the card must, at any given moment, correspond to the state of the transaction. At the end of the call, the card is returned immediately without any additional processing and must automatically have the value of the balance remaining on completion of the operation.

The optical coding techniques using microscopic structures, which have been developed at the central research laboratory of Landis & Gyr and which are the subject of more detailed articles in the same issue of this review, satisfy the conditions set out above and, in particular, offer the high level of security required. It is therefore on this basis that development of the PHONOCARD project has taken place.

5. Conditions specific to the telephone equipment application

The particular application of holographic technology for the realization of a card operated telephone entails a series of specific requirements and involves the following limiting conditions:

- It must be possible to distinguish three quite different levels of information in the equipment:
  a) A number of "value bits", units of account for the telephone call, arranged along a track, which will be progressively erased in the course of the call.
  b) A "family" code, allowing the card to be identified as belonging to a given network. Obviously, the cards used in different countries must not be mixed up. A series of types of different holographic structures can be produced; it is thus possible to attribute a "family" code to each type of structure, this constituting the authenticity element which must be recognizable on each value bit.

c) A "type" code, making it possible within a family to distinguish several categories of cards (according to the user organization or the tariff category for example). For this, a number of bits at the beginning of the track are used, coded by preliminary selective erasure ("m out of n" code) so as to obtain a binary figure which is characteristic of the type. At the beginning of the call, this figure is read by a reader which therefore scans the first n bits in the read mode only, before proceeding to look for the first valid value bit.

Figure 1 shows the basic structure of a telephone "debit" card coded according to the above principles.

- The choice of the value of the bit used on the card is important for the convenience of the user. This unit of account, which can in principle be chosen arbitrarily, should be neither too small nor too large for optimum convenience of the telephone user.

  It must be small enough to ensure a sufficiently precise deduction of the charge yet large enough for the card to allow trunk calls or international calls of adequate duration. It may correspond to that of a small coin frequently used (for example, 20 centimes in Switzerland). The simplest thing is to give it the value of one call charge pulse as defined in a given country by the system of charging on the basis of periodic pulses.

- The choice of the number of value bits, in other words the value of the card as purchased, is also an essential factor liable to affect the behaviour of the user. A card which is too expensive may discourage occasional users whereas a card which is too cheap does not allow an international call of any great length. The capacity currently allowed by the Landis & Gyr holographic technique is a maximum of 120 bits per track (240 bits for a card with two tracks). For the Administrations which have shown interest in the system, the value of 100 bits seems to be the optimum. For Swiss conditions (0.20 S.Fr. per bit), this would correspond to a 2.5 minute call to the United States. In addition, a second category of cards with 20 (or 25) bits is principally intended for occasional users of the telephone, being better adapted to the "small consumers" who limit themselves to local calls.

- The production cost of the cards is evidently decisive for a telephone application. It must be extremely low so as not to impose to heavy a charge on the application of the system, exceeding the savings which may be achieved elsewhere. A target price of a few percent of the nominal value of the cards sold appears to be realistic and corresponds to the interest which the Administration derives from the capital constituted by this form of credit.

- The speed of erasing the value bits is relatively low, at the most 1 to 2 bits per second (depending on the tariff conditions and the unit of account). In Switzerland, the shortest period currently applicable, for a pulse worth 0.10 S.Fr. (a very low value compared with the average for other countries), is 0.511 seconds (calls to Australia or New Zealand). A value of 3 bits/second was decided on as the maximum erasing speed.

- The power available is very low. Although the objective of achieving complete independence of an external power source and of drawing all the power necessary for operation of the telephone from the telephone loop alone has not yet been attained, nevertheless great importance is attached to achieving as low a consumption as possible so as to reduce to a minimum the volume and cost of the ancillary power supply arrangement.
- A device making it possible, when the credit is running out, to change rapidly from one card to another without interrupting the call is essential.
- Lastly, all the facilities normally offered by a high performance coin operated telephone must be provided in the card operated phone. The "credit carry over" function is particulary worthy of mention in this context: at the end of a call, the user must be able to use the remaining credit for one or more further calls without needing to have the card returned to him and then having to reinsert it for each successive call. For this, it is only necessary to actuate the handset rest briefly or to push the appropriate button (the mode of operation will depend on the philosophy adopted by the Administration) for the call in progress to be cut off and for the dialling tone to reappear on the line so as to allow a further call. The credit remains displayed, immediately available for the new call.

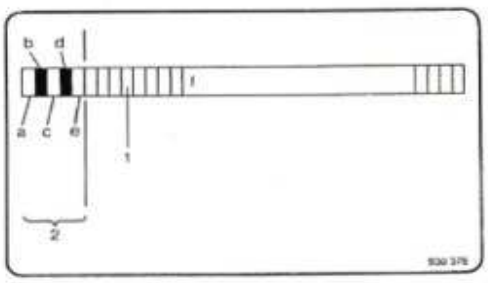

Fig. 1 Structure of a telephone "debit" card
1 = bit value
2 = "type" code

Example:

Position	a	b	c	d	e
Information	1	0	1	0	1

6. Construction

Figure 2 gives a view of the telephone in the version corresponding to its first use in public service. The elements of the PHONOCARD telephone are grouped in a strong stainless steel case of compact and aesthetic form. The handset is partially recessed and arranged logically on the left-hand side. On the right, underneath the instructions for use in pictographic form are the liquid crystal display (LCD) for indicating the credit and a keypad which is more robust and more practical than the old-fashioned rotary dial. The card reader is located at the bottom of the equipment with the slot for insertion of the card horizontal.

The block diagram of *figure 3* shows the sub-assemblies which make up the telephone and which will be briefly described, starting with the card reader which is the heart of the equipment. We will restrict ourselves here to describing the essential functions of the device since the physical and technological basis of the Landis & Gyr optically coded card reader is the subject of a detailed article in this same review (see page 21).

6.1 Card reader

In the PHONOCARD reader, once the card has been inserted it is held fixed and it is the read and erase heads which move. A mechanical locking device prevents removal of the card during the call and release is caused by an electro-magnet a few seconds *after* replacement of the handset. In this way, any pulses which may arrive at the end of the call (as is the case for certain old types of exchanges still in service) are also counted. If the supply voltage is absent, the locking mechanism is rendered inoperative.

The read head examines the holographic structure by reflection, but through the base material of the card, and is located underneath the card whereas the erase head, mounted on an articulated carrier, is located above the card. The erase head only moves to contact the sensitive track, with a

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Fig. 2 PHONOCARD telephone

pressure determined by a spring, once the card has been com pletely inserted. This avoids the risk of damage to the head on insertion or withdrawal of the card or if thin metal objects should be maliciously introduced into the slot.

The read and erase heads are mounted on a moving carriage, driven by a stepping motor via a screwed rod. The exact positioning of the carriage is controlled electronically by means of a code disk integral with the drive screw.

The carriage moves so as to scan the coded track, starting from one end and stopping at the first value bit recognized as valid. When a unit of value is "consumed" by the equipment, this bit is erased in its turn and the carriage advances by one step.

The reader has its own electronic circuit, grouping the photo-electric

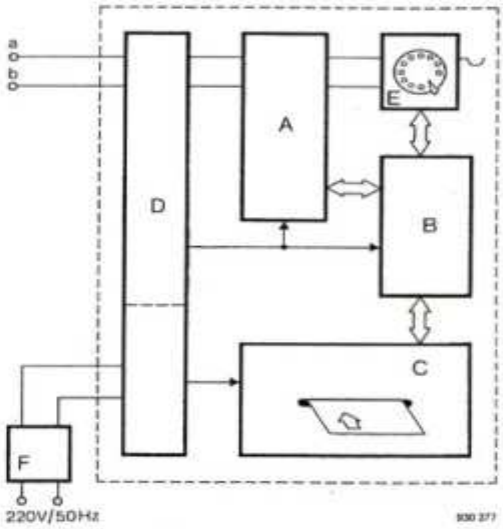

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Fig. 3 Block diagramm of the PHONOCARD
A analogic circuit
B logical circuit, microprocessor
C card reader
D power supply
E telephone
F transformer for external power supply
a,b telephone lines

measuring circuits, analogue-digital conversion of the signals and control logic, which ensures correct transfer of the input and output signals to and from the main logic circuits of the telephone equipment.

This interface between the reader and the telephone in which it is incorporated has the following functions:
- recognize valid cards (by verification of the "family" code)
- decode the information bits of the "type" code
- command the read and erase processes
- command the carriage movement
- count the number of value bits erased and, by subtraction, deduce the balance remaining on the card.

The input signals acting on the reader are:
- read command
- erase command
- carriage advance command
- card return command (release of the card).

The output signals delivered by the reader are:
- card present
- beginning of track
- presence of a valid value bit.

At this point, attention should be called to an essential feature of the system: the checking, by simultaneous reading, of the state of erasure of the value bit consumed in the equipment. This original property of the Landis & Gyr optical technique enables the energy used to be minimized by stopping the erase process as soon as it has gone sufficiently far and also ensures in all cases that an erase command is in fact carried out as far as necessary. In addition, it provides an important safeguard against fraud: the value bit must not only be recognized as valid by means of its special code but it must also be recognizable as *erasable*. An erase command which is not executed (not followed by the disappearance, at the same position, of the "value bit present" signal) automatically leads to the ejection of the card and the termination of the call (i. e. the disconnection of the telephone line).

Figure 4 gives a view of the reader (open).

6.2 Analogue circuit

The printed circuit (card A) carries all the analogue part of the electronics. In particular, it accomodates:
- the telephone circuit, connected to the handset and to the telephone line, which performs the normal functions of the telephone proper;

- the call charge pulse detector plug-in circuit, adapted to suit the pulse transmission system used;
- the generators of acoustic signals needed for operation of the telephone.

6.3 Logic circuit

All the logic functions of the equipment are performed by means of a microprocessor whose programme is stored in read only memories (EPROM are used in the prototypes). This is the "brain" of the equipment, ensuring the correct performance of the functions, in particular the "accounting" (determination of whether or not the credit is sufficient to authorize the call) and the control of the display.

The microprocessor is also used for controlling the dialling signals (transmission of the number called) from the keypad. The keypad contacts are arranged as a matrix and connected directly to the microprocessor system. Detection, suppression of spurious signals and transmission on the telephone line are controlled by the programme. It is thus possible to inhibit the transmission of certain specific previously programmed numbers (blocked numbers) or to authorize such transmission without a card being inserted (free numbers, for emergency calls for instance). By means of appropriate links, it is possible to select dialling by pulses or by multi-frequency signals.

6.4 Power supply

Power is derived from two sources:
- The speech line of the telephone provides power for the telephone circuit and the microprocessor which controls the system.
- An external source supplies the card reader.

This power supply system makes it possible to ensure that emergency calls can be made, without a card, even in the event of a failure of the external source (reader out of operation).

Power supply via the telephone line is ensured by a d.c. converter inserted in the line. Energy is stored in a capacitor charged by this converter. The maintenance of the charge on the capacitor when the equipment is not in use is ensured by a stand-by current of less than 1.5 mA taken from the line.

The power supply incorporates a voltage monitoring device which prevents all calls if the power should be cut off.

6.5 Operating

Use of the telephone is very simple and the sequence of operations is completely analagous to that for a coin operated phone:

a) Lift the handset
   - zero credit is displayed
   - the dialling tone is obtained immediately
     At this point, it is immediately possible to make a (free) emergency call without inserting a card.

b) Insert the card, printed side up, in the direction of the arrow
   - the card is read and the credit remaining on it is displayed (expressed as a number of charge units)
   - if the initial credit is greater than or equal to the minimum credit required for making a call, the user is authorized to dial the number he wishes to call (or, if the number has been dialled previously and memorized, it is transmitted along the line at this point)
   - if there is no credit or if the card is not valid it is ejected
   - if the credit is not zero but less than the minimum credit required, the user is warned optically and acoustically. He then has the possibility of changing to a new card while still using the residual credit on the first card by proceeding as described below (see e)

c) Dial the telephone number required. It is possible to dial as soon as the dialling tone has been obtained after insertion of the card.

   The number dialled is memorized in the equipment and is only transmitted along the telephone line when establishment of the call is authorized by the existence of sufficient credit on the card. This function of memorization makes the speed at which the number is transmitted to the line independent of the speed at which the user dials.

d) As soon as the person called lifts his receiver, the equipment receives one or more call charge pulses transmitted by the exchange. The credit display is reduced by one unit every time a call charge pulse is received, triggering the immediate erasure of one value bit.

e) If, in the course of a call, the credit available on the card is reduced to a value such that it will only allow a further 15 seconds of conversation, the user is warned by:

   - an acoustic signal audible in the earpiece
   - a flashing light.

   Once these warning signals appear, the user has the possibility of prolonging his call beyond the 15 seconds if he has a second valid

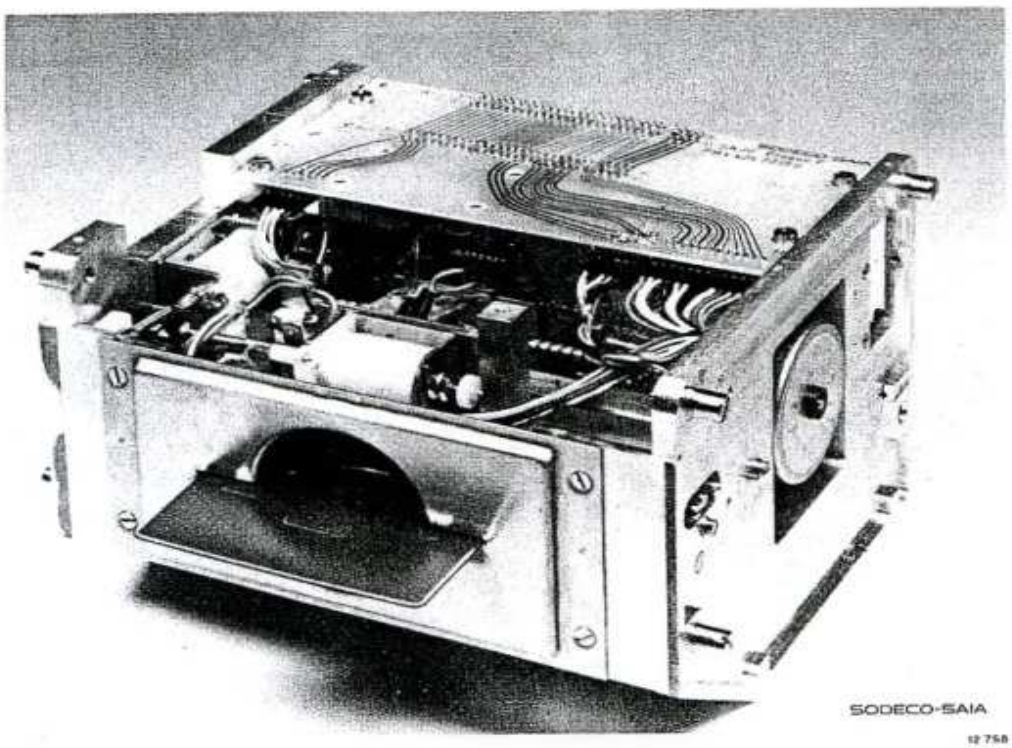

Fig. 4 Card reader, opened

card available. To do this, he has to carry out the following operations:

1. Press the button located to the right of the card insertion slot:

- the remaining credit on the card is erased rapidly and memorized in the equipment
- the card is returned with zero credit.

2. Insert the second card before the credit which has been memorized and displayed is used up.

These operations are carried out without interruption of the call, which therefore continues until the remaining credit which has been memorized and displayed is used up; use of the credit of the second card then starts without the call being affected.

Note: The button controlling the erasure of the card and its return with all its credit removed is inoperative when it is actuated outside the warning phase.

f) At the end of the call, the user replaces the handset and his card is returned to him bearing the latest credit balance.

If, during the call, the credit should be used up, the connection is cut off and the card is returned to the user with zero credit.

g) Successive calls
It is possible to keep the card inside the equipment in order to make several successive calls. To do this, it is only necessary, after each call, to depress the handset rest for approximately 1 second. When the user hears the dialling tone again, he can dial the desired number. The same thing is possible if the call has been unsuccessful, due to an engaged number for instance.

h) Checking the credit
It is possible to check the credit carried on a card without having to telephone and without having to occupy a line, even for a moment.
In this case, the PHONOCARD functions as an ordinary card reader.

The procedure is as follows:

1. Insert the card without first lifting the handset.

2. Read the amount of credit which is displayed for a few seconds.

3. Recover the card which is automatically returned after these few seconds.

7. Preliminary trials

The Sodeco-Saia company in Geneva has coin operated telephones installed in its offices and workshops for use by staff members. About a year ago, 8 of these telephones were replaced by PHONOCARD telephones operated by holographic cards, as a first phase of experimentation. The cards are sold at the company cashier's office. A discount of 33% on the «telephone call value» was introduced in order to encourage employees to make maximum use of the cards so that as much experience as possible on the behaviour of the equipment and its users could be rapidly acquired. The result greatly exceeded expectations, since the traffic with the card operated telephones was three times what it had been when they were coin operated. The financial advantage and the novelty value must not be neglected in the evaluation of the experiment, since they certainly had a favourable effect. However, these factors alone do not account for such a success; the advantages (convenience, calls of practically unlimited duration) offered by the use of cards is clearly demonstrated by these trials.

The Belgian Telephone Administration, the Régie des Téléphones et Télégraphes (RTT), has been interested for a long time in the idea of card operated telephones. In Belgium, there are few coins in circulation and the value of the largest coin, 5 Belgian francs, considerably restricts the use of coins for public telephones since it corresponds to one charge unit only. Following fruitful collaboration with Landis & Gyr, the Régie decided on the installation of card operated telephones. Four telephones have been installed in the Head Office of the RTT in the centre of Brussels and the reception of the public has been

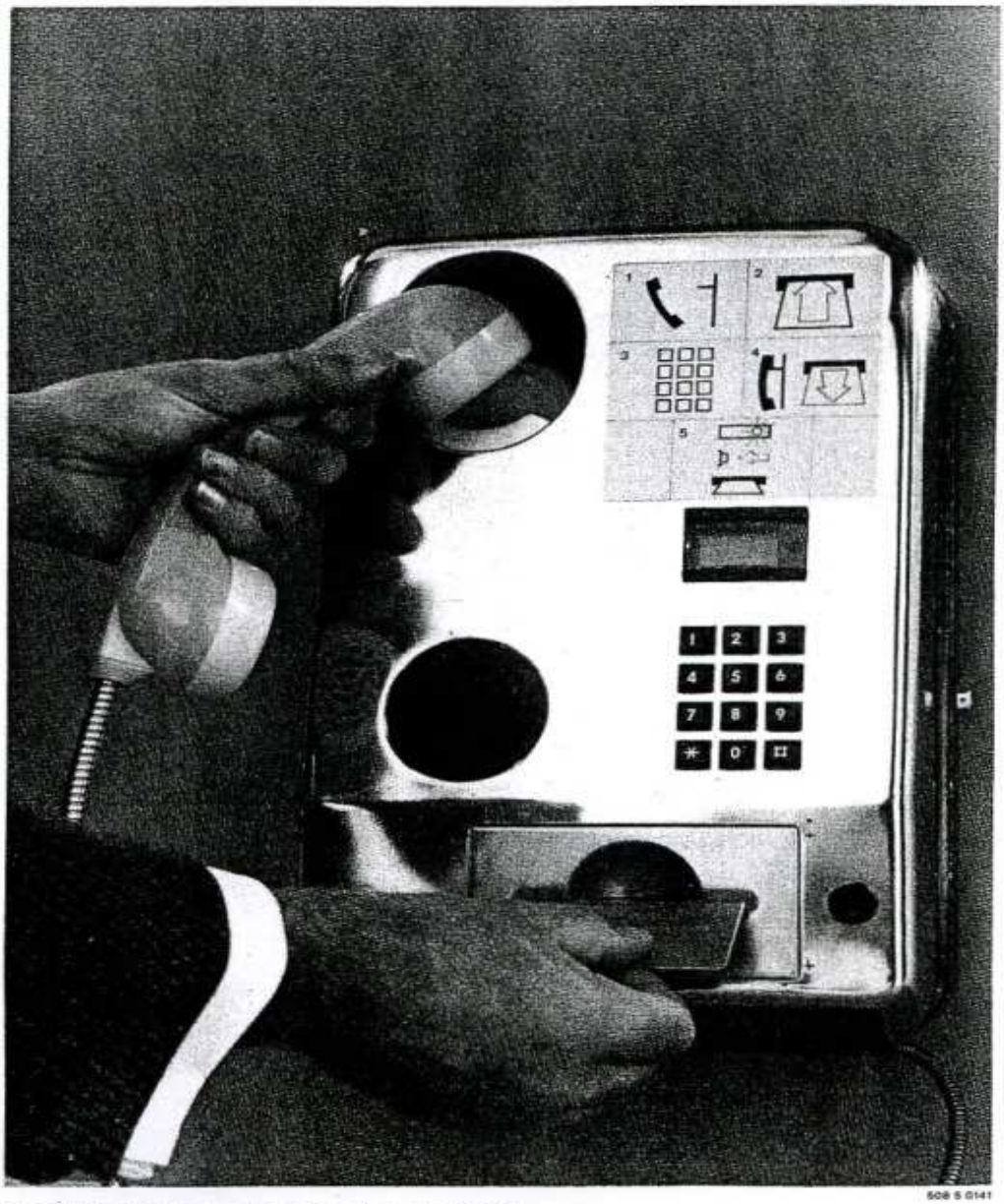

Fig. 5 Using the telephone by inserting the card in the slot.

most favourable. Traffic has doubled, as compared with coin operated telephones, with considerable use for international calls. Users are very satisfied and the average receipts per telephone per day are at the 1000 bit or 5000 fr. b. level.

At present, about 120 cards are sold per day, i. e. 110 twenty-unit cards and 10 hundred-unit cards for the four telephones in service. Since the interest of the Régie is to promote the sales of 100-unit cards at the expense of the 20-unit cards, it has been decided to introduce a discount for the high value cards in the form of a bonus of 5 extra free bits. The new 105-bit card will therefore be sold for the price of 100 bits. It is hoped to thereby modify the proportion of 20-unit to 100-unit cards sold. The ration is currently 11:1, the 5% discount should bring it down to 7:1 and in the longer term to 4:1.

In view of the success of these trials in Brussels, they have been successively extended by putting into service some twenty telephones in the streets of the capital, near kiosks.

A subsequent stage is planned in Belgium on a much larger scale and extended to the whole country.

Several other Administrations in Europe are actively interested in similar PHONOCARD trials.

8. Conclusions

The conclusions can be expressed very briefly: thanks to PHONOCARD people telephone more. This is of benefit to everyone. Fuller utilization of the equipment cannot be other than profitable for the Administration. It can thus favour a reduction in costs. The more rational solutions made possible may prevent, or at least limit, tariff increases and it is therefore the users who will have reason to be pleased. Moreover, the use of a card instead of coins is so much more convenient. People are inclined to talk at greater length, the threat of being cut off because of a shortage of coins has essentially disappeared, people can call relatives in North Africa or friends in Italy or Norway without constraint. In this communications age, the card operated telephone has its part to play.

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www.optical-cards.com
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