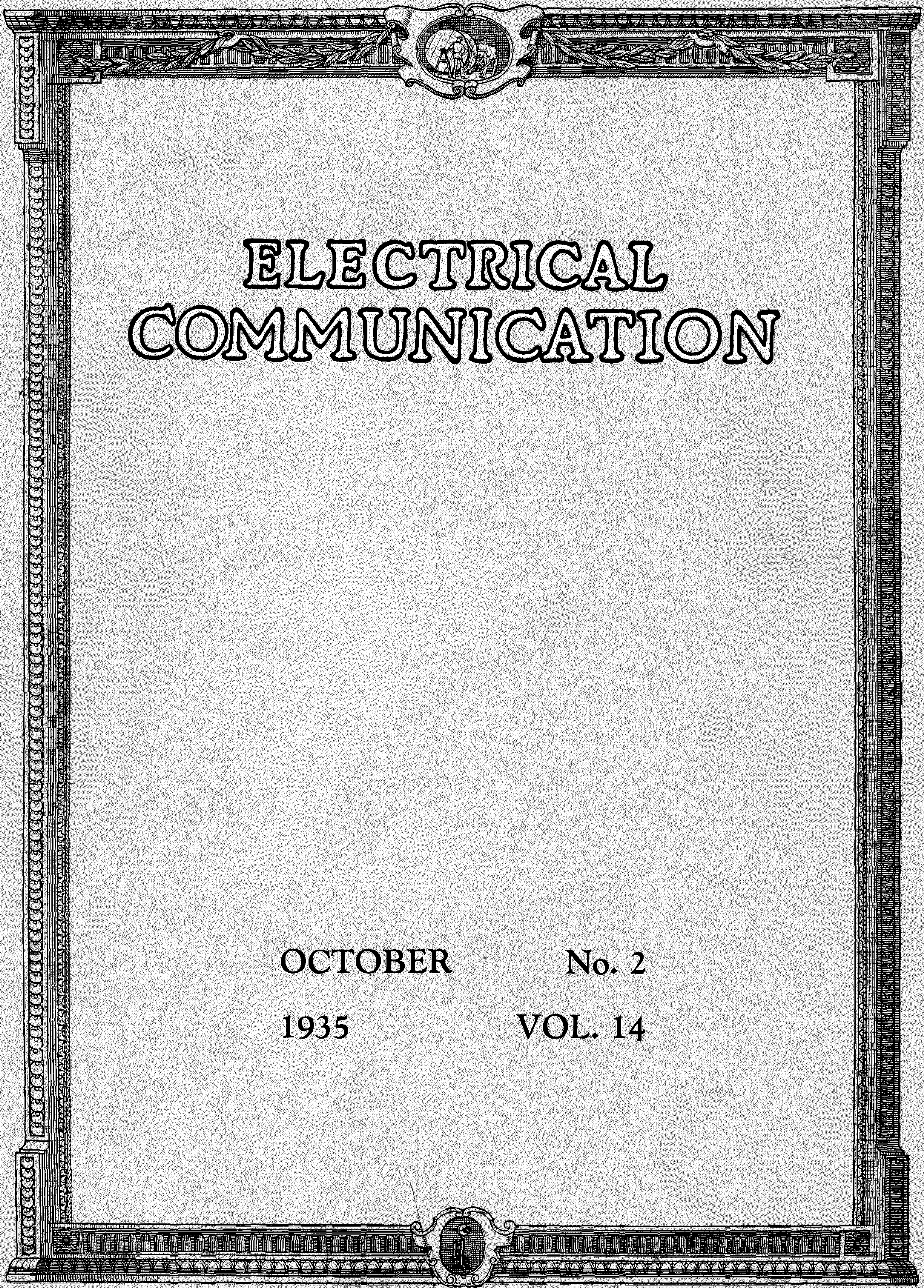
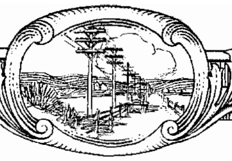


ELECTRICAL COMMUNICATION

OCTOBER No. 2
1935 VOL. 14



ELECTRICAL COMMUNICATION

A Journal of Progress in the Telephone, Telegraph and Radio Art

H. T. KOHLHAAS, Editor

Published Quarterly by the

International Standard Electric Corporation

Head Offices
67 BROAD STREET, NEW YORK, N. Y., U. S. A.

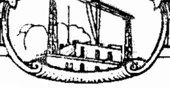
European General Offices
CONNAUGHT HOUSE, ALDWYCH, LONDON, W. C. 2, ENGLAND

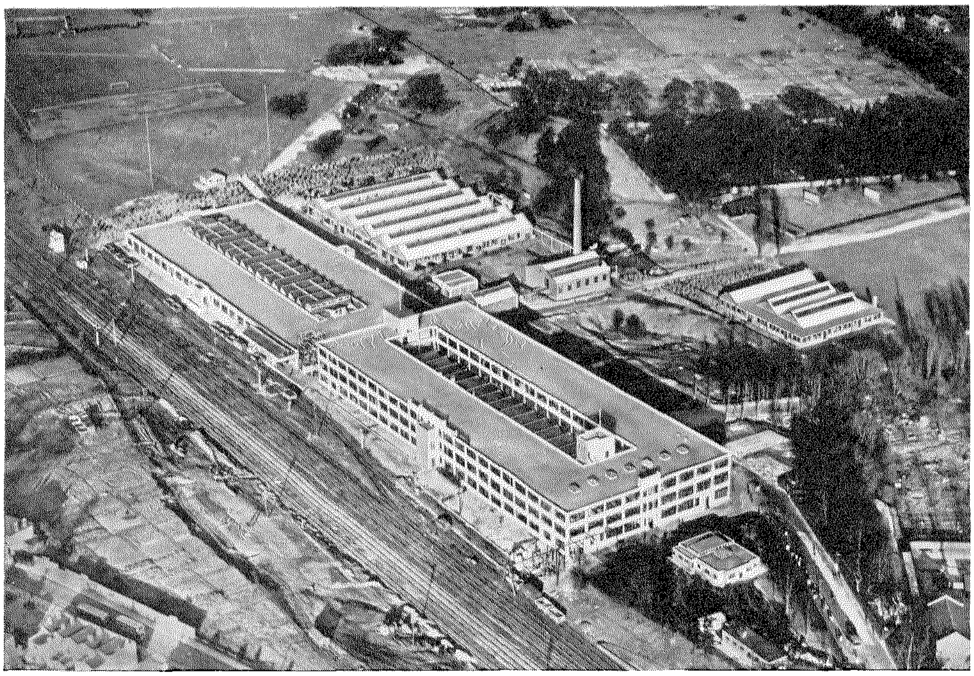
G. E. Pingree, President S. G. Ordway, Secretary Joseph A. Redegeld, Treasurer

Subscription, $3.00 per year; single copies 75 cents

Volume XIV OCTOBER, 1935 Number 2

CONTENTS





NEW PLANT OF STANDARD TELEPHONES AND CABLES, LIMITED, AT NEW SOUTHGATE, ENGLAND, FOR THE MANUFACTURE OF TELEPHONE AND RADIO APPARATUS AND EQUIPMENT.

Some Considerations Regarding a Toll Fundamental Plan for Europe

By BRUCE H. McCURDY

Assistant Chief Engineer, Societatea Anonimă Română de Telefoane, Bucharest, Rumania

I. Introduction

IN a previous paper[1] the author discussed the importance of fundamental plan studies in meeting economically the present day demands for a universal intranational telephone system. The present paper deals with the international phases of the same problem.

Although the method of attack and the variables dealt with differ somewhat in the case of the international network, the final objectives are the same as those for the national fundamental plan and may be summarized under the same three headings as given in the previous paper[1]:

(1) Minimum number of circuits for a given service,
(2) Minimum grade of circuits throughout the system consistent with demands of satisfactory service,
(3) Minimum plant costs (both from the standpoint of initial investment and annual charges) for the facilities provided.

The international fundamental plan, however, rather than dealing specifically with the economic features and the problem of direct application to plant, will concern itself with the more basic questions such as the general form of the network and the allocation of transmission limits to the various parts of the international system. Its main concern will be with the second of the three objectives, i.e., minimum grade of facilities consistent with the demands of satisfactory service.

The C.C.I. has spent a very considerable amount of time in studying the problem of acceptable overall transmission limits and the method of expressing all contributory factors in terms directly applicable to plant design studies. The next step is to allocate these limits in such a way that, consistent with the guarantee of a satisfactory grade of service for every connection set up, engineers will have the greatest possible latitude in designing the national portion of their respective networks. While certain temporary allocations have been made, they are somewhat arbitrary and are by no means complete. A glance at the questions now before the 3rd and 4th C. R. of the C.C.I.F. will indicate the amount of work along this line which still remains to be done[2]. The need for coordinating these studies into a general "Toll Plan for Europe" was recognized when the following question was placed before the Plenary Assembly of the C.C.I. at Paris in September, 1934:

Question 5 of 3rd C.R. (1932-4): Is it desirable to set up a general program of international telephone connections which will include a plan of international telephone centers and alternate routes? In the affirmative:

> (a) "What should be the transmission characteristics, total equivalent, time of propagation, transient period, crosstalk, noise, etc., for the largest section of line and for each of the different sections considered separately."

At the meeting of the C. R. held in Paris in October, 1933 this question came up for its first discussion and it was the opinion of the meeting that a general fundamental plan of this sort was desirable and that a start should be made in the study of its form and of the resulting electrical characteristics.

The various administrations were asked to present their toll fundamental plans especially with respect to the toll centering plans and limiting transmission standards in order that the 3rd C.R. could discuss the question of a general European toll fundamental plan at the Stockholm meeting of June, 1934. Some eight admini-

---

[1] "Toll Plant Engineering," *Electrical Communication*, January, 1933.

[2] See especially Questions 2, 5, 12, 26, 27, and 28.

strations complied with this request. Unfortunately, the amount of work which had to be covered by the various commissions at Stockholm was such that it was impossible to allocate sufficient time to Question 5 to allow its being studied fully. A small subcommittee was appointed to study the matter and, as a result of this work, certain transmission features of such a fundamental plan were presented and adopted, first by the 3rd Commission and later by the Plenary Assembly at Budapest. It was found, however, that before any really complete answer could be given, a considerable amount of additional study would be required. As a consequence, old Question 5 was broken down into a number of specific new questions which are now before the various commissions for study and answer.

Unfortunately the basic question of a general toll plan for Europe, as a specific or formal project, has disappeared from the list of questions to be investigated. All of the contributory investigations leading up to such a plan will be found under one question or another now on the program. Their exact interrelation, however, is in many cases not at all clear. By grouping such questions under the more general heading of "European Toll Fundamental Plan" or "European Toll Distribution Plan" and attacking them in the light of their contribution to or bearing on such a plan, this interrelation will be made apparent. Furthermore, the correlation of the various questions with their specific practical application will indicate the form in which the answers to each question shall be given, in order to be of most value, and will in many instances indicate practical methods of attack. In other words, such a general toll plan will be the connecting link between the laboratory investigator and the field operating engineer.

With such an idea in view the author wishes, in this paper, to point out from the viewpoint of the operating engineer, the essential steps involved in coordinating the engineering problems that require solution in providing economically an efficient interconnecting telephone network for Europe and to show how these may be coordinated and simplified by means of a formal toll fundamental plan.

II. General Purpose of the European Toll Fundamental Plan

Mr. H. S. Osborne in his paper "*A General Switching Plan for Telephone Toll Service*"[3] states "To achieve universal service . . . circuits must be provided in such numbers and so arranged that connections between any two telephones can be established quickly and without too many intermediate switching points. Also the telephone plant must be designed for such standards of transmission that these connections, when established, permit satisfactory conversation." This might well be taken as a statement of the final objective of the various deliberations of the C.C.I. As will be noted, the achievement of universal service requires the joint investigation of two main fields of activity: (a) exploitation: "Circuits . . . in such numbers and so arranged"; and (b) transmission: "that *these connections*, when established, permit satisfactory conversation"; and it will be well to consider for a moment the extent to which the C.C.I.F. can be expected to investigate and coordinate these two fields.

(a) *The Exploitation Problem.* In a unified system such as that encountered in the United States, the exploitation problem will play a considerable role in shaping the ultimate form of the toll plan finally adopted. In Europe, on the contrary, its role in the initial steps of the study will not be so important because of the existing wide divergence in local conditions, operating methods, service demands, etc., as well as the fact that each national network must be considered as a separate and independent economic unit. However, the European toll plan as foreseen by the author will, when completed, be a distinct aid in meeting many of the problems of exploitation. In its final form the toll plan will specify in much more detail the exact part played by each link of a built-up international connection. There are two factors which, today, make such an exact definition essential. In the first place, the demand for a truly universal interconnection of subscribers—and this means *any* subscriber to *any* subscriber regardless of location—is becoming sufficiently important to

---

[3] "A General Switching Plan for Telephone Toll Service," by H. S. Osborne, *A.I.E.E. Transactions*, 1930, p. 1549, and *Bell System Technical Journal*, July, 1930.

require recognition. In the second place, the economic situation is demanding the utmost economy in providing the necessary facilities. It is all very well to say that new developments are making possible circuits of high quality capable of meeting almost any requirement. Nevertheless, improved circuits cost money, and modifications take time. Furthermore, there is a very great amount of plant now in service which can and must be kept in service for a long time to come. A general toll plan with its exact specification of service requirements for various classifications of international circuits will provide a basis, entirely lacking today, for a cooperative study by the exploitation forces and the engineering forces in each local administration. Such a study should go far toward helping to meet the growing demand for economical universal service.

(b) *The Transmission Problem.* As has already been mentioned, it is with the transmission phase of the problem that the C.C.I.F. will have most directly to deal and it is this phase and the related questions now before the C.C.I. for study that the author proposes to discuss in this paper.

There is today a fairly close agreement covered by specifically established limits for the transmission performance of a given overall circuit. The problem now before the C.C.I.F. is the allocation of the allowable contribution made by the national and international portion of the European network to the overall limits which are finally established. This is by no means a simple problem, especially when the great variation in local conditions, both physical and economic, within the various independent operating units, and the engineering practices which have been developed to cope with these conditions, are considered. To be successful and acceptable to all, such an allocation of transmission limits must be in a form which, *while guaranteeing the meeting of all transmission requirements on every connection put up, will impose no unnecessary restrictions and will allow the greatest possible latitude in the design of plant within any administration's area.*

The attempt to allocate the various transmission limits, many of which are very closely interrelated, without first having some fundamental switching plan as a basis to which all solutions will be referred, will inevitably result either in arbitrary and possibly unfair allocations or in a complication of the problem which may well make the attempt futile. A fundamental switching plan logically arrived at and based primarily on the individual requirements of the separate administrations will, however, provide a safeguard against such errors or complication in the study. In the first place, by referring each portion of the transmission study to this plan, the interrelation of the various factors will be brought to the front. In the second place, such a plan will provide a very valuable correlation between the field of laboratory experimentation and that of practical application. Many of the problems now before the C.C.I. for study such as, for instance, the allocation of echo contribution between the various parts of the overall connection, are extremely complicated and the final solution will, for reasons of practical application, have to be in the nature of a compromise or approximation. By referring each solution to the general plan, the relative bearing of each limit under discussion to actual plant design and consequently the importance of *theoretical accuracy* as compared with *practical approximation* can be made apparent to an extent not otherwise possible.

III. Fundamental Divisions of the European Toll Network

From the standpoint of design the European toll network must be considered as consisting of two main divisions:

(a) The intranational transmitting and receiving network made up of

(1) Subscribers' set and sub-loop,
(2) Toll switching trunk to toll center,
(3) Toll connection to the major international switching center.

(b) The major international network which by means of direct or built-up circuits interconnects the major international switching centers.

Such a circuit would be of the form shown in Fig. 1.

The terms "international" and "national" have been used in accordance with present practice but are somewhat unfortunate since they do not exactly define the part which a given circuit plays in the overall system. Fig. 2 partially illustrates this difficulty.

Let us take a group of major international centers such as that illustrated in Fig. 2. In this case it has been assumed that, because of geographical distribution, it is more economical to have two main international switching centers in one country (i.e., X and Y). Under such a layout the circuit group X-Y, although being entirely within a single country, partakes of the characteristics of an international circuit similar to DE or EF of the general circuit of Fig. 1 and, therefore, should be designed to the same standards. (The possible non-economy of a circuit group X-Z when X-Y and Y-Z are needed will be apparent to those who have dealt extensively with toll centering plans.) Such a discrepancy between definition and the actual use is, however, not serious. When, however, we come to a connection between subscriber w, and subscriber z, there may arise a type of connection in which the definition of intranational and international circuits may be decidedly misleading. Circuits of the wZ and zY types exist in large numbers and their establishment is perfectly sound[4]. Under such a scheme the route wXYz might very well prove more advantageous in every way than the connection, wWXYZz. We would, however, then have the anomaly of a connection in which the portion of the circuit which we have designated as "major international" is a strictly national circuit while the "national transmitting" and "national receiving" portions are in reality *international.* There is a further difficulty in designating the circuits wX and zY as international circuits in that if we do so we must design them in accord with the standards set for international links of the type D-E of Fig. 1 and thus force a grade of facility much higher than that required. Under the layout shown there is no fundamental difference between the part circuit wX plays and the part xX plays. xX is designed to meet the transmission requirements imposed by the established limits.

$x_t + xX = S_t$ = limit for national transmitting equivalent, and

$x_r + xX = S_r$ = limit for national receiving equivalent,

where x_t and x_r are the limiting transmitting and receiving losses respectively of the tributary area served by x;

wX is determined by a similar set of equations:

$$w_t + wX = S_t \text{ and } w_r + wX = S_r,$$

which are decidedly less severe than those for an international circuit as at present defined.

If therefore we are to foresee an establishment of limits which will allow the three ideals of Section I to be met, we must first define more specifically the part to be played by all types of circuit groups. The author would therefore suggest as a first step toward solving the problem of universal interconnection:

(a) that a standard connection be agreed upon whose parts will be defined in accordance with the part they play in the overall without reference to whether the circuit crosses international frontiers or not;

(b) that existing switching centers and circuit groups be classified in accordance with these definitions.

This is not as difficult a matter as it might seem. Each administration would have available

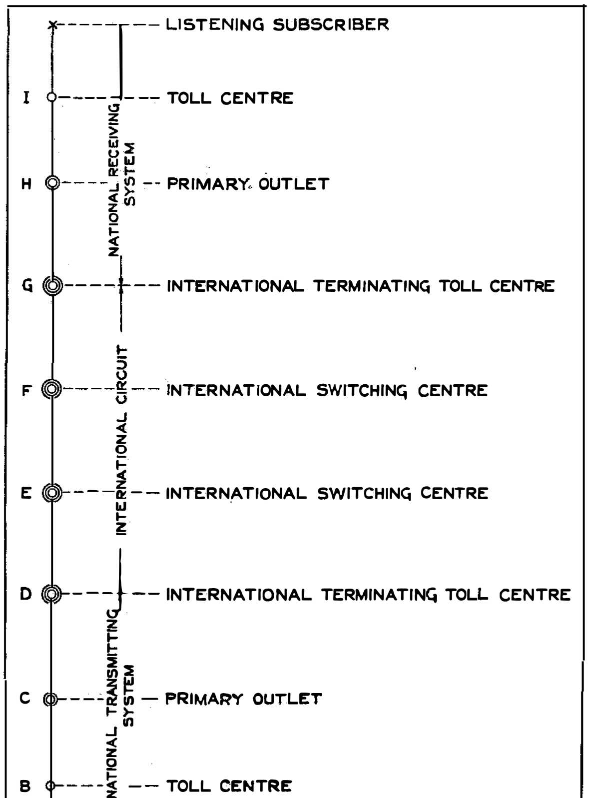


Figure 1—Present Standard Circuit for International Calls.

---

[4] For instance Cluj-Budapest, Cernauți-Lwow, Rusciuc-Bucarest, to give examples with which the author has had actually to deal.

its own intranational switching plan and from its routing books would be able in a short time to classify its centers and circuit groups. By taking this data from all administrations a small committee could very soon iron out the discrepancies and arrive at a general classification for all of Europe, giving the categories of all toll centers and classification of toll groups. All future circuits would be classified in the same way when established. The Rumanian contribution to such a joint study would be the Chart of Fig. 3.

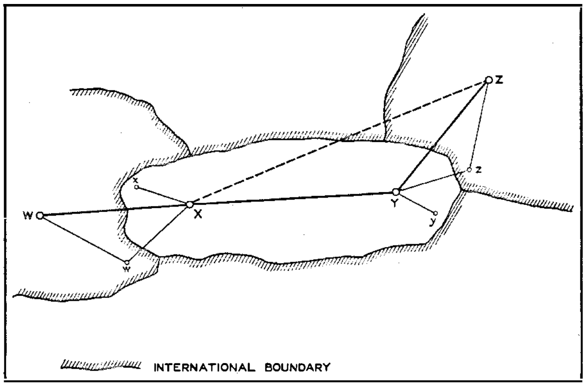


Figure 2—Schematic of a Group of Major International Centres.

IV. Control of Transmission Characteristics on International Connections

Having arrived at a standard classification of centers and circuits, the next step would be to investigate the method of controlling the transmission characteristics in such a way that:

(1) A satisfactory grade of service would be guaranteed on all connections.

(2) The greatest possible latitude would be allowed in designing circuit groups used both for international and intranational traffic.

IV-I. Transmission Factors to be Controlled

The transmission factors which must be kept under control if we are to guarantee universal interconnection come under two general classifications:

(a) Those factors which, regardless of their value—within certain practical limits—may be considered as contributing in a continuous manner to the effective transmission rating of the overall connection and may be considered as being subject to mutual compensation, i.e., an increase in one may be compensated for by a decrease in another.

(b) Those factors which, on the one hand, have specific and individual limits which cannot be exceeded without making the circuit inoperative but which, on the other hand, have no bearing on the effective rating of the connection when kept within these limiting values. Under this classification come echo, singing margin, and intelligible crosstalk.

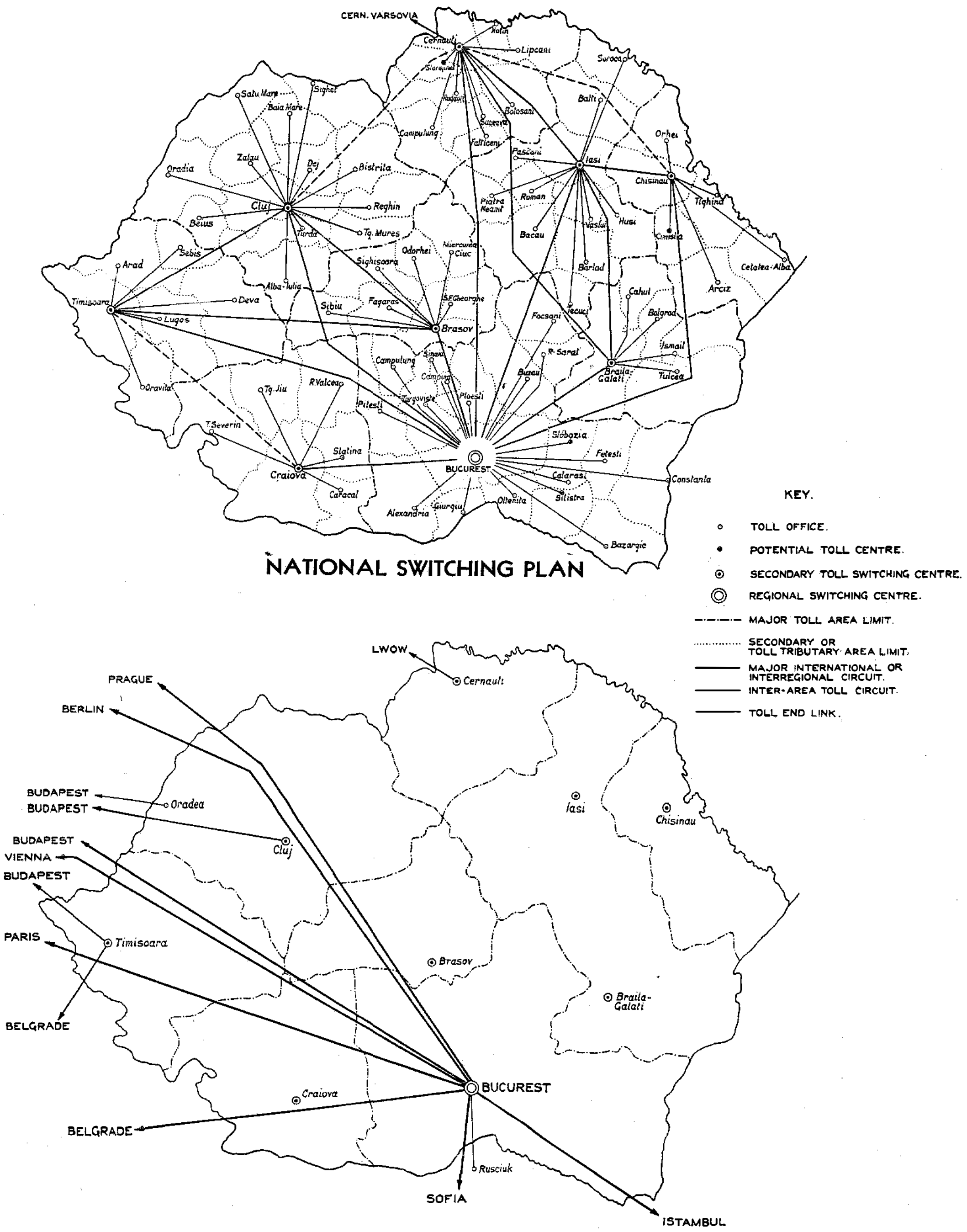
The main reason for making such a classification of the transmission factors is found when we consider the methods which must be followed in controlling them. The first group (i.e., those which contribute to the effective rating of the overall circuit) may be considered as inherent characteristics of each individual link, the corresponding overall result being arrived at by direct combination of the relative contribution of the individual parts[5]. The second group of factors, especially echo, which will be found to be a controlling influence on long built-up circuits, is not, theoretically, subject to such direct combination.

The overall volume attenuation, for instance, is obtained by adding directly the volume attenuation of each of the individual links making up the connection. The contribution of any given link to this overall value is a definite figure dependent on the electrical constants of that particular link and independent of the characteristics of the other links with which it is used. When we come to consider echo, however, this simple combination no longer holds. We may calculate the echo effect for each echo path in a given link. The contribution made by each of these echoes to the echo effect on a built-up connection, however, cannot be determined unless we know how much delay and attenuation are added to the echo path by the other links involved in the circuit. This contribution to the overall echo effect is not therefore an inherent characteristic of the individual circuit.

The control or limitation of this latter type of transmission phenomena must therefore be attacked in a manner entirely different from that followed in the case of transmission loss, noise, etc., the effects of which are determinable from the characteristic of the individual link itself.

---

[5] This is not, of course, strictly true of the transmission penalty resulting from cutoff frequency, a low cutoff in one section masking the effect of a higher cutoff in other links.



NATIONAL SWITCHING PLAN

INTERNATIONAL SWITCHING PLAN

Figure 3—National and International Switching Plan for Rumania.

IV-2. The Control of Effective Transmission

The control of effective transmission involves two main problems:

(a) The establishment of an acceptable overall performance standard and the development of a method of rating circuit performance which will allow all factors affecting subscriber satisfaction to be evaluated and combined to give for any combination of circuits the resulting subscriber-to-subscriber satisfaction.

(b) The assigning, to each portion of the standard international circuit, limits for effective performance such that any connection which is set up—provided of course it conforms to the accepted standard connection—will meet the accepted overall performance standard arrived at under (a) above.

The first part of this study is primarily a laboratory problem. Not only are the necessary investigations well outlined but, also, the work involved is well under way and a satisfactory solution can now be foreseen.

The second part, however, is directly concerned with the question of practical application, and a satisfactory solution will be possible only after a well defined toll switching plan for Europe with its standard connection has been arrived at and after a study has been made of what the author would propose to call the "inherent losses" of the portions of the network which are used both for intranational and international traffic. The type of study necessary is very similar in form to that outlined under section III of the paper on "Toll Plant Engineering" mentioned above, except in the degree in which the "inherent losses" of the various parts of the network can be varied.

Theoretically it would be possible, in arriving at a most economical type and form of plant for Europe as a whole, to pool all data concerning the European systems, and by a trial and error method arrive at a solution which would result in a minimum expenditure for the complete network in a way similar to that which is now followed in carrying out a loop and trunk study for an exchange area. In actual practice, however, such a study would be beyond the range of practicable accomplishment. Furthermore, there is the question of internal economy (i.e., within each individual operating organization) which must be considered. It cannot be expected that any administration or operating company will agree to any general upgrading of its own plant in order to make a saving in the plant of another administration, or even in its international circuits, even though that saving might be many times the additional cost of upgrading its own plant. In view of political divisions and internal economy, the European Fundamental Plan therefore must be attacked primarily from the following standpoint:

(a) What, *within each administration or operating company*, is the form of distribution which most economically meets the needs of its own *internal traffic* and how does this line up with the "standard international connection" mentioned above?

(b) With such a system of distribution in effect, what are the resulting electrical characteristics of the various parts and what does this mean in each national network with respect to the parts of the standard international connections used both for international and intranational traffic?

(c) What degree of uniformity is there in these inherent national losses? If there is a wide variation, to what extent can those which are out of line be brought into line by a revision of the centering plan rather than by expensive upgrading of plant?

(d) Taking the limiting cases, after a full study of (c) above has been made, and working toward the accepted overall limits, what margin is left for the major international network and what does this mean in type of circuit? Is such a circuit practicable? If not, to what degree must we limit the national networks so that the overall accepted standard can be met?

Such a study may seem exceedingly involved. However, unless some such study is carried out, will not any allocation of limits be mere arbitrary approximations? If we are to meet the requirements of "minimum grade of facilities" and arrive at limits to which the local operating engineer may carry out his design in order to obtain "minimum plant costs," such an analysis is essential.

In allocating effective transmission limits to the various parts of the standard connection, one point which should be mentioned is the desirability of having the limits expressed as a single performance rating rather than as an individual limit for each of the characteristics involved. The great variation in plant design practices, geographical distribution of centers, etc., in the various administrations throughout Europe is such that any attempt to specify anything other than effective performance, will greatly restrict the local engineers in their design of the intranational network. One of the advantages which should result from the present studies on effective transmission is the possibility of expressing the contribution made by all transmission characteristics in terms of their relative effect on overall performance. Since the final objective is also one of combined overall performance, there is no fundamental reason for restricting individual effects once we have a method of calculating their contribution to the final performance rating of the circuit.

IV-3. Control of Echo, Singing Margin, and Intelligible Crosstalk

As has been explained above, echo, singing margin, and intelligible crosstalk differ from the class of factors just discussed in such a manner that their control must be attacked from an entirely different angle than the factor contributing to the effective rating of the overall connection.

Let us assume for the moment that the effective transmission limits for the standard international connection have been arrived at as outlined in section IV-2. With such limits established and all toll centers and circuits classified in accordance with the part they play in the international network, the meeting of the overall standard of effective performance would be guaranteed. There still would remain, however, echo, crosstalk, and singing margin to be controlled since none of these is involved in any of the above standards.

As has already been explained, these three factors differ from those already considered in that they cannot be compensated for by varying other characteristics; and, especially in the case of echo, the contributions made by each link to the overall result are not subject to direct combination, and are not a direct function of the individual links. Theoretically, therefore, they could be controlled only by examining every type and length of built-up connection. This latter procedure is obviously impossible and some other procedure must be adopted even though this may involve slight approximations.

The most practicable method developed to date is to take as a basis the fact that for any given circuit or combination of circuits the amount of echo effect, the intelligible crosstalk, and the singing margin are each a function of the transmission loss at which the toll circuit portion of the circuit is worked. That is, there is a minimum transmission loss at which a circuit of given length and characteristics can be worked before the echo limit, say, is passed; and likewise for the singing margin and the crosstalk limits. It has been found that this relationship between length and transmission loss can, if properly made use of, provide a sound engineering basis for controlling the three factors under discussion, provided some fairly close idea can be obtained as to approximate ranges of attenuation lengths, etc., for the various parts of the standard connection.

There are numerous ways in which the so-called principle of minimum net losses can be used to limit echo, crosstalk, and singing on built-up connections. In all cases, however, these methods depend on the use of approximations which, within certain relatively restricted ranges, give results sufficiently accurate for engineering purposes. As an illustration of this point, we may employ the so-called net loss factor method by drawing a family of straight lines which, for each type of facility, coincide very closely with the actual curves of minimum net loss. Now it can be shown that if the built-up connections involve lengths of circuits falling in the range where the straight line giving the net loss factor for a given type of facility coincides with the actual curve of minimum net loss, the results obtained by the very simple and straightforward net loss factor method coincide very closely with the results obtained by the elaborate and laborious method of setting up each connection and analysing it for echo, crosstalk, and singing margin. Outside of this range the method begins to break down. The successful application of this method, therefore, depends upon a knowledge of the range in which the various types of facilities may, for other considerations, find application. This knowledge can be obtained only by having available a well defined switching plan in which not only the part played by each link is well defined, but also the possible ranges of transmission loss, the types of facilities, etc., are known. With these data available it will be possible to proceed with the establishment of limiting values of attenuation for various types of facilities when used in specific parts of the standard connection in such a way that echo, crosstalk, and singing margin limits will not be exceeded.

V. Final Form of Proposed European Fundamental Plan

As the first and basic step toward meeting the three requirements of:

1. Minimum number of circuits for a given service;
2. Minimum grade of facilities throughout the system consistent with the demands of satisfactory service;
3. Minimum plant costs for the facilities provided;

a tentative European Fundamental Plan should be prepared along the lines outlined. It should provide:

(a) A specific classification of toll centers and toll circuits in accordance with their actual use in both internal and international service;

(b) Specific limits in terms of effective transmission for each type or classification of toll circuit, such limits being established after a full study of the inherent characteristics of the various national networks and so chosen as to give the greatest possible freedom in the design of the national portions of the network;

(c) A limit for minimum allowable losses for various types of facilities when used in specific parts of the national and the international portions of the European network, such allowable losses being determined after a full study of the inherent characteristics of the various national networks.

With these three groups of basic data available, each administration could then proceed, both in the matter of utilizing existing plant and in providing new plant, to engineer its systems to meet the third requirement: minimum plant costs for the facilities demanded by service requirements.

All of the above may appear to be a rather ambitious program. However, subscribers throughout Europe are demanding that something be done to provide a reliable universal service. The time has come when a concerted and coordinated attack of the problem is required, and it is here that the C.C.I. in its joint study of the whole problem can be of the greatest help. To wait until theoretically accurate answers are provided to all questions is neither necessary nor desirable. A tentative working plan based on the procedure outlined above will not only be a decided step toward providing the public with the service it desires, but will aid very materially in smoothing out many complicated points and in deciding where the emphasis must be laid in future studies.

Radiotelephone System Employed for the Intercontinental Broadcast of the Thirty-Second International Eucharistic Congress*

By A. M. STEVENS

Technical Director, Compañía Internacional de Radio (Argentina)

THE radio system hook-up required for the Thirty-Second International Eucharistic Congress called not only for a guaranteed intercontinental distribution of the programs emanating from the Congress itself, but for the successful reception and distribution of a highly important feature originating more than 7,500 miles from the Congress audiences.

There is probably no more severe or exacting test that can be placed on the reliability and quality of a radio circuit than the requirement of satisfactory transmission and reception of broadcast programs intended either for rebroadcast or for dissemination to a large audience by means of public address systems. Certainly no part of the program was the cause of more thought and anxiety than the transmission and reception of the four-minute message and benediction of His Holiness, The Pope from the Vatican City radio station on Sunday, October 14, 1934.

The requirements throughout the Congress were as follows:

(1) International distribution and satisfactory reception of specified programs, usually of several hours duration.
(2) Daily communication between the Vatican and the Congress authorities in Buenos Aires.
(3) The satisfactory reception and general distribution of the Papal message on the closing day.
(4) The satisfactory rebroadcast from specified centers of definite portions of the Congressional programs.

Radio audiences in and around the large capitals of South America have become as critical and difficult to please, in the last few years, as those in any country where broadcasting has been under intensive development for many years. The grade of perfection reached in the broadcast field, and the fact that foreign reception of high quality short wave programs is no longer a novelty, render impossible the retransmission of a program sensibly inferior to that of a local studio.

While the international radio telephone channels have been brought to a high stage of reliability, and for ordinary commercial telephone purposes are more than adequate, the fact remains that two of the oldest "bugbears" of radio transmission, namely static and fading, still require consideration.

Years of operating practice over radio circuits varying from 1,000 to 15,000 kilometers has shown that a change in wavelength of a fraction of a meter, or the use of an entirely different path, means success or failure for the transmission. With these prime difficulties in mind, plans were laid early in June not only for multiple channels, but for multiple reception of the various channels.

The first circuit proposed was a direct one between the Vatican City station and the Buenos Aires station of the Compañía Internacional de Radio (Argentina). While the circuit was satisfactory for commercial telephony, it could not meet the requirements of broadcast working. An excellent direct circuit was soon made available, however, by the use of the radio equipment of the Compañía Internacional de Radio (España) at Madrid, this station acting as a repeater point for the Vatican and Buenos Aires transmitters. With this circuit assigned for use in transmission of the regular programs, experience had indicated the necessity of having other channels in reserve. Arrangements, therefore, were made not only with the British General Post

---

* For additional articles on the Thirty-Second International Eucharistic Congress, the reader is referred to the July, 1935 issue of *Electrical Communication:* "Transmitting the Program of the Thirty-Second International Eucharistic Congress," by Kenneth McKim, and "The Public Address System and Corollary Installations for the Thirty-Second International Eucharistic Congress," by Ricardo T. Mulleady and W. White.

Office for the use of the London terminal as a general distribution center for all of Europe, but with the German Reichspost for its Berlin terminal, to supply an auxiliary channel in case of unforeseen and unavoidable difficulties on the routes via Madrid or London. In the final hookup, therefore, not only three separate high quality high power short wave channels were available, operating simultaneously on different wavelengths, but also provision was made for the multiple reception of two of them at the Plátanos receiving station in the outskirts of Buenos Aires. By multiple reception, is meant the use of two or more high gain antennae feeding simultaneously one receiver of a special type, to be described at length hereinafter.

At the Hurlingham transmitting station and at the Cuyo central terminal, lines and repeater equipment were overhauled and equalized from 50 to 6,000 cycles, while all of the transmitters were realigned to give substantially similar overall characteristics.

For the provision of multiple reception at Plátanos, two new radio receivers, and three new double "V" universal antennae were provided. The latter were to supplement the two zigzag high gain "Bruce" arrays already in commercial use on the Berlin and Madrid circuits. The antenna constants were calculated to give the maximum gain, and to minimize fading by the use of proper tilt angles and by placing the antennae as high above the ground as possible. Masts with an overall length of 32 meters were employed, giving the antenna wires a net clearance of 29.6 meters above ground. A novel feature incorporated in these antennae was the use of a new type of aperiodic termination network at the receiving end. This network in combination with a simple 700 ohm resistance at the opposite end of the antenna gave practically constant gain over the entire range from 14 to 40 meters. On actual test runs, a small drop of approximately 1.5 db. was found at 20 meters. In one series of comparative test runs, the gain of these antennae was found to average 1.5 db. above the "Bruce" arrays.

The new terminating network or antenna coupling unit consists essentially of two overlapping impedance-transforming radio band pass filters designed to operate between the balanced horizontal double "V" or rhombic antenna and the transmission line. The radio frequency characteristic is essentially from 14 to 40 meters when this unit is used as a matching impedance between the 700 ohm rhombic antenna and the transmission line. The coupling units are provided with carbon block lightning arrestors and, in addition, the circuits are so arranged that the operator at the receiver can test the continuity and measure the resistance of the entire antenna.

The three rhombic antennae were built 8 wavelengths long for a frequency of 20,000 kc., or 4 wavelengths long at 10,000 kc. While it is desirable that antennae for use in multiple reception should be spaced not less than 10 wavelengths apart, a compromise between length of transmission lines and the physical dimensions of the antennae had to be made. If antennae 8 wavelengths long at 14 meters are spaced only 10 wavelengths, center to center, these antennae will overlap. If they are spaced 10 wavelengths apart at 30 meters, the transmission line losses become too high. A compromise layout was made in which the antennae were placed at the apexes of an isosceles triangle, and behind the two "Bruce" type antennae.

In practical operation it was later found that excellent results could be had in the way of fading reduction by using not only various combinations of the horizontal rhombic antennae, but by using them in combination with the vertical "Bruce" arrays. As special switching panels had been provided, quick changes of antenna combinations could be made with the two special receivers.

To cover completely the three incoming channels from Europe, a third monitoring receiver of the Standard type III model was used. By means of the switching panels provided for the transmission lines, the two multi-channel receivers could be quickly switched to cover any two of the incoming programs. All three channels were sent on into the central terminal in the Cuyo terminal station, which had been provided with a high quality amplifier and loud speaker with suitable baffle board for monitoring purposes. Similar monitoring equipment also had been provided in the Plátanos receiving building for checking all channels.

The special receivers designed to work with the arrays arranged in multiple on the various

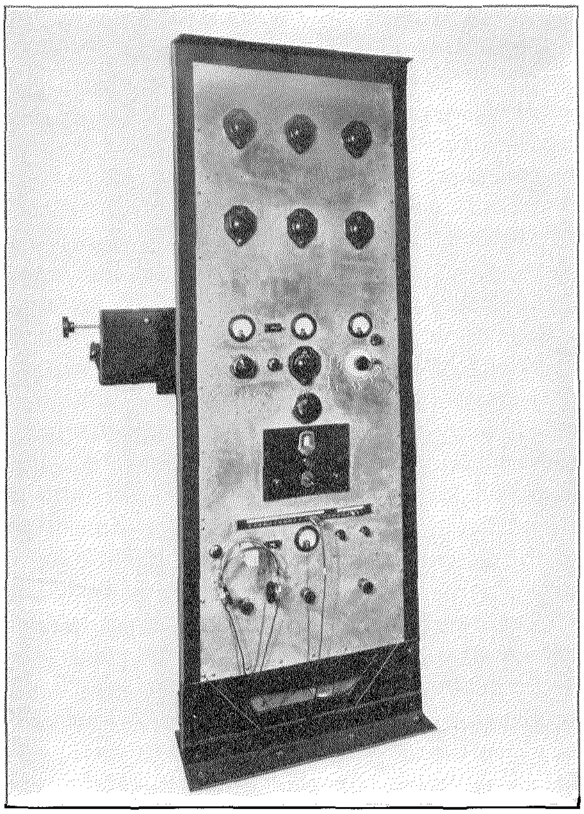


Figure 1—Diversity Receiver No. 1 Containing Three Antenna-Coupling Units. Crystal Controlled Beating Oscillator with Thermostatic Control shown on the Left of the Receiver.

channels are of the superheterodyne type, but differ materially from the receivers generally classed under this name. To provide the very highest quality, it was felt that the first beating oscillator should have the same degree of frequency stability as is maintained by the modern short wave transmitter. Crystal controlled electron coupled oscillators were provided and, to secure flexibility in tuning, the intermediate frequency amplifier was made variable over the usual intermediate broadcast range of from 1,500 to 550 kilocycles. This was done in order to facilitate construction. The electron coupled oscillator being rich in harmonics, permitted a single crystal to cover a wide range of frequencies when used in conjunction with the variable intermediate frequency amplifier. Each receiver was designed for use with from one to a maximum of three antennae.

The receivers are shown in Figs. 1 and 2. Fig. 1 shows the single bay receiver designed for use on the Berlin-Buenos Aires circuit, with the crystal oven attached to the left side of the bay. The upper dials, reading in pairs vertically, are for the tuning controls of the first radio frequency amplifier and the first detector circuits. The horizontal row of 3 milliammeters are for the crystal oscillator grid and plate circuit, the second detector plate circuits, and the automatic gain control circuit. The intermediate frequency tuning panel is in the center of the bay just above the jack field which, in conjunction with the ammeter just below, enables the operator to read all tube plate and filament currents. All tubes used are of the heater type, and the sets can be operated either by a-c. or d-c. filament supply. In order to reduce the inherent set noise to the minimum, however, both sets are operated from storage batteries operated on the charge-discharge system.

The action of the automatic gain controls of these receivers was checked by means of a well shielded radio frequency generator, which had a frequency range varying from 100 kc. to 25,000 kc., and an output voltage variable from .5 microvolt to 1 volt. The oscillator had a variable modulation unit capable of varying the percentage modulation of the output up to 90 per cent at a constant frequency of 400 cycles. The receiver gain control action was found to be capable of handling a variation of 40 db. in the input voltage, with approximately a 2 db. difference in the output level.

The three bay receiver (Fig. 2) is considerably more complicated than the single bay receiver, but has the advantage of being more flexible in operation.

As in the single bay set, each first detector is preceded by a single stage radio frequency amplifier but, in the three bay set, each first detector has an independent beating oscillator which enables using three separate variable intermediate frequency amplifiers. These amplifiers are mounted on the central bay, the various tuning and gain controls appearing in the center of the bay. At the right, the third bay contains, reading down from the top, indicator lamp bank, standard volume indicator panel, second detector plate meters, automatic gain control units and, just above the jack field, there is a duplicate set of high quality, high gain amplifiers which have a sufficient output level to enable the operator to feed the signal directly to the technical operator's position without the use of a repeater at the line terminal building. Both in the single bay and three bay receivers, the first radio frequency amplifier grid is controlled by the automatic gain control system, with the result that the output of the antenna having the highest signal level predominates in the audio output of the set. Experience showed that while fading and noise might be very noticeable in any one antenna, the output with two or three antennae was practically free of fading and noise. Either receiver, by means of special transmission line switching boxes, could be associated with any desired combination of antennae. It was found at times that the addition of a third antenna did not noticeably improve the output, while at other times the use of one or two vertical "Bruce" antennae with one of the rhombic antennae gave much better results than when using antennae all of the same type. Both receivers functioned extremely well, their operation being a large factor in the successful rebroadcast of the Eucharistic Congress programs.

The entire radio hook-up at Buenos Aires is shown schematically in Fig. 3, and corresponds exactly with the plan followed on the final day when every unit of the entire plant of the Compañía Internacional de Radio (Argentina) was needed to handle the various circuits. With the aid of the British General Post Office stations, and the very efficient cooperation of its staff of

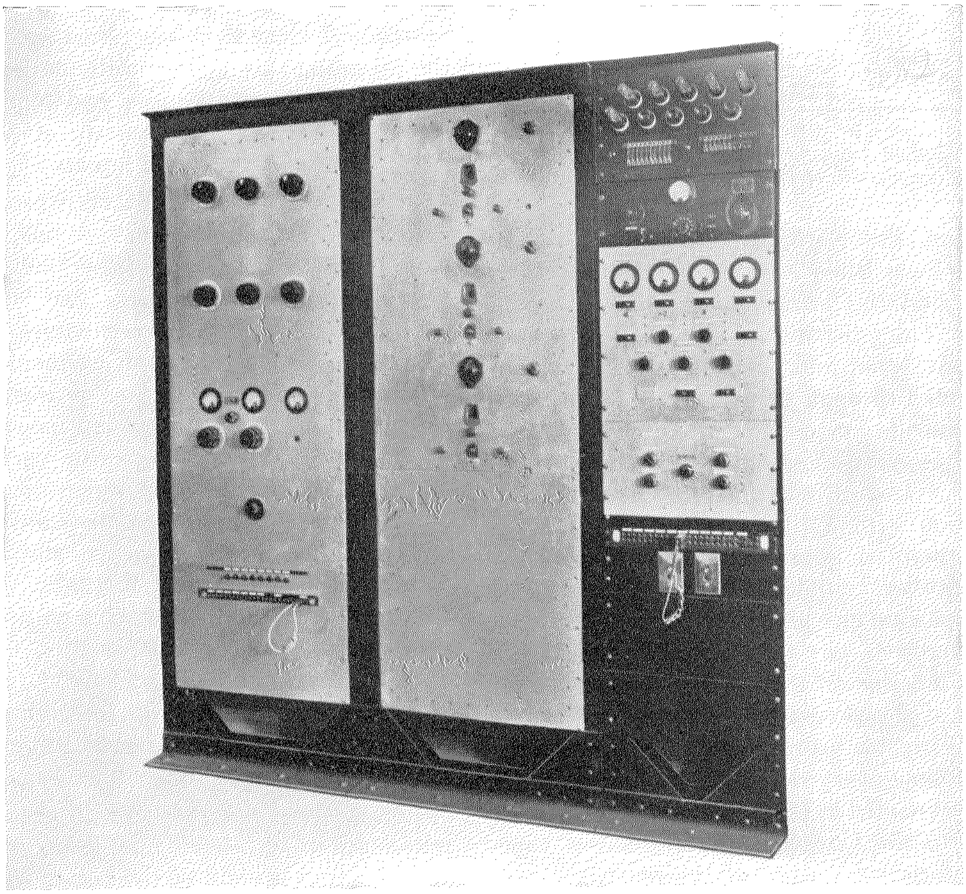


Figure 2—Diversity Receiver No. 2 of the Buenos Aires-London Circuit used during the International Eucharistic Congress.

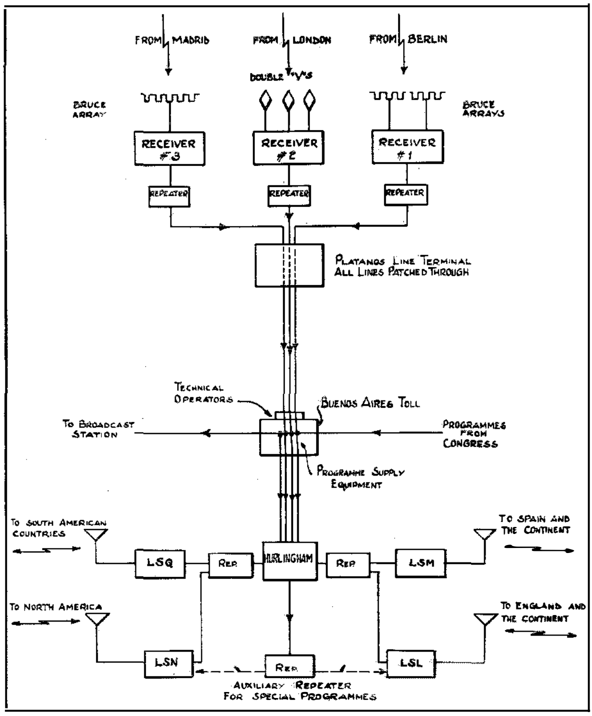


Figure 3—Block Diagram of Radio Plant Employed in Transmission of Eucharistic Programs.

technicians, the European distribution of the programs from Buenos Aires, with the exception of Spain and the Vatican, were made through London. The distribution of the programs throughout Spain and the relay to the Vatican were effected through the station at Madrid and the nationwide system of the Compañía Telefónica Nacional de España. For these circuits a type IV Standard 60-kilowatt transmitter, in conjunction with a Sterba high gain directive antenna pointed approximately on Paris, was used. Another Standard type IV transmitter with a high gain antenna directed on Madrid was used as an order wire circuit for London, Berlin, and Madrid, since it was impossible to interrupt the flow of the programs over the other transmitter. With this arrangement, the Vatican was able to follow every detail of the program as it was being enacted in Buenos Aires, and the Papal message to the Congress, therefore, was timed exactly since every word of the master of ceremonies was audible to His Holiness, The Pope.

With regard to the transmissions from Europe, all the three channels from the Vatican, namely, Madrid, Berlin, and London, were received at Plâtanos as previously described, and relayed to the Cuyo central, where the technical operators were able to choose the channel best suited for rebroadcasting.

Programs for the United States and Colombia were fed by the regular New York circuit transmitter. On many occasions, Lima and Bogotá were able to use this same channel, but to ensure reception in case the 14 meter channel failed, as well as to supply programs to Santiago (Chile) and Rio de Janeiro, the fourth transmitter, which is a type III Standard 20-kilowatt unit, was placed on 30 meters. As a matter of fact, many small cities, not only in the Argentine, but in Brazil as well, took advantage of this service and used it to supply small stations which in turn rebroadcast it to their local radio audiences on wavelengths between 200 to 450 meters.

Sixty-five different stations in the United States and Canada participated in distributing the programs; six had an antenna power rating of 50 kilowatts or over, five had 25 kilowatts or more, while there were twenty of 5 kilowatts. The others varied from 1 up to 3½ kilowatts.

In South America, with the exception of the Argentine, fifteen stations on medium wavelengths distributed the programs in Brazil, Colombia, Chile, Uruguay, and Peru, while International associated companies at Rio de Janeiro and Bogotá rebroadcast the programs on approximately 30 meters. In the Argentine, some nineteen stations using antenna powers varying from 1 to 60 kilowatts gave a very thorough coverage. In Europe, fifteen high power stations on long and medium waves distributed the programs, while the short wave stations of the Compañía Internacional de Radio (España) at Madrid and the Vatican station at Rome put the program out on 30 and 50 meters. Thus a total of at least one hundred and twenty-two different stations assisted in the wide dissemination of the many addresses and the choral singing throughout the Congress.

Fig. 4 shows not only the International System's radio and land line network in South America, but several of the non-system stations which were able to pick up the short wave channels and rebroadcast the programs to their local communities. Fig. 5 shows the European short wave radio stations and the land line network

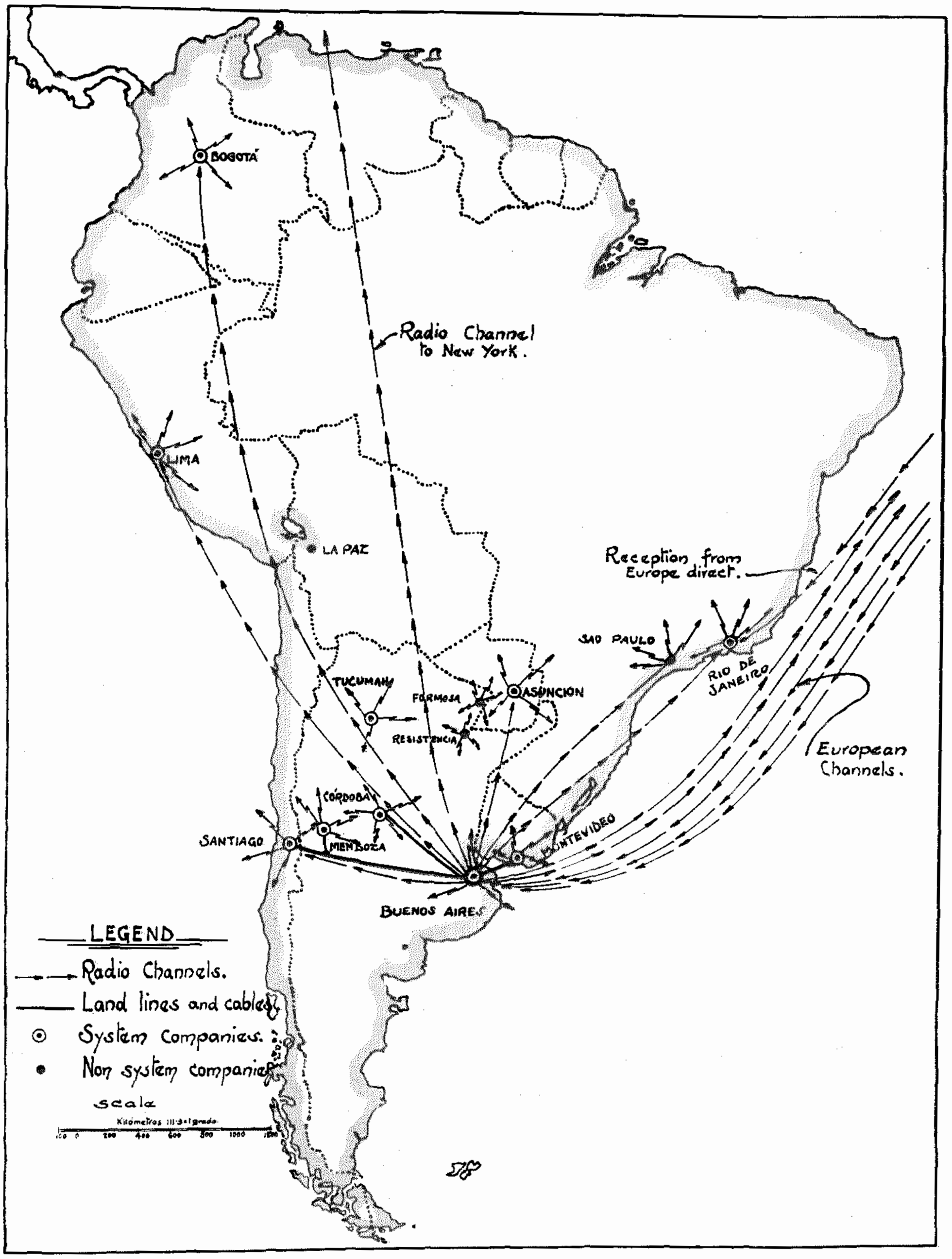


Figure 4—Distribution System of the International Telephone and Telegraph Corporation and Associated Companies in South America which Transmitted the Programs of the Thirty-Second International Eucharistic Congress.

employed in handling the programs destined to and emanating from the various European centers.

Reception and Retransmission Station HJY at Bogotá

The reception and the retransmission of the Eucharistic Congress program for listeners in Colombia was handled over the new short wave radio channel recently constructed by All America Cables, Inc., for the direct Bogotá-Buenos Aires telephone service. The receiving antenna used was of the double "V" or rhombic type

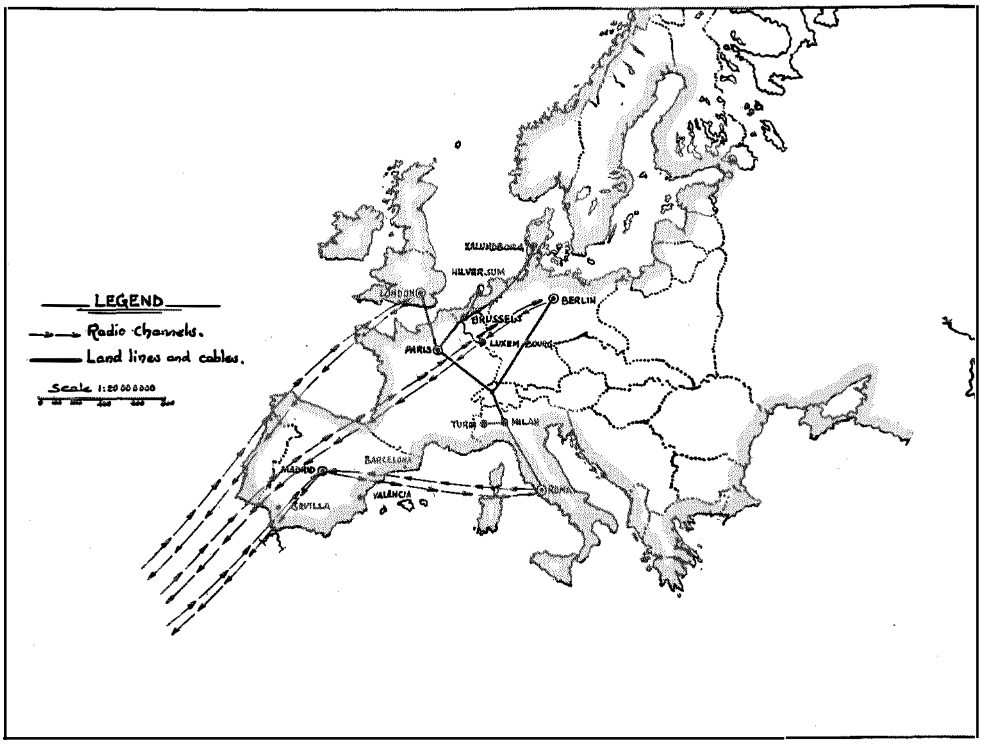


Figure 5—Land Lines and Radio Networks Employed in European Distribution of Programs Transmitted from the Thirty-Second International Eucharistic Congress.

directed on Buenos Aires. It was equipped with the latest type of terminating networks, which will pass any frequency from 20,000 to 7,500 kilocycles (15 to 40 meters), at the same time rendering the antenna highly directional and free of a large percentage of the interference usually encountered on short waves. The terminating network at the receiving end of the antenna is really a band pass impedance matching filter which matches the 700 ohm impedance of the antenna to the 70 ohm low impedance transmission lines.

By means of transmission lines the signals from the antenna are fed directly into a Standard Electric type III commercial receiver using the usual superheterodyne or double detection type of circuit. A two-stage radio frequency amplifier precedes the first detector, the latter being followed by a high gain intermediate frequency amplifier and a second detector whose input voltage is limited by an automatic gain control circuit which regulates the bias of several preceding radio frequency stages. The audio frequency output is controllable by a 40 db. adjustable attenuator.

Since the transmitting and receiving equipment is located on the same site and only 500 meters apart, the terminal equipment was placed in the transmitting building to simplify the installation. From the technical operator's position in the transmitting building the programs were sent to the control turret of the transmitter to be rebroadcast on a frequency of 9,930 kc. (HJY, 30.2 meters) and at the same time relayed to the All America Cables office in Bogotá for distribution to the long wave stations HKF on 1,050 kc. (285 meters) and HJ3ABH on 1,005 kc. (298.1 meters).

An interesting feature of the program distribution in Colombia was the rebroadcasting by a radio station in Barranquilla and by another in Manizales. The owners of these stations picked up the short wave signals from HJY with short wave receivers and supplied the programs to their stations working on long waves. Thus these listeners received portions of the programs after they had been retransmitted three times. Including these two stations, Colombia was well served by four long wave and three short wave stations, two of which were the stations of the Compañía Internacional de Radio (Argentina).

Reception and Retransmission in Chile

The transmissions of the Eucharistic Congress were received at Santiago (Chile) over two radio channels from Buenos Aires; one on 10,300 kc. (LSQ) and the other on 14,530 kc. (LSN), and over the International land line. Reception on both channels was generally satisfactory, but availability of the land line during the broadcasts proved a further safeguard for a proper circuit at all times.

These transmissions were sent to the local broadcast station "La Chilena Consolidada," which extended the connection via the lines of the Compañía de Teléfonos de Chile to its station in Valparaiso, and also to another station in Santiago, "El Diario Ilustrado." The transmitting station of the Cia. International de Radio, CEC, was only put on the air on October 14th for the Pontifical message, in order to give Lima and Bogotá another source of radiation apart from Buenos Aires.

The following is a description of the equipment used in connection with the above transmissions:

Receiving Station—Pudahuel

Location—25 km. west of Santiago.

Connection—Three open wire circuits, two of which are equalized up to 6,000 cycles, of 102 mils copper.

Equipment—Two type III Standard Electric superheterodyne receivers and one National type AGS superheterodyne receiver. No directive antennae were available for Buenos Aires; an inverted L antenna was used.

Transmitting Station—La Granja

Location—15 km. south of Santiago.

Connection—Two open wire circuits equalized

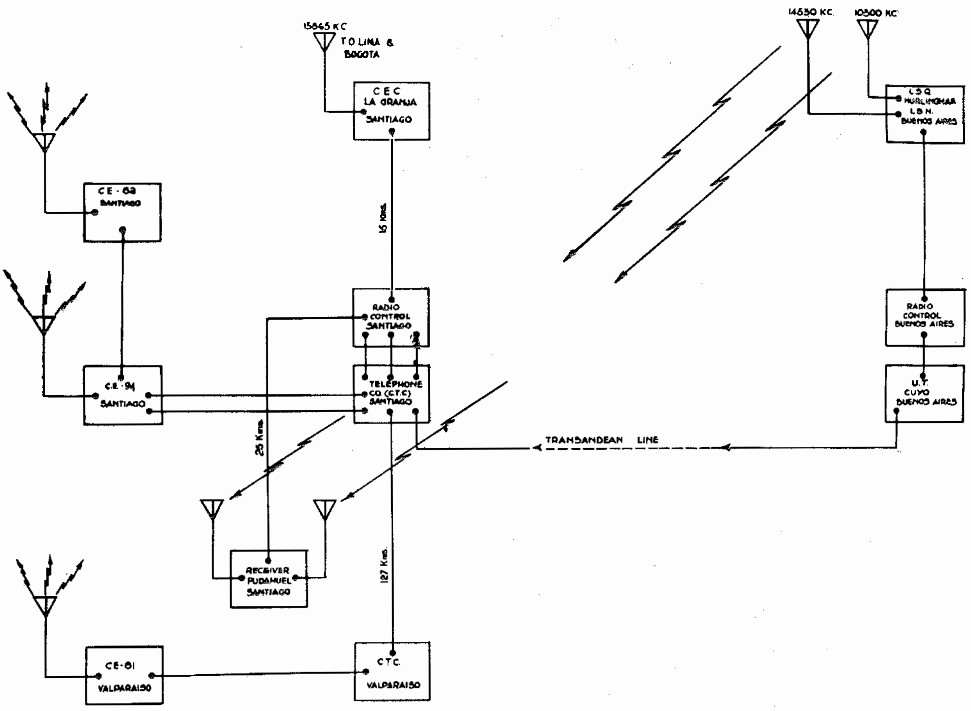


Figure 6—Schematic of Connections for Transmissions and Rebroadcasting in Chile.

to 6,000 cycles, of 102 mils copper, and two underground and overhead cable order wires.

Equipment—A Standard Electric type III transmitter with crystal control and water cooled tubes. The last stage is a 30 kw. amplifier (2-15 kw. tubes), but only the intermediate amplifier (2 kw.) was used on this occasion as it proved to be adequate for Lima and Bogotá on previous tests. A directive Diamond type antenna pointed on Lima, tuned to 15,865 kc. was used.

Control Center—Santiago

Equipment—The equipment consists of repeaters, power amplifiers, loss and gain controls, volume indicators, etc., manufactured by Standard Telephones and Cables, Ltd., London.

This office acted as the feeding and control center for the local broadcasting stations.

All connections between the control center and the local broadcast stations in Santiago were by underground cable. The connection to "La Chilena Consolidada" in Valparaiso was made over an equalized toll circuit of No. 12 copper, 127 km. long; and, in Valparaiso, by underground cable from the Telephone Company office to the local broadcast studio.

Fig. 6 shows schematically the connections that were made for transmissions and rebroadcasting in Chile.

Immediately following the close of the Congress, mail began coming in to the Compañía Internacional de Radio (Argentina) from numerous scattered points including Santo Domingo, Porto Rico, Bermuda, Australia, the Falkland Islands, Georgian Islands, Magallanes, East Africa, etc. These reports gave very high praise, not only to the program itself, but to the high field strengths and generally satisfactory technical character of the transmissions.

A Universal Differential Duplex Telegraph Set

By E. P. BANCROFT

Postal Telegraph-Cable Company, New York, N. Y.

THIS paper describes a new type of duplex telegraph set designed for universal use wherever duplexing apparatus is required in connection with the operation of grounded telegraph circuits.

Long direct current grounded telegraph circuits are almost universally operated on a duplex basis. The equipment developed for this purpose heretofore has been largely of two general types:

(1) Terminal Sets—Duplexing apparatus used at the ends of the circuits.
(2) Repeater Sets—Apparatus used at places between terminals for repeating and amplifying the signals.

It is not unusual to find that stations normally operating as repeaters are temporarily required to function as terminal stations or that terminal stations are required to operate as repeaters. To avoid the necessity of installing additional sets which would be used at infrequent intervals, most telegraph administrations have devised a third type of set generally referred to as a universal set. Such sets are designed so that either by the operation of a few switches, or by the substitution of one group of apparatus for another through the use of adapter plates or the like, they can be arranged for either terminal or repeater operation. That the universal set has not found more general application has been due to the fact that flexibility has been obtained at the expense of increased complexity and cost.

The advantages to any telegraph administration of a single all purpose duplex set are many. Equipment, installation, and operating problems are greatly simplified while operating room space and the amount of spare equipment required to meet emergency and unusual conditions are reduced. These advantages prompted the design of the universal duplex set described herein. It meets modern requirements as to simplicity, flexibility, and cost, and is intended for use at both repeater and terminal stations on all types of grounded telegraph circuits where either duplex or half duplex operation is desired. It is equally well suited for use on circuits used only for telegraph purposes or on circuits derived from telephone circuits either by simplexing or compositing. Furthermore, the set will repeat telegraph signals with exceptional fidelity at all speeds up to the highest frequencies attained with modern printing telegraph equipment.

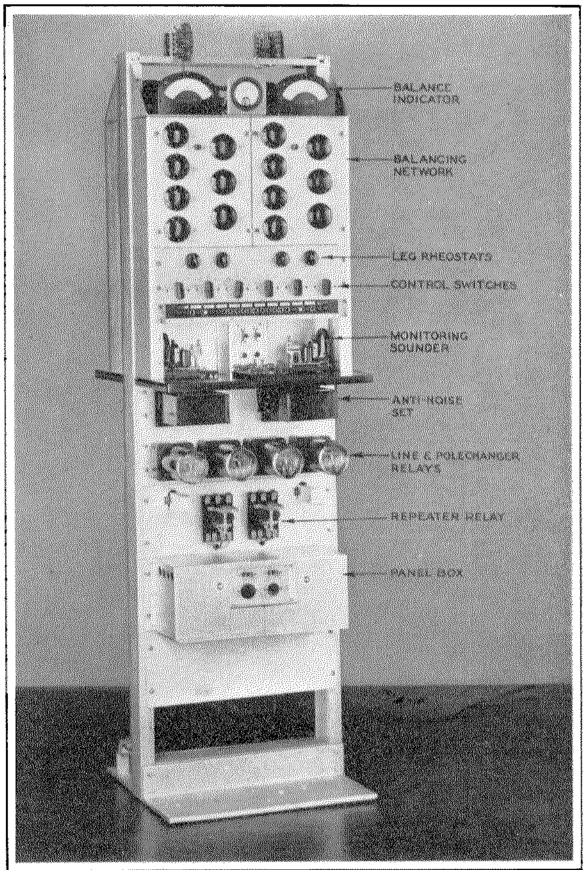


Figure 1—Universal Differential Duplex Telegraph Set.

To those familiar with duplex equipment, it will be evident from reference to Fig. 1 that the arrangement of the apparatus in the new set represents a radical departure from existing practice. The older type of repeater racks with the open shelf or superstructure has been replaced by a compact, neat appearing metal framework requiring a minimum of floor space. Each rack or framework carries four duplex sets and occupies an area 20 inches by 24 inches or approximately 7/8 of a square foot per set. When aisle space is included, an allowance of 4 square feet per set will be found to provide ample working space. The racks are 6 feet 3 inches high and are provided with a cable run along the top as well as a shield for protecting the wiring from dust and dirt.

The design is particularly adapted to modern manufacturing and installation methods in that the equipment may be assembled and wired in the factory and then be shipped as a unit. In this case the installation work consists only in locating the units in the office and making a few external connections to the set at terminals already provided. Installation costs are thereby reduced to a minimum.

The four sets mounted on each rack are arranged with two sets on the side facing the observer, as may be seen in Fig. 1, and two on the reverse side. The two sets on each face of the rack are located one on either side of a vertical center line so that each piece of apparatus may be readily associated with its related units.

All parts such as switches, rheostats, jacks, etc., that are used or require manipulation during the normal lining up, adjusting, and operation of the set are conveniently located above the shelf. The balance indicating meters are located near the top of the rack with their scales approximately 5 feet 7 inches from the floor. Monitoring sounders, one for each set, are located in recesses which serve as resonators. The shelf supports the sounders and the single pole changer telegraph key, which may be associated with either set at will. At the same time, the shelf provides a convenient writing space for making records, etc.

Hand formed cables—one for the equipment on each face of the rack—connect the various units of equipment to each other and to the terminal strip located at the top of the rack. These cables are placed in the space between the two faces of the rack and are formed so that when any unit or panel is loosened from the rack it may be pulled forward for inspection or other purpose without disconnecting the leads thereto or injuring the cables. This construction gives excellent protection to the cables; and also, since the cables are effectively enclosed, facilitates the addition of heating units to protect against moisture effects in humid climates. Local power is brought to the set through a conduit foot rail along the base of the rack on each side.

The arrangement of the more important elements of the sets on the rack is clearly indicated in Fig. 1. A brief description of the individual units that have made possible the compact assembly and neat appearance, nevertheless, may be of interest. The most important contributions to the general design are the balancing networks or artificial lines, the control switches, and the panel box.

The balancing networks are of a new type and combine into one assembly apparatus that has heretofore consisted of several individual parts not adapted to panel mounting and occupying more than double the space of these new units. Figs. 2 and 3 show their internal construction in

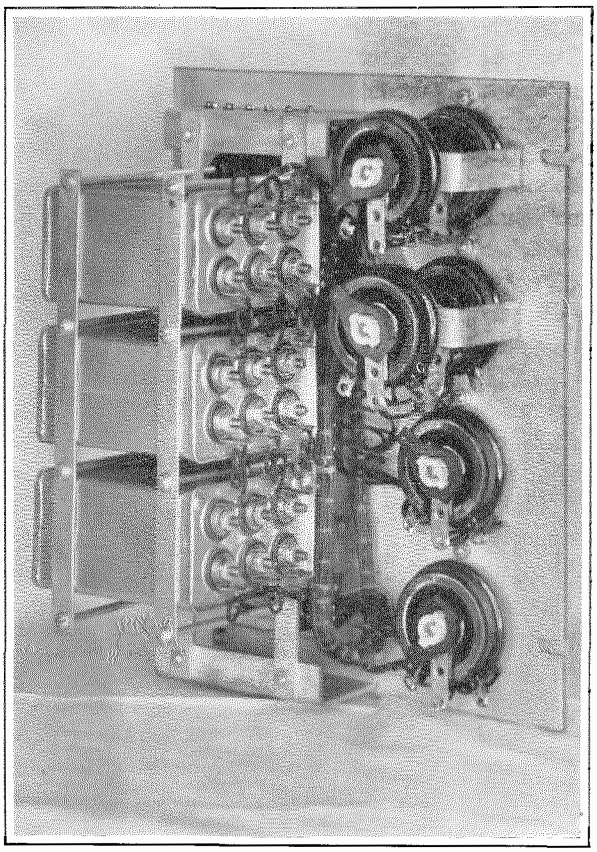


Figure 2—Balancing Network (Rear View) Showing Rheostats and Condensers.

detail. The rheostats shown in Fig. 2 are of the continuously adjustable or slide wire type and are controlled by the four dials on the left side of the front of the unit. The condensers, three in number, are of the multiple unit type. The switches for connecting the individual units of each condenser in the desired combination are shown in some detail in Fig. 3. Each condenser can be adjusted to any desired capacity from 0 to 2⅞µf. in steps of ⅛ µf. by setting its control dial at the desired point. The condenser dials are the three at the right of each unit on the face of the balancing network (see Fig. 1). The entire balancing network, including the line current control rheostats, occupies a space 9½ inches wide by 12¼ inches high by 6¼ inches deep.

The control switches shown directly above the jack strip are of the multiple position gang type, that is, each switch provides for the simultaneous control of a multiplicity of independent circuits. As an example, the "Leg" switch is the equivalent of nine individual five position switches. They are of a commercial type and are compact, reliable, and inexpensive. Three such switches are used in each set and control respectively the "Line," "Local," or "Leg" and "Monitoring" circuits.

The "Line" switch provides means for grounding the line for balancing purposes, for disconnecting the line battery, and grounding the line when the set is idle, and for reversing either the line relay or the line battery to permit a non-polar non-duplex station to be connected in series with the line between two terminals. This latter method of operation provides means whereby the intermediate station may communicate with both terminals and is usually referred to as "Upset Working."

The "Leg" switch provides for arranging the set for terminal duplex operation (Fig. 4), half duplex or reversed half duplex operation, repeater operation (Fig. 5), and for an off-position. The reversed half duplex operation is provided so that two half duplex sets may be operated as a half duplex repeater.

The Monitor switch provides for connecting the single telegraph key provided with each two sets into the receiving or sending leg circuits of either set. By properly manipulating the monitoring switch the repeater attendant may talk either to the receiving operator in series with the receiving leg or with the set cut off, or to the distant station in series with the sending leg or with the sending leg held closed.

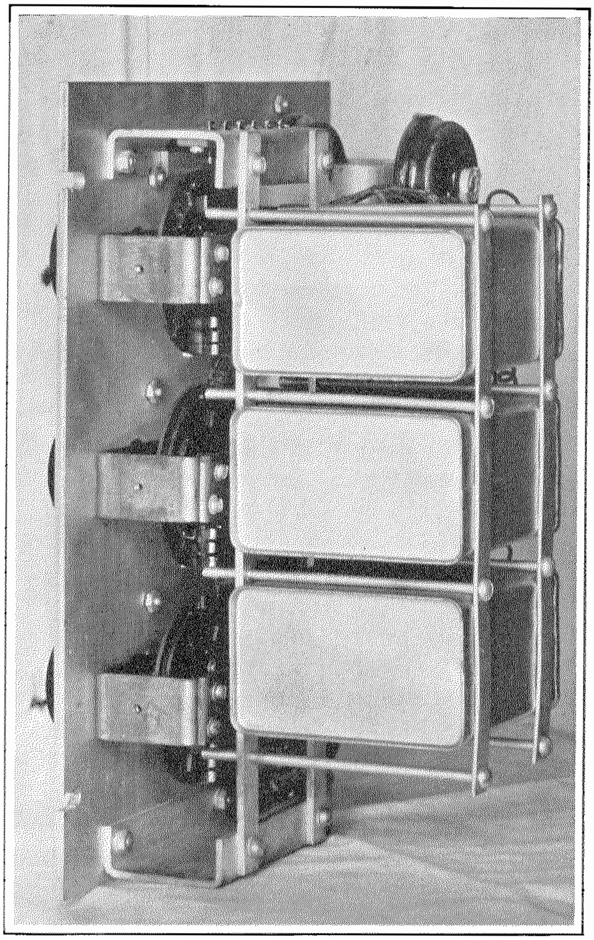


Figure 3—Balancing Network (Rear View) Showing the Condenser Switches.

One other element in the mechanical design that may be of interest is the panel box in which the current limiting resistances, power switches, and fuses are mounted. All the apparatus is mounted on a main panel or on structures attached to the main panel. The cover, which has doors that may be opened to inspect and replace fuses, etc., is fastened to the main panel by three screws at either end and can be easily removed when necessary.

The space below the panel box is reserved for mounting protective resistances for the line potentials, fuses, and switches or rectifiers for supplying line and local potentials in locations where only alternating current is available, or for mounting composite balancing equipment when required. When a number of these racks are installed in one office this space is left vacant and a separate rack is provided for mounting the line battery resistances, fuses, switches, etc.

While the development and use of newer and simpler types of apparatus have contributed largely to the neatness and compactness of the design, the final result could not have been attained were it not for the fact that the circuits used have been greatly simplified.

Figs. 4 and 5 show in simple schematic form the circuits used when the sets are arranged for terminal and for repeater operation, respectively. The change from the arrangement of Fig. 4 to that of Fig. 5 is accomplished by the operation of a single switch (the Leg switch) on each of two sets and by interconnecting the receiving leg of each set to the sending leg of the other by means of cords and plugs through jacks provided in the jack strip for the purpose.

Referring to Fig. 4, one of the most interesting features is thought to be the use of a neutral relay (repeater relay) provided with make-before-break contacts for repeating the received signals into the receiving leg. The relay is provided with two windings. One of the windings carries a biasing current equivalent to the normal operating current used in the other winding. The armature spring is adjusted so that the relay will remain either in the operated or released position when no current flows in the operating winding. The operating winding is supplied with polar signals from the contacts of the main line relay and the relay functions like a polar relay. Current from the spacing contact of the line relay neutralizes the biasing current and permits the spring to retract the armature, while current from the marking contact aids the biasing current and operates the armature. By using this method of operation faithful repetition of the received signals is accomplished and the usual tendency of the neutral relay to add a spacing bias is eliminated.

This same relay functions as the half duplex relay when the set is operated half duplex. For this condition the switch shown in Fig. 4 is moved to the left and the receiving leg is connected through the front contacts of the repeater relay, the switch, a winding of the pole changer relay to battery. At the same time ground is connected through a resistance to the back contact of the repeater relay. Signals received by the line relay operate the repeater relay to open and close the receiving leg. The pole changer

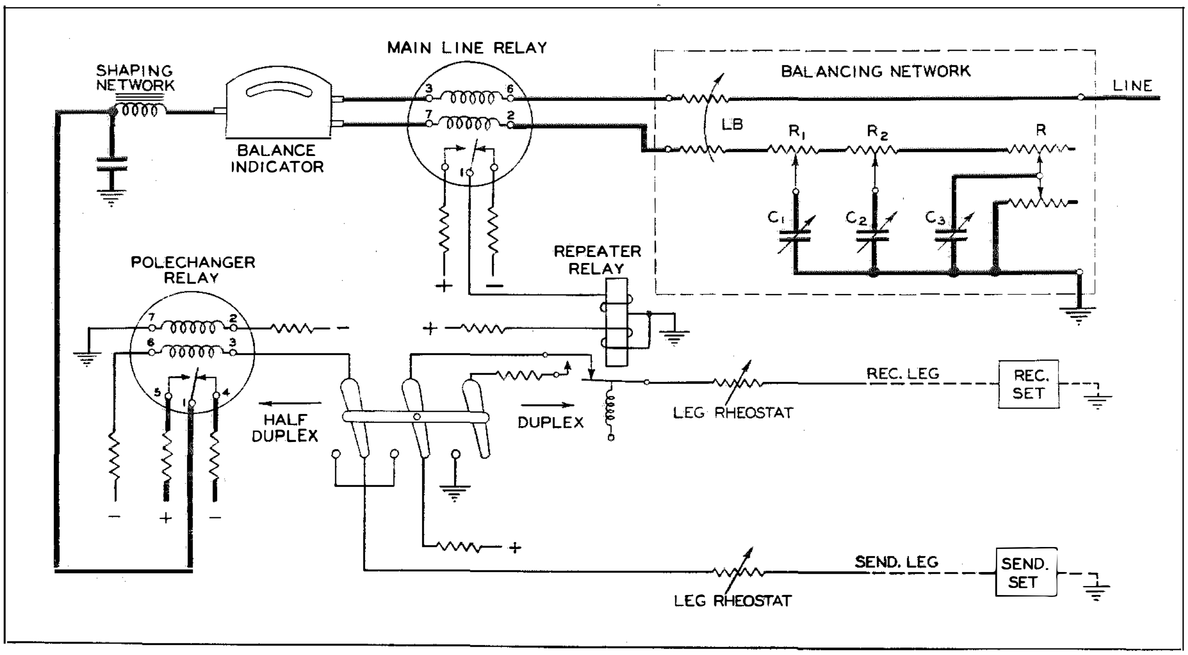


Figure 4—Differential Duplex Terminal Set Schematic.

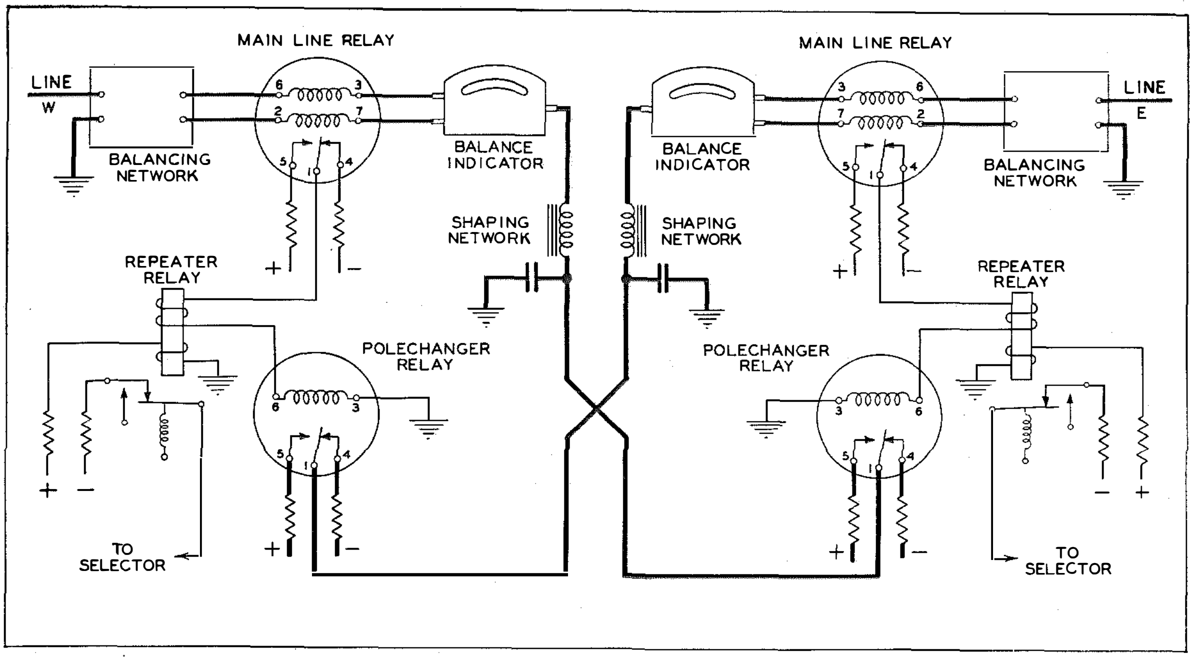


Figure 5—Differential Duplex Repeater Schematic.

relay is maintained operated through the closing of the ground connection at the back contact of the repeater relay before the leg circuit is broken at the front contact. Opening and closing the leg circuit at the receiving set operates the pole changer to transmit the signals to the line without in any way affecting the repeating relay.

The particular neutral relay used for this purpose is a high speed relay capable of operating efficiently at frequencies as high as 90 cycles per second or 180 bauds. At a signalling speed of 60 cycles the contact efficiency of this relay is as high as 98 per cent when operated on polar signals having a strength of 30 milliamperes through one winding and a biasing current of 60 milliamperes through the other.

The line and pole changer (transmitting) relays are of a modified Wheatstone type which produce signals practically free from chatter and which have a contact efficiency of about 90 per cent at a speed of 60 cycles and an operating current of 30 milliamperes through one winding. Other types of modern polar relays can be readily substituted for those shown where such a substitution appears desirable.

The circuits for the balancing network are shown in the upper right-hand corner of Fig. 4. The three section artificial line there shown differs from the usual type of line in a number of respects. The condenser timing resistances R_1 and R_2 are potentiometers rather than ordinary adjustable rheostats and are used as a fixed pad ahead of the adjustable balancing resistance R, thereby protecting the latter against excessive currents. The resistance R consists of two continuously adjustable slide wire rheostats coupled together and controlled by a single dial. The first and second balancing condensers C_1 and C_2 are connected respectively to the potentiometers R_1 and R_2 while the third balancing condenser is connected to the circuit at the junction of the two sections of the adjustable resistance R. The timing resistance for the third condenser is thus automatically set according to the electrical length of the line over which the equipment is operating. The twin adjustable resistances LB consist of two slide wire rheostats coupled to a single shaft and dial and are used for the purpose of controlling the magnitude of the line current. The reaction of field operating personnel to this balancing network is that the balancing operations are simplified, and that better balances are obtained and in less time than with other types with which they are familiar.

Fig. 5 needs no particular description since it is the simple type of high speed repeater familiar to all telegraph engineers. However, it should be noted that for each half of the repeater the same three relays used in the terminal set are to be found. It is this feature of the design, namely, the use of the same parts for all conditions of operation, that has contributed so largely to the simplicity of the equipment. In Fig. 5 the repeater relay is used for monitoring purposes and to operate a selector or other calling-in signal devices.

The service trials of this equipment, both as repeaters and as terminal sets under widely varying conditions, have been entirely satisfactory and it is now proposed to standardize this apparatus for use in new installations at either repeater or terminal stations throughout the Postal Telegraph-Cable Company's plant.

Aluminium Die Castings and Their Field of Usefulness in the Telephone Industry

By FRANÇOIS VAN LAETHEM

Bell Telephone Manufacturing Company, Antwerp, Belgium

Die casting methods as applied in the production of telephone apparatus are presented in this paper. The process of aluminium die casting and alloys used are briefly described and illustrations are given of representative die cast parts.

IN THE manufacture of telephone apparatus and its accessories, the urge to reduce labour cost has been very strong. Each part entering into the production of modern telephone apparatus, particularly apparatus for automatic exchanges, has been analysed and reanalysed to determine the method of producing it at the lowest possible cost. The result is that at present each part for its purpose is an example of the survival of the fittest, regardless of whether it is a screw machine made part, a punching or plastic moulding, an electric spot or arc welded frame or a die casting.

The die casting process is a comparatively recent development. It consists in forcing molten metal into a metallic die, especially built for each type of part.

The molten metal fills perfectly all the cavities and impressions of the die and surrounds the steel cores. The number of cores may be multiplied when the parts to be cast are of increasingly intricate shape. In comparison with parts obtained by other manufacturing processes, such as common foundry, punching, etc., the introduction of die cast parts results in an important saving in machining.

If the casting die has been built with great accuracy and has been designed so that it is not affected by pressure and heat, the parts produced will be accurate and interchangeable. An important saving can then be realised in dispensing with the otherwise required fixtures, jigs, tools, and gauges. Not only does the adoption of die cast parts reduce the number of manufacturing operations but, where mass production is involved, die casting is particularly adapted to the requirements of pleasing form, facility in assembly, and quick production with the minimum number of operations.

Die castings are taking, and probably will continue to take, an increasingly important place in telephone manufacture. The equipment for their production has undergone important improvements during the past few years; die casting alloys are produced with remarkable strength; and the possibilities of use of die cast parts have become unlimited for this industry.

In the factory of the Bell Telephone Manufacturing Company, Antwerp, aluminium base alloys are used exclusively at present. Recently, considerable progress has been made in the zinc die casting process. New zinc alloys, coupled with refined alloying procedures and the use of pure metals, should result in stronger, denser castings, which are stable and not subject to disintegration.

A modern aluminium die casting machine is illustrated in Fig. 1. Several of these machines are in use by the Bell Telephone Manufacturing Company at Antwerp. Fig. 2 shows a section of the machine. The metal is melted in a cast-iron, gas heated crucible (C), in which a gooseneck (B) is held by means of trunnions (S) about which it can oscillate. The gooseneck is provided with an injecting nozzle (D), and a rear filling nozzle (F); it is closed with a top cover. This cover carries the high pressure air inlet pipe (R).

To fill the gooseneck with metal, the filling nozzle end (F) is submerged in the molten metal, by means of an operating lever (H). When full, it is raised again by the operating lever, the rear nozzle being locked against a cone shaped stop (A) forming a seal. At the same time, the injecting nozzle (D) is brought into line with a collar (E) having a tapered sprue hole provided in the furnace side die mounting plate. This collar is water cooled. The press part of the machine is attached to the furnace, making a unit. Both die plates (M) and (N) are movable on the guide bars (P) and at the commencement of the

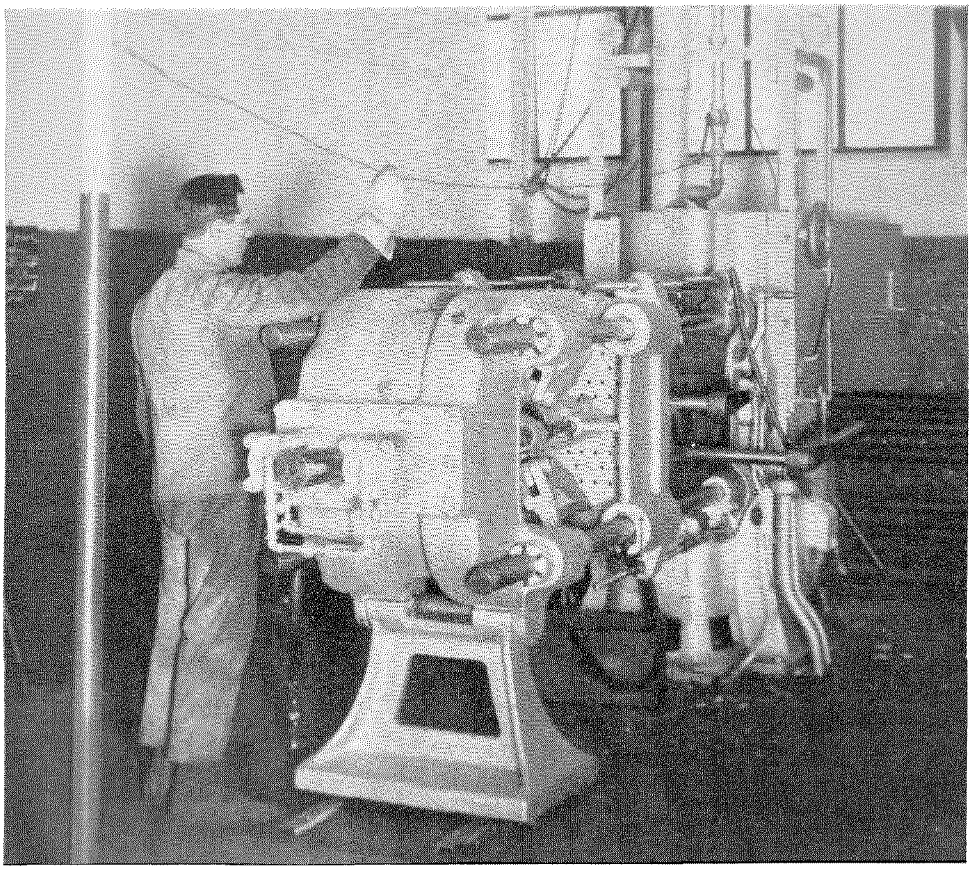


Figure 1—Aluminium Die Casting Machine.

backward movement, they move together with the die still closed between them.

The travel of the plate at the furnace end is arrested, after being moved far enough to break the sprue, between nozzle (D) and water cooled collar (E). The ejector side of the die and the back die plate are then carried on until the die is fully opened. The casting is always arranged so as to stay in the moving half of the die. The ejectors are fitted through the rear wall of the moving half of the die, and in casting position their ends are flush with the bottom of the impression. They are brought into use by means of a rack movement pushing the casting out of the die.

The die is operated by means of two hydraulic rams (z), the pressure being about 16 kg./cm^2.

The sequence of operations is relatively simple. The open die, mounted on a movable die carriage, is cleaned out with a jet of compressed air. The gooseneck is then placed in casting position, the die is closed, and the cores are moved in place. When the closed die has been pressed against the injecting nozzle, it is given a shot. This means that the air pressure is turned on, forcing the metal through the gate of the die until the die itself is completely filled. After the air pressure has been maintained for an appreciable interval, the pressure is turned off and the die withdrawn from the nozzle.

Because of the high melting point of aluminium alloys and their powerful solvent action on iron and steel, the dies are made from a special chrome vanadium steel. The quality and heat treatment of the steel used in the die, combined with periodic air cooling from a temperature exceeding the critical range and rehardening, contribute to the life of the die. Thermal and chemical influences of the molten aluminium, however, cause very small cracks to appear on the steel after 5,000 to 15,000 injections. These cracks occur mainly on the surface near the injection gate and at the spots changing the direction of flow of the metal injected. By periodically normalising the temperature of the die, further penetration of these cracks is retarded and, in fact, they may often be eliminated by a thorough repolishing of the die.

The origin of the cracks may be attributed to the molten metal which, when being injected, heats up the part of the mould in immediate contact with it to about its own injection temperature so that the steel of the mould expands. As soon as the part is ejected from the mould, the surface of the die cools off again. Since the inner part of the steel mould remains at a constant temperature, expansion and contraction occur continually on the skin part of the die only. These continuous and rapid changes create fatigue of the metal to such an extent that, eventually, its elasticity is exceeded and small cracks appear at the surface of the mould. The molten aluminium alloy penetrates these cracks and intensifies the thermic reaction. It is, therefore, quite necessary that the metal of the mould should present the maximum of elasticity at its surface, a result which is obtained by applying to the chrome vanadium steel a suitable hardening process. When the dies are given a careful heat treatment, one set of dies may be used for producing anywhere from 50,000 to 200,000 castings before they need replacement.

Apart from the outstanding advantages derived in die casting to shape: viz., accuracy, uniformity, finish, and the elimination to a great extent of machining operations, still another important advantage is made possible by this process: inserts can be moulded into the work to form an integral part of the finished casting, so that a reduction in assembly costs is effected since castings produced with bearings, bushings, pins, studs, or other parts in place eliminate the need for pressing them in position or securing them with screws or rivets. Steel, brass, iron babbit, or even porcelain may be inserted into die castings. Screw machine parts, such as small knurled rods, screws, or nuts, are examples of inserts often used.

Means are required for holding inserts in the die until the metal has been cast and has had a

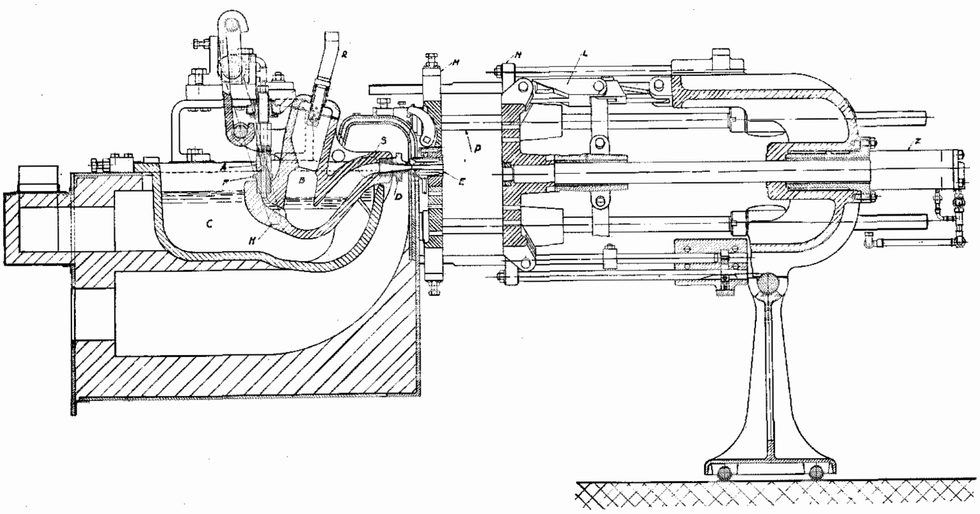


Figure 2—Section of Aluminium Die Casting Machine.

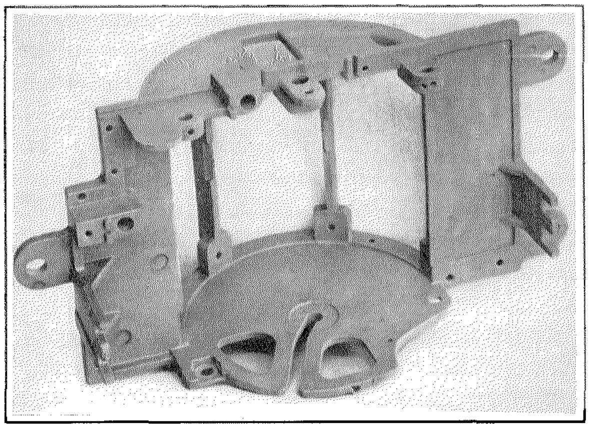


Figure 3—Aluminium Selector Frame (7-A.2 Rotary System.)

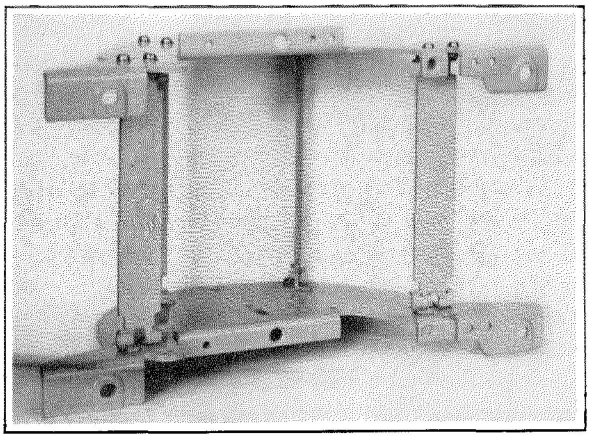


Figure 3-A—Punched Selector Frame (7-A.1 Rotary System)

chance to solidify. Inserts such as bushings are held in place by being fastened over steel cores. Another method is to provide a hole or a depression in the wall of the die and place the insert therein until the metal has been cast around it. This method requires that the insert be held to close limits.

Close limits must be adopted uniformly throughout the lengths of the inserts if both ends of these pieces remain free from cast metal. Broader limits may be adopted if one end projects from the casting. The part of the insert which is sunk in the metal should be provided with a rough surface or contain a hole, a thread, or a knurled surface so as to oppose any twisting force or pulling effort.

When bolts are used as inserts, their surface must not be threaded for a few millimeters beyond the point where they protrude from the casting. Should the thread of the screw be cut so as to touch the casting, it is impossible to prevent molten metal from embracing the thread line for some distance and this metal is very difficult to remove. Regardless of precautions taken, it is not possible to obtain watertight joints at the inserts, but in general this lack of watertightness is not objectionable.

Thin walled pressure castings with rounded corners and embossed holes, strengthened by cross-ribbing, are superior in appearance. They are light in weight, neat looking, and possess maximum elasticity with minimum weight. In them, furthermore, the properties of the alloys are utilised to the best advantage, thus tending to reduce costs.

In order to avoid the occurrence of blow holes, die castings should be as uniform in cross-section as the design requirements will permit. Regularity of wall thickness is also desirable to provide for ready flow of the molten alloys.

Rounded corners, in addition to being conducive to neat appearance, facilitate polishing operations. Avoidance of sharp corners also tends to strengthen both the parts and the mould, since cracks are most liable to develop at these places. In addition, rounded off parts, strengthened by one or several ribs, lend themselves to the production of sounder castings, since the metal in these cases flows more freely and is less likely to enclose air pockets.

Accuracy, if not required, should not be insisted on as it involves a more careful operation of the machine or die and increases unnecessarily the cost of castings.

The minimum diameter of holes that can be cast is 2.3 mm. The ratio of depth to diameter varies from 1.3 to 5 times the diameter. In order to secure regular working of the machines, diameters of holes should be made as large as possible so that heavier cores may be used and breakage be reduced to a minimum.

In die casting, machine operation should be avoided wherever practicable and, therefore, all holes should be cast in the parts. Drilling is not recommended in pressure casting since tiny blow holes occur mostly at the places where there are embossings for holes.

Internal threads are not cast except for very conical threads or for threads of special shape

External threads can be obtained up to twenty-four threads per inch.

The draft or taper per inch of depth ranges from 1.5 mm. to 2 mm. per 100 mm. on the diameter for holes less than 3 mm. in diameter; 1 mm. per 100 mm. for holes of 3 to 25 mm. in diameter; and 0.5 mm. per 100 mm. for holes over 25 mm. in diameter. It is not always possible to adhere to these figures as the required shape depends on several factors: the number of parts to be ejected from the mould at one time, as these require greater effort when their size increases; the possibility of making ejection easier and thus increasing the hourly production; or the effort that the parts can withstand or that can be applied to the ejecting cores without injury to the latter.

In addition to the factors related to the mechanical operations and to the strength of the material, the pecularities of the alloy must be taken into consideration. When the construction or shape of the casting requires that in feeding the metal the flow of alloy be directed upon the end part of a core, this part of the die expands more than the remainder. This expansion is influenced by the rate at which the injections are performed, by the temperature at which the metal is injected, and by the rate at which cooling of the cores occurs. In such cases, more taper must be given to the core. It is also necessary to provide a draft to all hollows or recesses in the mould, as the shrinkage of the casting is not sufficient to allow easy removal from the mould. Notwithstanding all precautions that may be taken and adequate heat treatment given to the steel of the die, small cracks are eventually produced, into which the metal penetrates and clings; faults that are scarcely visible at the start increase steadily, and the slightest tearing away of metal when ejecting the casting rapidly becomes a serious defect, since grooves are produced in the die that prevent easy removal of the cast part and spoil it as well.

The shrinkage of the die casting is very small. In its first stages the casting is produced by a small spray of molten metal that is thrown on the relatively cold walls of the die and there quickly solidified; the shrinkage is thus partly

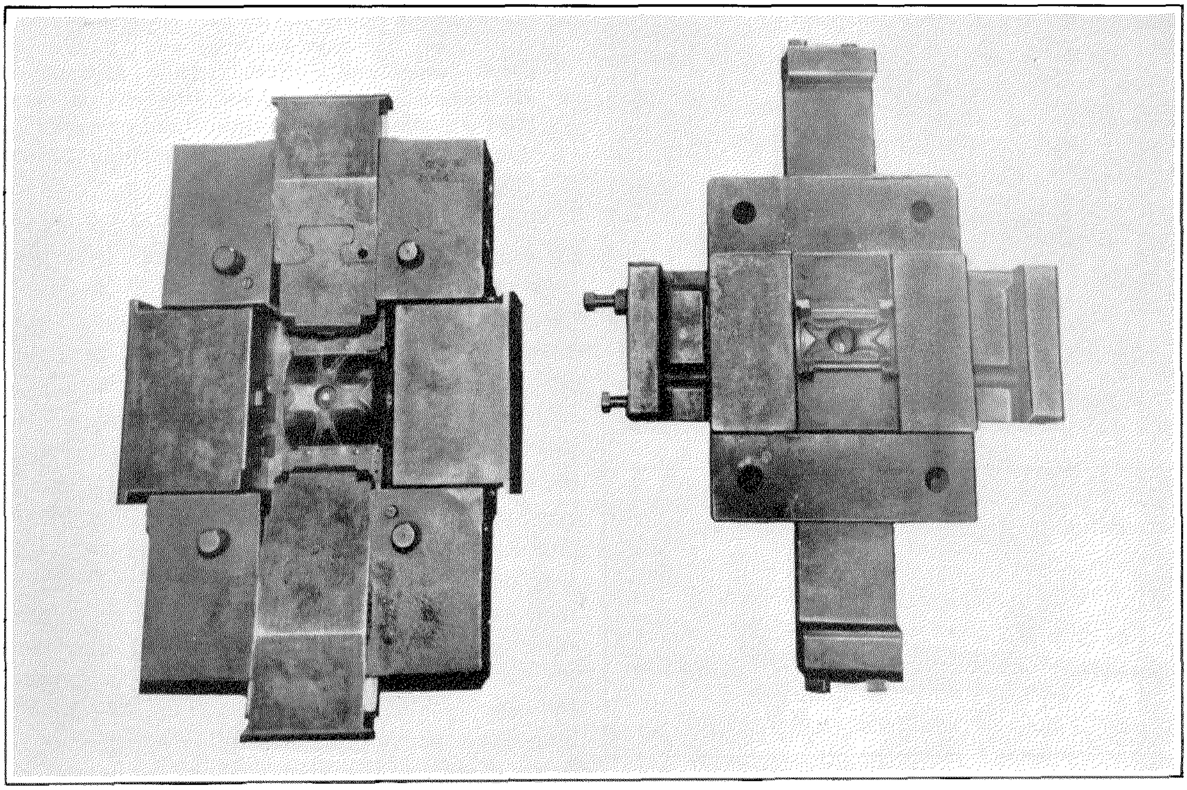


Figure 4—Mould for Selector Frame shown in Fig. 3.

balanced by the continuous feeding of metal.

The absorption of air causing porosity is slightly higher in pressure die casting; in this process the cavity in the mould is filled with molten metal under pressure, through a narrow gate. The gate is narrow so as to reduce the turbulence of the molten metal when entering the cavity and to allow a time interval during which the air in the cavity can be forced out through the vents. After the cavity is filled with molten metal, the small gate freezes and cuts off the source of hot metal. The skin of the casting next to the cold mould also freezes and the solidification shrinkage of about 7% is fed from the centre of the casting or from heavier sections which are still molten.

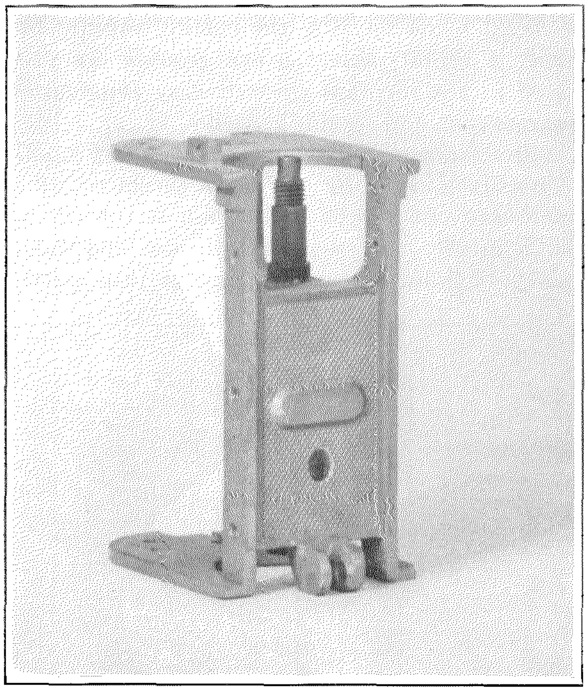


Figure 5—Brush Carriage Frame for Selector (7-A.2 Rotary System).

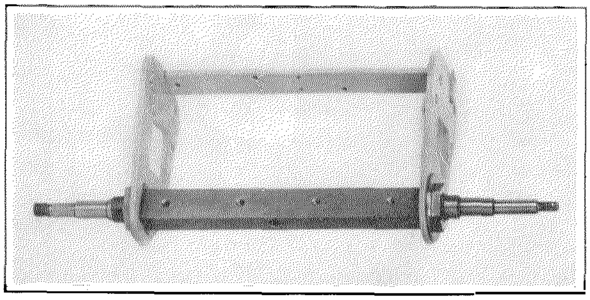


Figure 5-A—Brush Carriage Frame for Selector (7-A.1 Rotary System).

The former engineer of a prominent pressure die casting manufacturer explained this condition in an address before the Detroit Branch of the Society of Automotive Engineers, as follows:

> "Porosity is an inherent feature of commercial high pressure die castings. At first it was believed that this was due to the presence of air. The vacuum process was introduced so that the air was drawn out of the die cavity before the metal entered. Even if it were possible to maintain a vacuum under practical working conditions, this method does not offer the complete remedy. Practically the same results may be obtained without a vacuum if the proper size and location of the gate and vent grooves are carefully considered.
>
> There are two other causes for porosity, namely, uneven chilling of the metal and drossy, sluggish metal. As to the first cause, consider a die casting gated, so that the metal must travel through a thin section to reach a heavy boss. Normally the boss will solidify last, but since the thin section between it and the gate is already frozen, it has nothing to draw from to satisfy its natural shrinkage and the difference is made by a void or hole in the centre. This fact emphasises the importance of proper distribution of water channels in the die.
>
> The second cause is self-evident, for a die casting cannot have a cleaner surface than the original alloy. If too many impurities are in the alloy, its flow becomes sluggish and it chills before the shrinkage is satisfied even in uniform walls. However, the outer crust is so much greater in density and strength that it more than compensates for the porous structure in the centre of the wall."

Notwithstanding the presence of porosity, unavoidable in high pressure casting, it is possible to obtain castings resisting to 15 to 20 kg. per sq. cm. tensile strength, because the grain is always very close, when the operation has been perfectly conducted and made with good alloys.

Pure aluminium is seldom die cast or used for any commercial purpose, since it has been found that the addition of copper, silicon, and nickel produces an alloy superior to the pure metal from the standpoint of tensile strength, as well as of wearing qualities. Alloys of aluminium vary in composition, a popular combination being that containing approximately 92% of aluminium and 8% of copper. It has a tensile strength ranging between 13 and 15 kg. per sq. mm. and 1.25% elongation per 50 mm. This alloy is preferred in some cases for the ease with which it can be machined and for its bright colour.

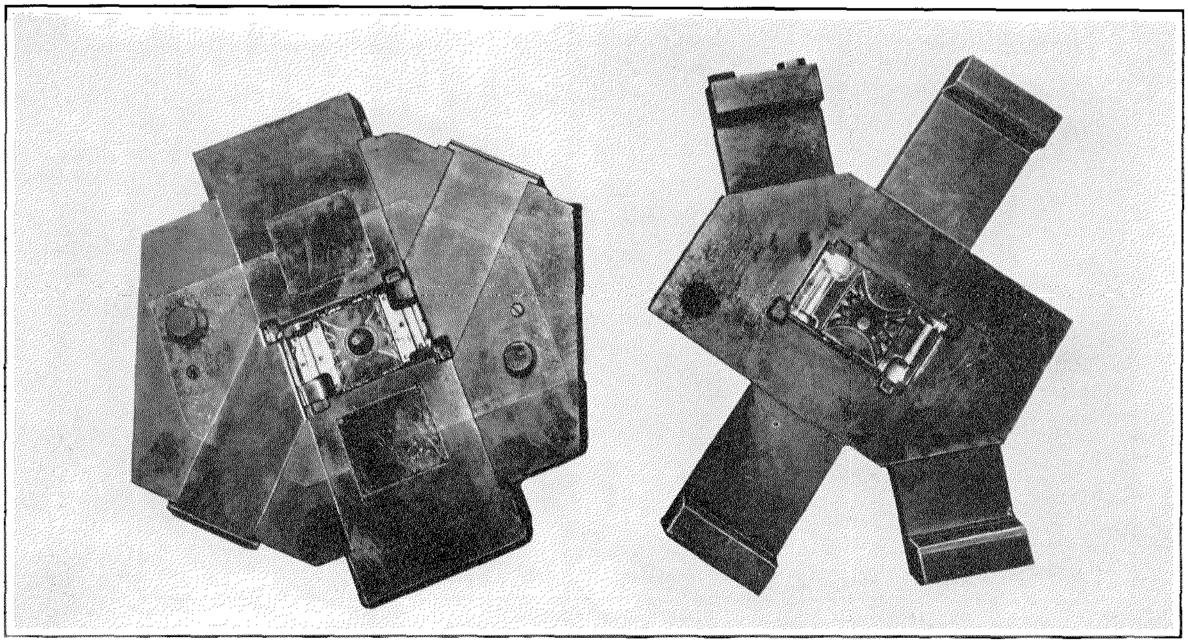


Figure 6—Mould for Brush Carriage shown in Fig. 5.

The addition of silicon increases the tensile strength and reduces loss due to shrinkage cracks. An alloy comprising only 5% silicon with the balance aluminium gives a closer grain than the aluminium-copper alloy, and is more ductile, tougher, and stronger. It has a tensile strength ranging from 20 to 22 kg. per sq. mm. and an elongation of 3.5% per 50 mm. With an aluminium alloy containing 12% silicon, an ultimate strength of 24 kg. per sq. mm. is obtained with an elongation of 1.5% per 50 mm. This is the lightest in weight of the three. The aluminium-silicon alloys have advantages over aluminium-copper alloys as regards casting properties and corrosion resistance.

Aluminium alloys do not crystallise and do not show signs of fatigue as quickly as other alloys. When a high polish is required, the slightest addition of nickel to the aluminium-silicon alloy is recommended.

The aluminium base alloys lend themselves well to the application of a great variety of finishing methods, including sand blasting, painting and lacquering, scratch brushing, bright dipping, ball burnishing, polishing, plating, and oxidising. However, they have very poor soldering properties.

Aluminium alloys melt at the comparatively high temperature of 650°C., and it is for this reason that high grade alloy steel must be used in building dies for casting aluminium parts.

In making the dies, impressions are often worked into solid blocks of steel, sometimes weighing more than 100 kg. in order to withstand the high casting temperature. Special cutters, the production of which often consumes as much time as the making of the die cavity itself, are often required. Under such circumstances weeks, and often months, are needed to build a die.

The aluminium selector frame used in the 7-A.2 rotary system and shown in Fig. 3, represents an important development for making accurate, intricate parts in one piece. It is illus-

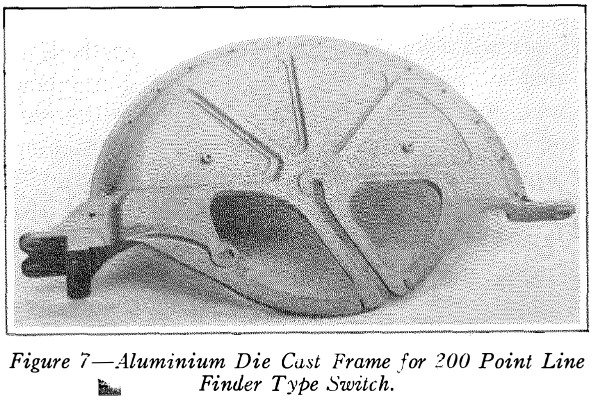


Figure 7—Aluminium Die Cast Frame for 200 Point Line Finder Type Switch.

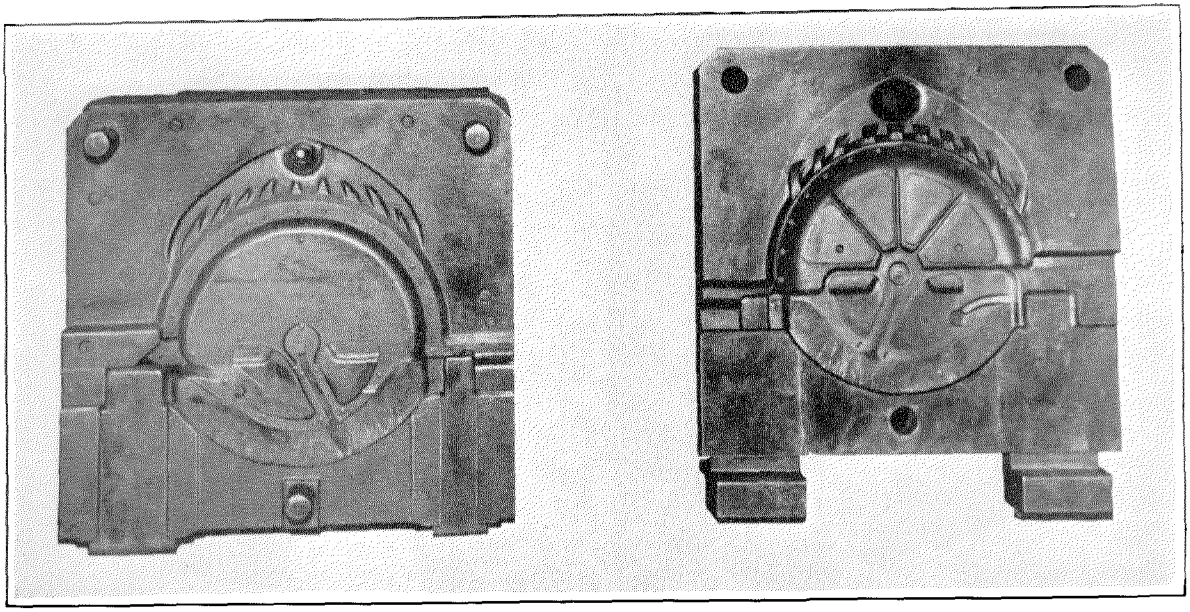


Figure 8—Mould for 200 Point Line Finder Type Switch shown in Fig. 7.

trative of the accuracy with which die castings can be produced. The casting measures approximately 270 by 135 by 120 mm.; it weighs about 0.550 kg. All holes are cast to the finished size. From the standpoint of intricacy, this die casting is an outstanding achievement. In this case an appreciable saving was effected by using die castings in preference to the punched parts previously employed (See Fig. 3-A).

The mould for producing the die cast frame is illustrated on Fig. 4. The movable die is provided with four sliding members. The figure shows the moving members withdrawn. They are operated by a rack and pinion. It furthermore contains the sliding cores and an ejecting device, both also operated by a separate rack and pinion.

The stationary die section is provided with two sliding cores located at an angle of approximately 45 degrees from the horizontal or the vertical, in order to produce the holes in the transverse parts. Shoes attached to the stationary die section prevent the sliding members from loosening under pressure. The stationary and movable die contain grooves or passages leading from the sprue which carries the molten metal to several different places in the die cavity. Pilot pins on the stationary die engage holes in the movable die to accurately register the two die members in the casting position.

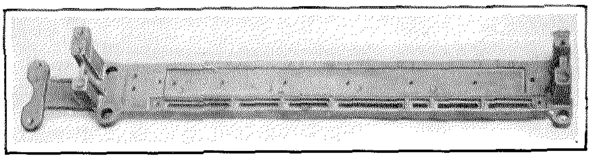


Figure 9—Sequence Switch Frame made of Aluminium Alloy.

Fig. 5 shows a brush carriage frame of the same selector. This part is cast with a threaded axis in place. The weight of this aliminium die cast frame is 110 gr.; the length is 90 mm.; the width, 60 mm.; and the height, 45 mm. The wall thickness measures 3 mm. All holes are cast to the finished size. The tapping of some of the holes is the only machine work on this part. The corresponding frame of the earlier form of selector using punched parts is shown on Fig. 5-A.

In Fig. 6 are shown the die members used in producing this frame. The die is of a relatively complicated construction with a parting line running along the middle of the part, and casts two pieces simultaneously. The movable part is provided with four slides placed in four different directions. The inserts are placed in position in the sliding members, when these are open, so that after casting, the axis forms an integral part with the casting. Accurate inserts guard against metal being cast on the thread. From observation of Fig. 6, it will be seen that the sprue passage is contained entirely in the movable die.

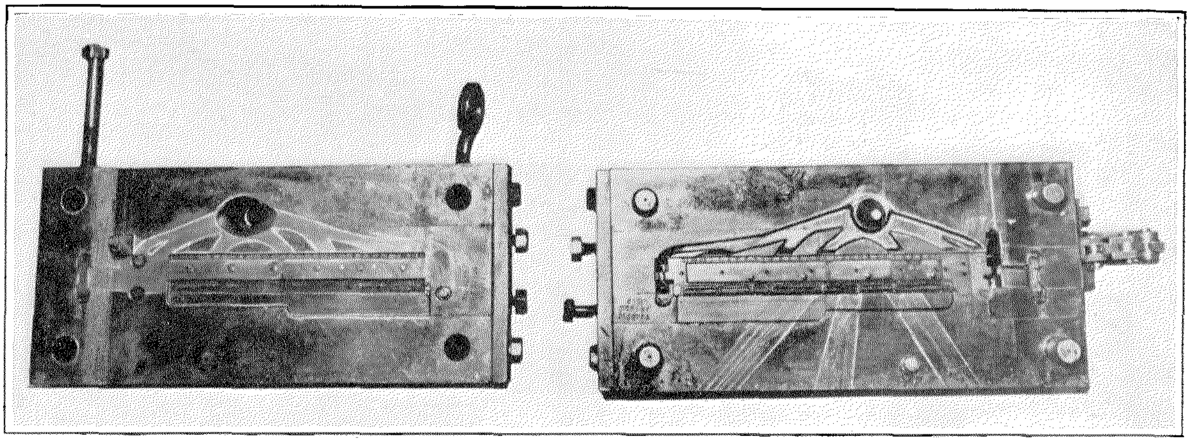


Figure 10—Mould for Producing the Sequence Switch Frame shown in Fig. 9.

An aluminium die cast frame for a 200 point line finder type switch is illustrated in Fig. 7. It has the following dimensions: 370 by 245 by 96 mm. and weighs about 630 gr. The wall thickness measures 3 mm. Fig. 8 shows the die for this part. It consists primarily of a stationary member and a moving member, and it will be noticed that the moving member is provided with a series of slender core pins which produce corresponding holes in the casting. Two slides are placed along the parting line for the side holes. Ejecting pins are located at various points on the moving die members to facilitate the removal of the finished casting; ejection of the work from the die is comparatively simple inasmuch as the shrinkage causes the casting to adhere to the core when the dies are separated. By drawing the cores through the die body in which they are housed, the work is freed.

The die is designed with the parting line located along one edge of the casting, from which fins can easily be removed. Several shallow vents may be seen on the face of the movable member. Moulds having no or few slides are provided with vents at the matching faces. As the metal is forced into the cavities, the gases escape through the vents, which are made by grinding slots in one of the die sections. Vent slots for aluminium die casting are from 0.2 to 0.3 mm. deep and 25 mm. or more wide, depending upon the size of the work. The metal enters these slots before congealing, forming thin flashes that are easily trimmed or broken off. If there is improper venting, gases pocketed in the cavities often cause spongy castings.

The sprue and the passage through which the molten metal flows to the die cavity are cut partly in the stationary die and partly in the moving die. Four holes in the moving member slip over pilot-pins on the stationary part to insure close registration of the two die halves for each operation.

Another interesting aluminium die casting is illustrated by Fig. 9. It is a sequence switch frame of very light construction provided with several narrow slottings for fixing the spring combinations. The mould for producing this part is shown in Fig. 10. The moving member is shown with the moving cores in casting position. A

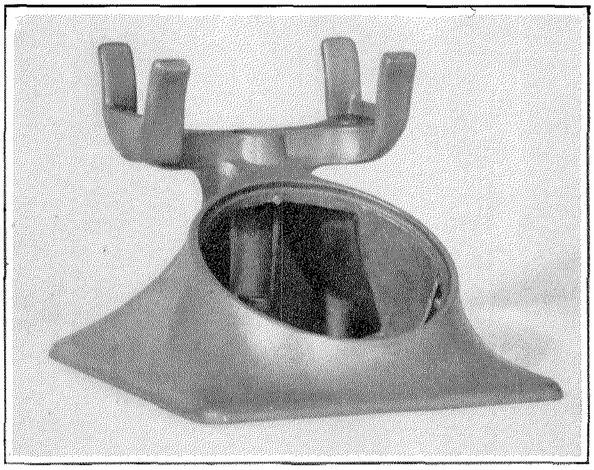


Figure 11—Subscriber Set Housing made of Aluminium Alloy.

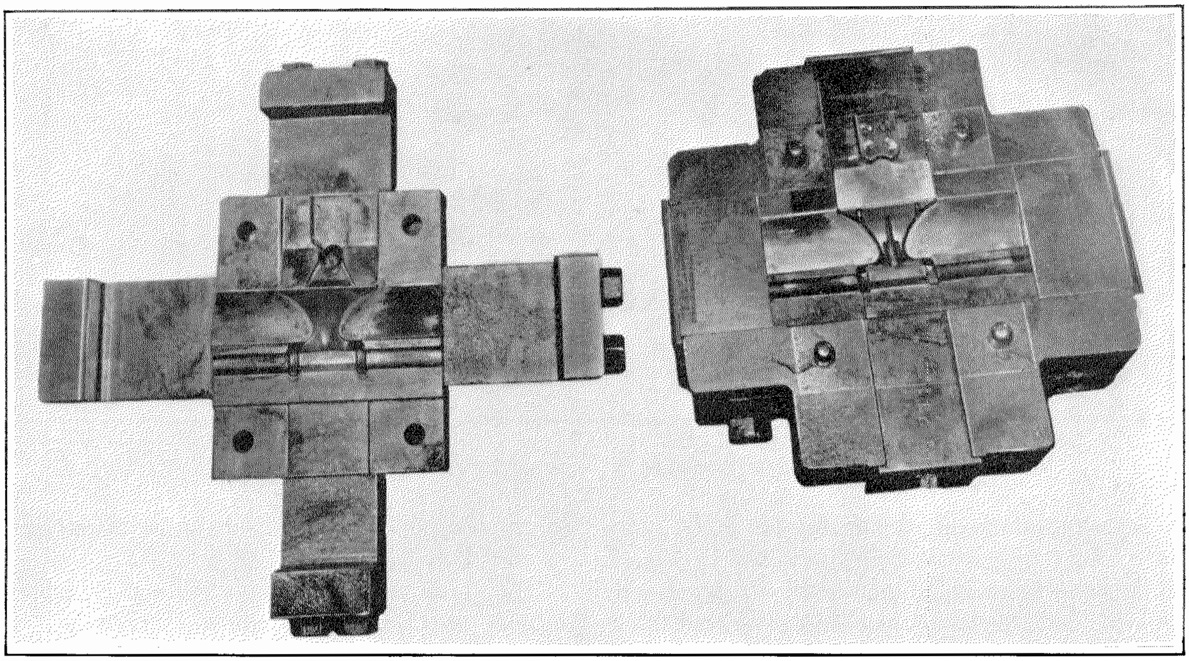


Figure 12—Mould for Subscriber Set Housing shown in Fig. 11.

swiveling lever allows withdrawing of the sidewise placed core. As with the die described previously, the casting is made to adhere to the moving member when the die opens. Air vents are seen on the stationary member. This casting measures 382 by 52 by 50 mm. and weighs 280 gr.

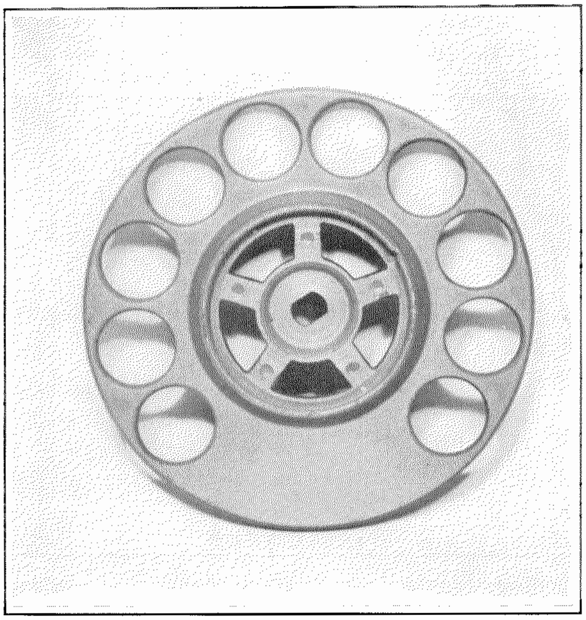


Figure 13—Aluminium Die Cast Finger Plate for Dial.

Fig. 11 shows a subscriber set housing made of aluminium alloy. Its design requires the use of a movable die which opens sidewise in the four directions after it has been withdrawn from the stationary die. This die, illustrated in Fig. 12, shows the various sliding members placed in casting position. The casting is approximately 135 mm. long, 122 mm. wide, and 103 mm. high, with walls only 3 mm. in thickness. Its weight is 280 gr. About 150,000 parts have been cast with this mould and, notwithstanding the high number of castings already produced, it is still in good working condition. The parts are later sand-blasted and given a bright black japan finish.

Dies of unusual interest were designed for casting aluminium finger-plates for dials, four at a time. The plates and dies are shown in Figs .13 and 14, respectively. Sixty-four holes are cored in this die and by employing the die casting process for making the part, the machining of an oval central hole is avoided. The die is designed with the parting line located along the middle of the casting.

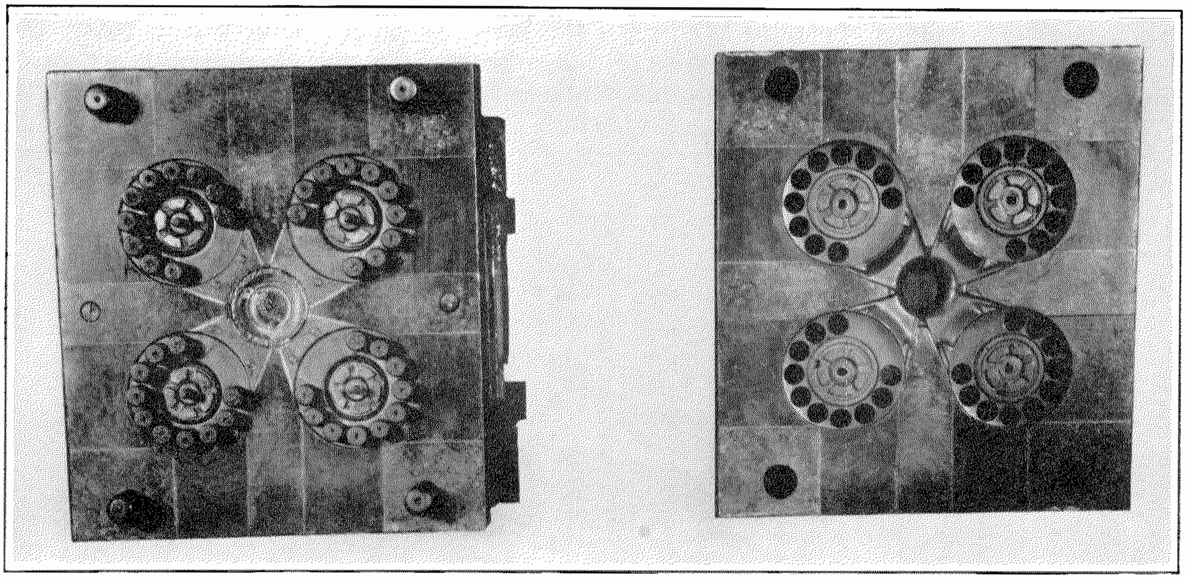


Figure 14—Mould for Finger Plate shown in Fig. 13.

The gate and flash left in this casting are readily removed by the use of a trimming punch and die. The moving die is generously provided with ejector pins, there being twenty-eight altogether. Air vents may be clearly seen at the movable die. The sprue and the passages through which the molten metal flows to the die cavities in the movable die, are cut entirely in the stationary die. This part has a diameter of 80 mm. and weighs 40 gr. Approximately 2 mm. of metal separate the different finger holes.

Fig. 15 illustrates an aluminium die cast back plate for dial, in which five 3 mm. tapped holes, four 2.3 mm. tapped holes, two 2.5 mm. screw holes are cored when the piece is cast and in which, furthermore, a brass insert is used as an integral part of the work.

The die shown in Fig. 16 is of relatively simple construction, with a parting line running along the middle of the part, and casts four pieces simultaneously. Three holes are cored sidewise in each of the cavities through the use of sliding cores. These cores slide in four different directions, but all in one vertical plan, so that they can readily be actuated through the use of rack and pinions. Ejecting pins may be seen at various points on the moving member, as well as the vents to permit the escape of air.

The above summarises the various advantages obtained with the use of the die casting process. In addition to the elimination of many machining operations and the consequent saving in labor and time, there is a saving in weight of the product and in the amount of material used. For example, the weight of the material in a 7-A.2 rotary automatic equipment—notwithstanding

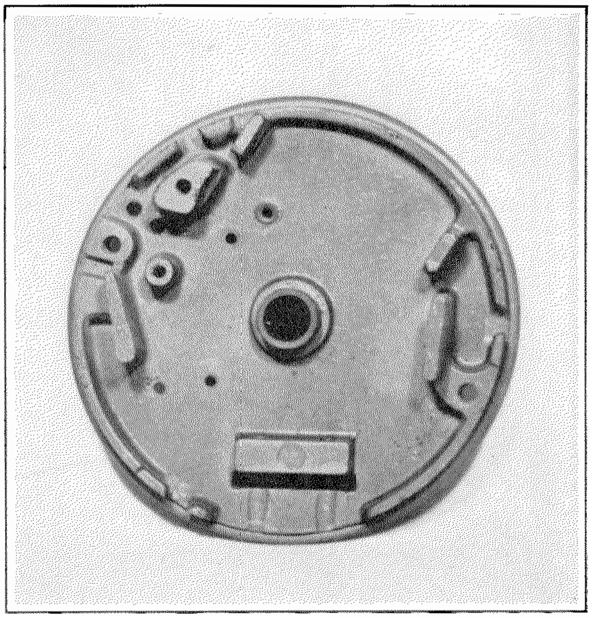


Figure 15—Aluminium Die Cast Back Plate for Dial.

the use of smaller units of apparatus in greater quantities per bay—is lower in the proportion of three to four as compared with 7-A.1 equipments, this result being to a large extent due to the adoption of die casting. Reduction in weight of the bay framework is thereby made possible.

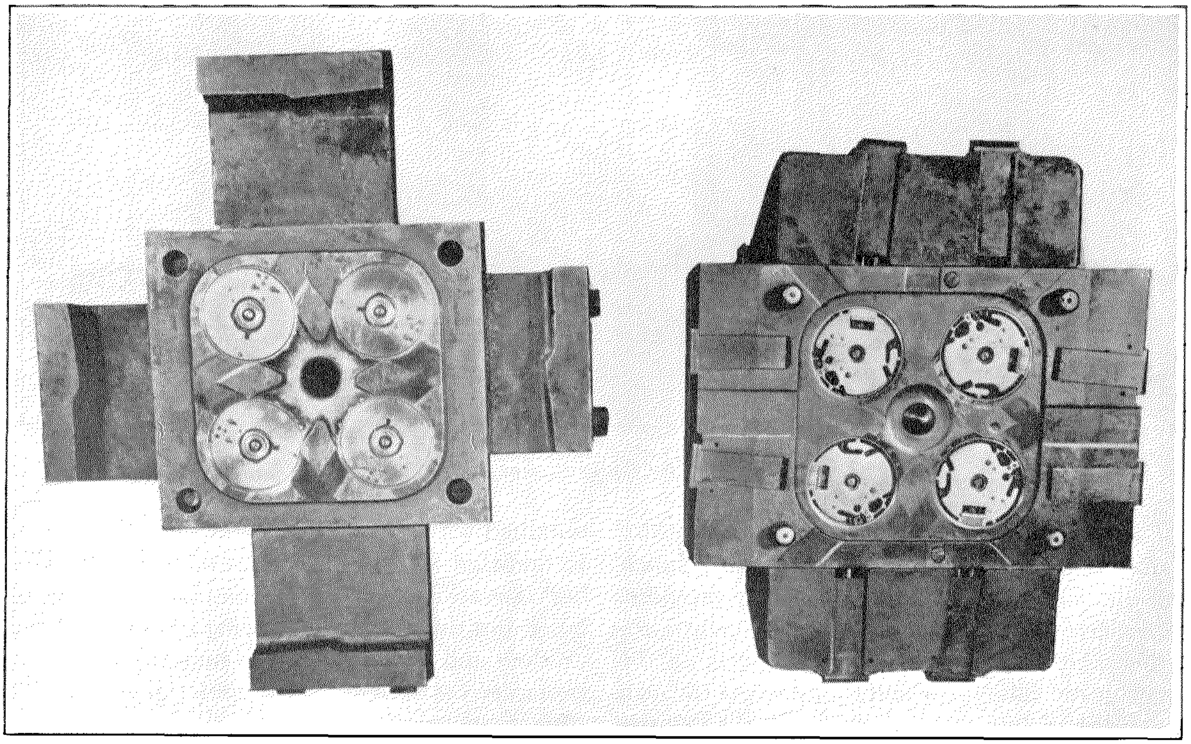


Figure 16—Mould for Back Plate shown in Fig. 15.

The Manufacture and Uses of Metal Powders*

By J. C. CHASTON, B.Sc., A.R.S.M.

Standard Telephones and Cables, Ltd., London, England

There is an extensive use of metal powders for paints and magnetic cores, and many interesting products are made by the compression and sintering of powders, e.g., tungsten and molybdenum wire, carbide cutting tools, oilless bearings, etc. Further developments in the use of powders are anticipated in the manufacture of alloys not obtainable by melting and as an alternative method of shaping metals. In this article the various methods of producing metal powders are systematically considered.

IN recent years numerous methods have been developed for making powdered metals, and the resulting products vary widely in uniformity of size, in size itself, and—what is often very important—in shape. In the matter of size, the maximum is largely a question of definition. In pharmacy, it is common to describe as powder, material that will pass a sieve having less than 10 meshes per centimetre[1] (*i.e.* particles ½ mm. or 500 microns in diameter), and this would appear as reasonable a definition as any. Aluminium powder used for the "Thermit" process is an example of such coarse powder. At the other end of the scale, it is possible to produce by the carbonyl process iron powders of a uniform diameter as small as 1.5 microns; and in a number of operations the product may contain particles as small as 0.5 micron. In addition, many metals can be produced in so fine a form that they exhibit the properties of colloids—but these can hardly be classed as metal powders. In shape, the possible variations are equally large. On the one hand, the particles may be in the form of almost perfect spheres, as in the carbonyl process; while on the other hand they may be produced as flakes with a width as much as 200 times as great as their thickness, as in the aluminium and bronze paint powders. These points are illustrated in Fig. 1 which shows a classified list of sixteen main processes and their products.

Attention may be directed in the first place to the various ways in which, when making powders from solid metals, fracture can be brought about: (1) The crystals may be broken away from one another—intercrystalline fracture; (2) they may be broken along a cleavage plane, if there is one—fracture on a cleavage plane; or (3) the fracture may proceed across the crystals—transcrystalline fracture. Methods involving intercrystalline fracture naturally require that the metal shall first be given intercrystalline brittleness, which can usually only be done by introducing some impurity that will collect in the boundaries and give rise to some form of local weakness. In addition, it is necessary to ensure that the crystals themselves are sufficiently small—since they must be at least as small as the particles of the powder which is to be produced. Fracture along a cleavage plane is naturally confined to a few metals such as bismuth and antimony. Fracture across the crystal is applicable, however, to practically every metal irrespective of crystal size or composition, and can be produced by a number of methods. In some of these the metal is torn apart by some kind of cutter, in others, fracture is produced by severe working.

Machining Processes

One of the oldest and crudest methods of producing metal powder is to cut small particles from the metal with a cutting tool or grindstone. Iron filings so made are used to some extent in "iron cements" and in firework manufacture. Such powders are essentially by-products, but magnesium powder is made in considerable quantities as the principal product of a machining process. The particles are cut off by milling or turning, and as shown in Fig. 2 are irregular in shape and bear the impression of the tool marks. They are rather wider than they are thick (the ratio is about 1:3 in the sample illustrated) and it is desirable that they should be slightly curved

---

* Paper read before the London Section of the Institute of Metals, January 10, 1935, and published in *Metal Treatment*, Spring 1935 Edition. Permission to republish in *Electrical Communication* is gratefully acknowledged.

[1] For all numbered references, see list at end of paper.

so that they will not pack too closely Loose packing encourages rapid burning. About five grades are usually marketed with maximum diameters varying from 300 to 75 microns.

Bessemer Process

For many purposes, the irregular-shaped particles produced by machining are quite unsuitable; for instance, bronze powders for paint need to be thin and leaf-like. At least one method has been introduced in order to flatten and polish particles first produced by a machining operation. This was developed by Sir Henry Bessemer when he was a comparatively young man and has considerable historical interest since it brought him in £3,000,000 and enabled him to afford those experiments in steel manufacture which culminated in the Bessemer converter and the era of cheap steel.

The first operation[2] appears to have been carried out on cast billets of copper alloy and to have been some sort of a multiple machining operation. Cutters acted on thirty pieces of brass simultaneously to produce small filaments about 1 cm. long at the rate of 2,000-3,000 per minute. The filaments were then rolled out by passing them through two rolls each 30 cm. in diameter and 45 cm. long, pressed together with powerful springs. In order to prevent the particles sticking together and also to impart a polish, three drops of olive oil were added to each pound of filaments. Further polishing was carried out by repeatedly pouring the powder from a height, and it was then graded by an air blast which carried the particles along a tunnel 12 metres

Raw Material		Principle Involved		Process	Average Particle Size Microns		Chief Products	Uses
					Thickness	Width		
METAL	Solid metal..	Trans-crystalline fracture	By tearing action	1. Machining	50	150	Mg	Flashlight powders
				2. Bessemer process	0.8	50	Cu & alloys	Paints, etc.
				3. Screening beaten foil	0.8	50	Au, Cu & alloys.	Paints, etc.
			Through severe working	4. Stamp mills	0.8	50	Al, Cu & alloys.	Paints, etc.
				5. Eddy mills	75		Fe Cu	Magnetic cores Commutator brushes
				6. Grinding sponge	100		Fe	Magnetic cores
		Fracture on cleavage plane		7. Grinding "cleavable" metals	150		Bi, Sb	Chemical purposes
		Intercrystalline fracture.		8. Grinding brittle electro-deposited metal.	180		Fe	Magnetic cores
				9. Grinding brittle metal made fine grained by hot rolling.	75		Ni-Fe alloy	Magnetic cores
	Molten metal	Granulation		10. Granulation into water	150		Pb, Sn	Chemical purposes
				11. Granulation by stirring	250		Al	Thermit
	Metal vapour	Condensation		12. Condensation at normal or low pressure.	—		Zn, Mg	Chemical purposes
CHEMICAL COMPOUND	Solid	Reduction		13. Reduction below melting point in hydrogen.	0.5 to 50		W & Mo Fe Ni, Co	Lamp filaments Magnetic cores Sintered carbide tools
	Solution	Replacement		14. Chemical precipitation	—		Pt & Pd Sn	Catalysts Mansbridgecondenser paper
		Electro-deposition		15. Electro-deposition as powder	—		Cu	Porous bearings
	Gas	Thermal decomposition		16. Carbonyl process	3		Fe Ni Ni-Fe alloy	Magnetic cores Sintered products (bi-metals, magnetic sheet, plating anodes,welding rod)

1 micron (μ) =0.001 mm.

Pins head—approx. 1.500 microns.
Aperture of 300-mesh sieve—approx. 53 microns.

Figure 1—Classified List of Sixteen Main Processes and Their Products.

long by 75 cm. wide. The particles distributed themselves according to their size along the floor of the tunnel, the very finest being retained by silk bags at the far end.

By suitable choice of alloy, a wide range of coloured powders could be produced; and these were further coloured by heating at various temperatures to produce oxide films on the surfaces. For many years, however, the manufacture of silver powder proved a stumbling block. Aluminium was not available and no white alloys yielded good flakes. The problem was finally solved by depositing tin on brass powder in a chemical tinning bath similar to that used for tinning common pins.

Screening Beaten Foil

The older, and probably the original, method of making leaf-like powder was also a mechanical process, but it utilised both tearing and repeated working in order to separate the particles. It was carried out simply by rubbing through a fine wire sieve pieces of very thin gold, copper, or brass foil made by the gold-beating process. In this operation small particles are either torn apart or bent to and fro until they break away from one another. The manufacture of powders by this process was chiefly centred in Nuremburg; but the operations were expensive, and competition from Bessemer caused the collapse of the industry about 1865.

Stamp Mills

The method which is now almost exclusively used for making paint powders resembles the Nuremburg process more closely than the latter's first successful rival. The principle of mechanical tearing which was the basis of the Bessemer process has now been entirely abandoned, and subdivision as well as flattening are effected by repeated working. The origins of the stamp-mill process appear to be obscure, but it seems to have been fairly well known in 1896[3], and since then it has been widely used in Europe and America. Its ability to produce aluminium powder has undoubtedly been an important factor in its favour.

The process consists in subjecting the metal to the action of stamps in a series of mills, in which it is beaten out and broken up into flake-like particles [4,5,6,7]. In order to prevent consolidation of the product it is usual to use progressively lighter stamps as disintegration proceeds, and also to add small amounts of stearine or olive oil. It does not appear usual to feed material continuously to the mills, but rather to stamp each charge for a predetermined period—regulating the process by "programme clocks." It is particularly important to guard against stamping for too long a time, as this is said to produce a rough, useless powder.

In its details the process is modified slightly, according to whether the material which is stamped is a copper alloy or aluminium. Heavier stamps can be used for copper alloys, and the metal does not need to be rolled to so thin a sheet or cut into such small pieces before it is fed to the first mill.

Copper alloys[7] may be cast in billets 12 mm. square by 1 metre long, rolled, annealed, pickled, and cut to clippings about 6 mm. square and 2.5 mm. thick. The annealing operation is of some importance, as uniformity as well as softness is desirable in order that a uniform product be obtained. The clippings are stamped to powder in three mills[4], graded by air separation, and polished to a brilliant finish in a horizontal drum through which passes a shaft carrying radial arms fitted at their extremities with short, stiff bristles. The shaft is revolved slowly at about 100 r.p.m. and the brushes rub against the sides of the drum and polish the powder.

The alloys used for making "bronze" powders of various shades range in composition from pure copper to 70:30 brass. Real tin bronzes are rarely used, and nearly all "bronze" powders are made from brass. A wide variety of colourings is obtainable by heating these powders in open trays with oil, vinegar, wax, paraffin, sulphur-bearing oils, or sulphuretted-hydrogen solutions, or by dyeing with organic dyes. The colours produced by these operations cannot, of course, be regarded as permanent, but by repolishing the powder with a little stearine, a very fair degree of durability is obtained.

Aluminium powders—or "aluminium-bronze" powders as they are frequently called—are made in very much the same way, except that the stamps are lighter, and thinner material is used as a starting point. It is not uncommon to use trimmings from foil manufacture (about 0.04

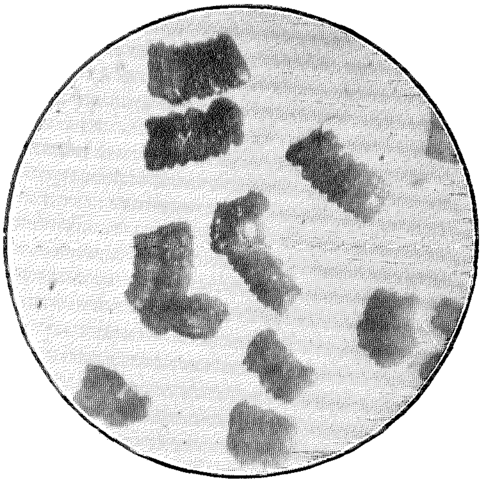


Figure 2—Magnesium Powder × 40.

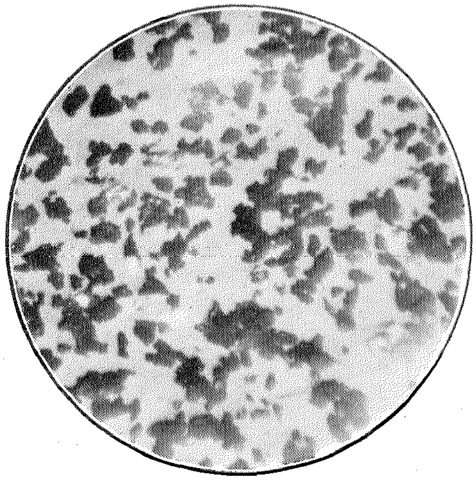


Figure 3—Aluminium Powder (Stamp Mill Product) × 75.

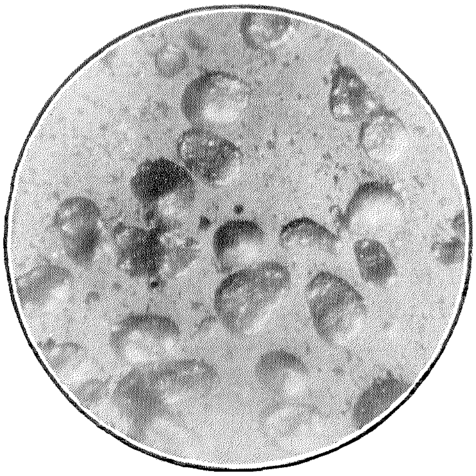


Figure 4—Iron Powder (Eddy Mill Product) × 40.

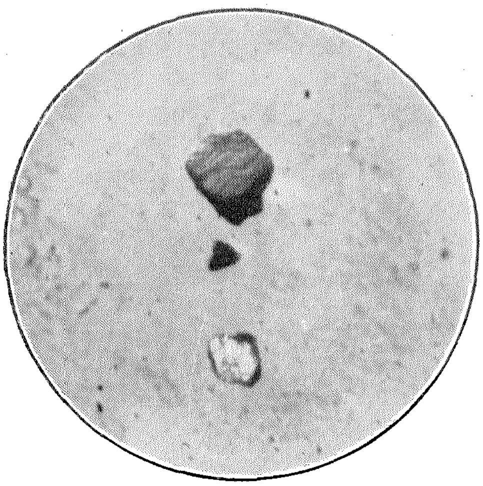


Figure 5—Antimony Powder × 40.

mm. thick) as the raw material. The operations, particularly those of air separation and polishing, are rather more dangerous with this more reactive metal and some serious explosions have occurred in the past. It is usual to design the mills so as to reduce the free space above the powder to a minimum, to earth all metal parts, to use wood as far as possible in construction, and to operate the plant in small isolated units. In the event of a fire of aluminium powder, it is believed that common salt is the best extinguisher.

The aluminium powder produced in the way described is not sufficiently fine for use in lithographic printing, and material for this purpose is given an additional grinding operation. It is mixed with a thick solution of gum arabic and ground for 4 to 6 hrs. in an edge runner fitted with granite cones. The gum is washed out, the gum is washed out, the powder graded in water, dried at 40° C., and finally polished with a little olive oil.

"Bronze" and "aluminium bronze" powders made by these processes consist of fine, thin, brightly-polished flakes, covered with a thin film of lubricant. This grease is valuable in protecting the powder against tarnishing when it is to be used for decorative purposes, but it renders it less valuable for chemical purposes such as for calorising or as a precipitant. In size, the particles usually range from 0.3 to 1.3 microns in thickness, and have a width from 5 to 200 times as great as this. A photo-micrograph of a typical sample of aluminium powder is shown in Fig. 3.

The largest use of bronze and aluminium powders is in paint for decorative and protective purposes[8, 9]. Their great value in this respect is believed to depend on their property of rising to the surface of the medium, "joining hands" under the influence of surface tension, and forming a series of very thin metallic layers over the surface. It is to this action that their value in preventing "bleeding" of underlying coats and in acting as primers on such materials as creosoted woods is ascribed. Aluminium powders have great covering power, are opaque, form a protective coating electro-positive to most common metals, are resistant to sulphur (a useful property in connection with laboratory decoration), and are easily washed. Their very high reflectivity to light and heat radiations is an important property and makes them of value in painting furnace bodies (where heat radiation must be kept to a minimum), oil-storage tanks and airships (where heat absorption must be avoided), and cinema screens (where high light reflectivity is desired). Their waterproofing properties make them of value for painting aeroplane fabrics and foundry patterns. Mixed with bitumen, the powders prevent its disintegration in sunlight and improve its value as a protective coating for steelwork. Aluminium powders are generally considered to "mature" on keeping, but after they are mixed with paint vehicles their colour tends to deteriorate.

Apart from their use in paints, aluminium powders are used to give a moiré effect to cellulose plastics, to protect rubber-cotton balloon fabrics from light, and (mixed with graphite and molasses) as a coating for steel-ingot moulds. Aerated concrete, which is light in weight and possesses good thermal-insulating properties, is made by mixing aluminium powder with ordinary cement. Hydrogen is formed by reaction of the aluminium with the alkali of the cement and aerates the mass.

Eddy Mills

For many years the stamp mill remained the only mechanical mill capable of pulverising malleable metals. Attempts to reduce a malleable metal to powder in ball mills showed that the metal was rounded into lumps and then worn away by attrition—often at a rate little faster than that of the steel balls. Recently, however, the eddy mill method of producing excessive working on metal particles and of deforming them so severely that fracture occurs has been developed[10]. The metal, usually in the form of wire about 1.3 mm. diameter chopped to lengths of 1 cm., is fed into a closed chamber in which are mounted two fans or impellers. These are rotated in opposite directions at a high speed and whirl the particles up into two opposing eddies. The particles are thus caught up and hurled against one another in the central part of the mill, where they pound and bend each other until they are broken up to the desired size. All impact occurs between the metal particles themselves and there are no beaters or other similar parts which might wear and so contaminate the powdered product. The material can be fed continuously and automatically and the ground product removed by air separation.

Since about 1923 a small factory, devoted exclusively to the manufacture of powdered metals by this proces, has existed at Cöpenick, a suburb of Berlin. Each machine stands between two electric motors on a bed-plate about 1.5 m. long, and produces 5 kg. or more of powder per hour. It is usual to maintain an atmosphere of coal-gas to prevent oxidation of the powder. In shape, the particles are about equi-axed, and many exhibit a most characteristic appearance perhaps best described as saucer-shaped, bearing a depression on one surface presumably caused by impact. This is illustrated in Fig. 4 and its occurrence in a sample of dust is a certain pointer to its origin. The product of these mills is obviously unsuited for paints—as it is by no means leaf-like—and the chief applications of the process have been for making powdered iron for magnetic cores and powdered copper for copper-graphite commutator brushes.

Grinding Sponge

Attempts to powder malleable metals in a ball mill are usually unsuccessful but, if the metal is fed in a spongy condition, sufficient bending may occur to break the sponge into small particles. This principle has been applied to produce iron

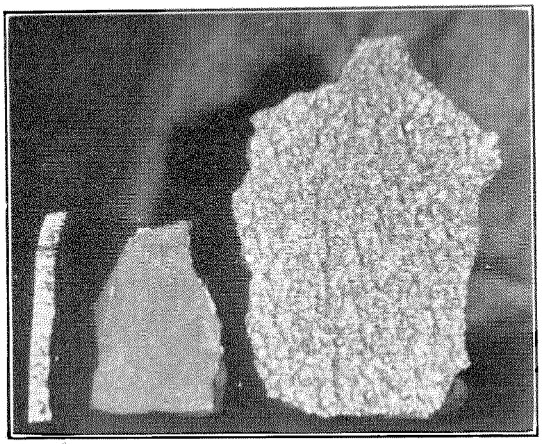


Figure 6—Brittle Cathodes of Electrolytic Iron × $\frac{2}{5}$

powder from spongy iron formed by direct reduction from the ore, and could probably be extended to other spongy products.

Grinding Cleavable Metals

With a metal having a well-marked cleavage plane, the problem of reducing it to powder is very much simplified. Little difficulty is experienced in handling it in a ball mill, and such metals as antimony and bismuth are easily reduced to almost any degree of fineness by such means. Some powdered antimony is illustrated in Fig. 5. These metals are used in their powdered form for chemical purposes.

Grinding Brittle Aggregates

(*a*) *Made by Electro-Deposition.*—The reduction to powder of a metal possessing marked intercrystalline brittleness is likewise a relatively simple operation. The process is, however, of special metallurgical interest in view of the methods that are adopted to bring about intercrystalline brittleness and to ensure that the crystals themselves are of the requisite size.

The first commercial application of this method was on iron electro-deposited under such conditions of acidity and current density that a fine-grained, brittle deposit was obtained[11]. An electrolyte containing ferrous sulphate, ammonium sulphate, and ammonium chloride is used and is maintained just on the acid side by periodic additions of sulphuric acid. The anodes are of mild steel, and a current density of about 1.3 amps./sq. dm. is used to deposit the iron on polished-steel cathodes. The deposit is allowed to grow to a thickness of 3 mm. to 6 mm., and it is usual to add a little glue to prevent excessive "treeing." The cathodes are then removed and washed, the deposit stripped off, broken into small pieces, and ground down in Hardinge conical ball mills. A sample of the broken cathode is shown in Fig. 6. Fig. 7 shows a photo-micrograph of the powder and illustrates how the acicular shape of the crystals is retained. The product is not so fine as many of the others considered. It is usual to grind to pass an 80-mesh sieve (with apertures 180 microns wide) but the particles vary over a wide range and about 50 per cent. will pass a 200-mesh sieve, *i.e.*, will be less than 74 microns in diameter.

The iron powder made by this process is mainly used for magnetic cores of inductance coils in which the losses from eddy currents must be kept at a minimum. In making these, the iron particles are tumbled in an alcoholic solution of shellac, the solvent driven off, and the coated particles pressed to the required shape under about 14,000 kg./sq. cm. It is necessary to use such high pressures in order to deform the iron particles sufficiently to lock closely into one another, and thus obtain high effective magnetic permeability. If the operations are properly carried out the insulation does not break down, and the core behaves as a composite of perfectly insulated particles.

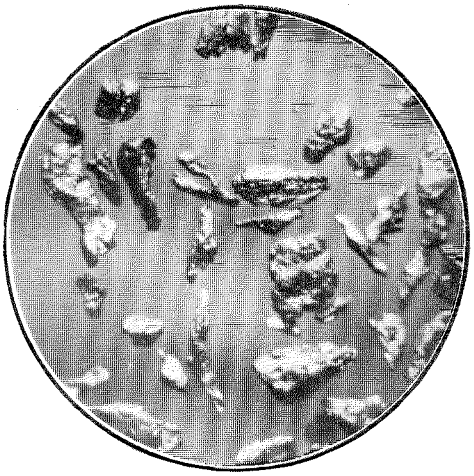


Figure 7—Iron Powder (Ground from Electrolytic Iron) ×40.

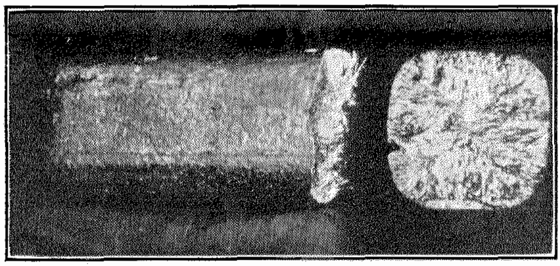


Figure 8—Brittle Ingot of Nickel-Iron Alloy × $\frac{2}{5}$.

An application of insulated compressed iron dust is for the cores of tuning coils of broadcast receivers in order to allow the size of the core to be reduced while maintaining the same inductance. This enables losses to be reduced and simplifies shielding. For this application, where the frequencies of the currents in the coil are high, it is necessary to use a very fine powder, and other methods of making iron powder are to be perferred.

(*b*) *Brittle Metals made Fine-Grained by Hot Rolling.*—Very shortly after the discovery, in 1923, by Elmen and Arnold of the magnetic nickel-iron alloy known as "Permalloy," attempts were made to produce it in powdered form, as it was seen that with this alloy it should be possible to make cores with lower hysteresis losses than with powdered iron, and with higher effective permeabilities.

As a result of this work—carried out largely by C. P. Beath and H. M. Heinicke of the Western Electric Company of Chicago a most interesting method has been developed[12]. The first step was to produce an alloy of iron with 70 to 90 per cent. of nickel which should possess intercrystalline brittleness. This proved relatively simple, for the alloy resembles nickel in its working properties—and normally needs to be carefully deoxidised with manganese and magnesium to be produced in a malleable form. It was therefore only necessary to leave out the deoxidiser to produce a brittle metal. The ingots obtained by casting an alloy treated in this way usually consist of long needle-like crystals which can easily be broken away from one another but which are themselves quite malleable. The appearance of the fracture of such an ingot is illustrated in Fig. 8. In this condition the crystals are obviously far too large to be of any use for making dust. It was found, however, that the ingots—although but a collection of large crystals weakly cemented together—would hold together sufficiently strongly to be hot rolled at a high temperature, and by this means the crystals can be reduced to a size small enough to give fine particles. The really striking feature of this process is that the new crystals possess brittle grain boundaries. It is usual to explain the intercrystalline brittleness of nickel as due to the presence at the crystal boundaries of a thin, weak, easily-melted film of Ni-Ni_3S_2 eutectic. But it is difficult to account for a continuous film of this around the crystals produced by rolling. It may be that at the high temperatures used in rolling the alloy, the nickel sulphide goes into solution and then is thrown out again on cooling at the new crystal boundaries; but it is difficult to accept the view that the dissolved sulphur has such extreme mobility. The general problem of intercrystalline failure of metals is, however, by no means understood, and the present example may be quoted as a particular case of a generally perplexing problem.

In practice, the rolling operation is carried out by heating the ingot to a high temperature, and rolling down in stepped rolls, the process being so adjusted that by the time the last roll is reached the temperature is just below that required for hot-rolling to continue successfully. The metal then breaks up in the last pass and emerges as a shower of small fragments which are collected into a heap with shovels. Fig. 9 shows the appearance of the material at this stage. These small fragments are then pulverised in ball mills, sieved, insulated, pressed to the final form, and heat-treated to give magnetic powder cores. A photograph of the dust is shown in Fig. 10.

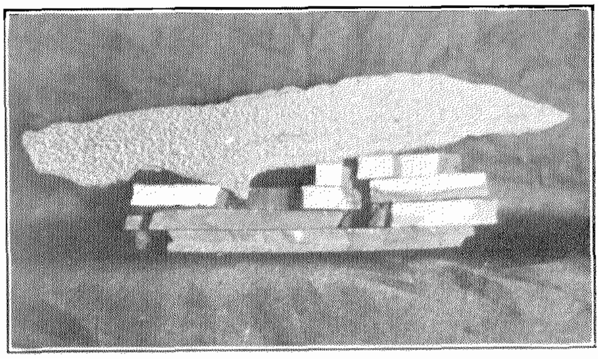


Figure 9—Hot-Rolled Brittle Fragments of Nickel-Iron Alloy × $\frac{2}{5}$.

The size distribution is not so wide as in powdered electrolytic iron, and the particles are reasonably equi-axed with an average diameter of about 75 microns.

Granulation Into Water

Granulation of a molten metal by pouring into water is a very old process. Lead shot is made by pouring molten lead through a sieve and allowing the globules to cool as they fall in air, finally collecting them in water. In this process, the addition of 0.5 per cent. arsenic is found to favour the production of spherical shot and to prevent the formation of elongated globules. The explanation[13] appears to be that the arsenic converts the solid skin of lead oxide (which, if present, tends to produce elongated drops) to a liquid film of lead arsenite, which remains molten down to 200° C.

Finer particles may be made by directing a stream of compressed air or steam against a stream of molten metal before it reaches the water. Aluminium is granulated in this way, and is produced as a dark grey, more or less spherical powder which is free from grease and more suited than the product of stamp mills for chemical and similar work. It is widely used for calorising, for the "Thermit" process, in the ammonal group of explosives, and as a precipitant for gold and silver in the cyanide process.

Granulation by Stirring Molten Metal

An interesting method of breaking up a molten metal is sometimes employed for making powdered aluminium. It is based on the observation that if this metal is stirred as it is solidifying in a crucible, it can be broken into a powder. A photograph of some powder made in this way is shown in Fig. 11. The process has been worked by putting molten aluminium in a shaking machine and operating it vigorously. It is commonly stated that in this operation the metal breaks up into grains because it is "hot short" at temperatures just below its melting point. Aluminium is certainly hot short at sufficiently high temperatures (probably on account of incipient melting at the crystal boundaries) and it might be possible to make use of this property by hot-rolling within a very narrow temperature range. It seems, however, much more likely that in stirring molten aluminium the powdering is brought about by entrapping oxide in the melt, thus forming oxide skins round the crystals first formed and preventing them from growing and uniting into a solid mass. Aluminium powder made by this method is sometimes used for thermit and the other applications already mentioned.

Condensation

Zinc dust is a common product of a condensation process, and is formed under certain conditions in the neck of zinc retorts. The essential factor for its formation is the presence of enough oxygen to form a thin skin of zinc oxide round each globule of zinc as soon as it is produced and so to prevent the condensed globules from coalescing. Zinc dust is used as a precipitant in the cyanide process for the recovery of gold as well as in other chemical processes.

Reduction of Compounds at Temperatures Below Their Melting Point

Those processes which produce a finely divided metal by direct reduction of a chemical compound will next be considered. The oldest, and possibly the most extensively practised of any, is carried out by heating a reducible compound in an atmosphere of hydrogen or other reducing gas at a temperature below the melting point of either metal or compound. In this operation, extremely wide variations in particle size, size distribution, and shape can be produced by suitable choice of compound, particle size of compound, composition of reducing gas, and temperature and time of reduction. In general, the particle size is smallest at low temperatures of reduction, and increases with increase in time and temperature of reduction.

Industrially, the most important application of this process is in the manufacture of tungsten and molybdenum powder, which is afterwards pressed and sintered into bars which are swaged and formed into wire and sheet[14]. Tungsten powder can be produced in sizes ranging from ½ micron to 500 microns in diameter, the usual size being 2 to 3 microns.

By reducing certain compounds of such metals as iron and nickel at low temperature the powder

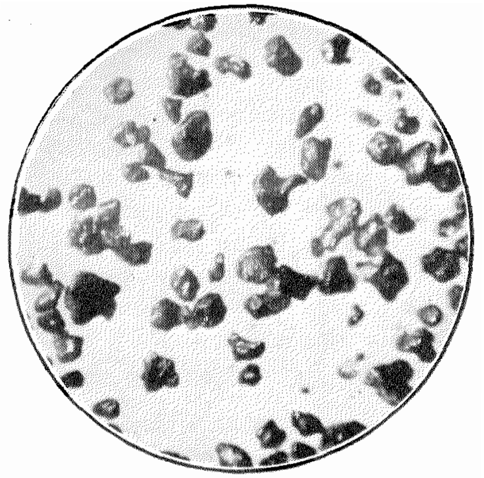


Figure 10—Nickel-Iron Alloy Powder (Ground from Hot-Rolled Brittle Fragments) × *75.*

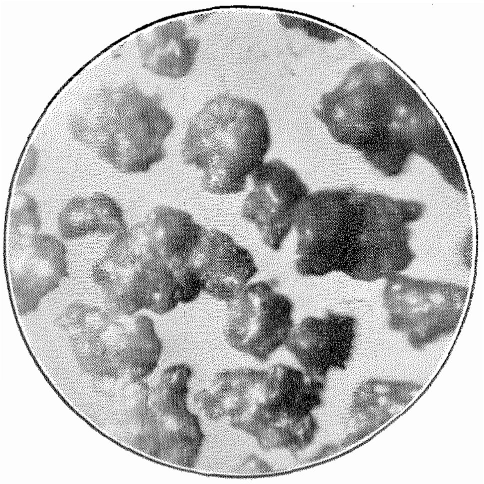


Figure 11—Aluminium Powder (By Stirring Molten Metal) × *50.*

Figure 12—Copper Powder (Electrolytically Produced) × *40.*

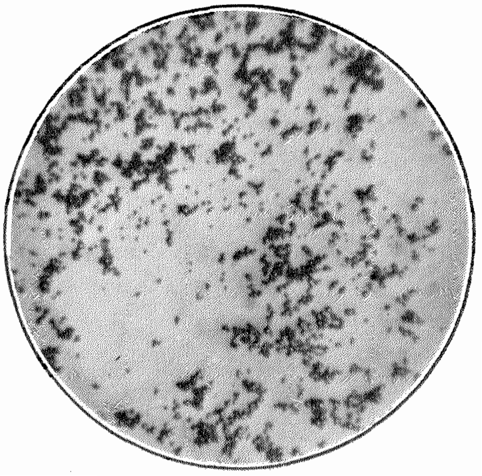


Figure 13—Iron Powder (Deposited from Iron Carbonyl) × *75.*

obtained is so fine that it will ignite on contact with air on account of the heat generated by surface oxidation. These are the well-known "pyrophoric" powders. Pyrophoric iron can be made by reducing iron oxalate at temperatures below 530° C., pyrophoric nickel-iron by reducing the mixed oxalates below 370° C.[15].

Reduction may be carried out as a batch operation in tube furnaces or as a continuous operation in which the oxide or other compound is placed in boats which are introduced into one end of a tube furnace and slowly pushed through against the stream of reducing gas.

Besides tungsten and molybdenum, other metals which are commercially made by reduction include iron, nickel, and cobalt. Powdered nickel is widely used as a catalyst, as in margarine manufacture. Powdered cobalt and nickel have recently found a most important application as the cements in carbide-tool materials. In this application, the powders are mixed with powdered tungsten or molybdenum carbide, pressed to shape and sintered.

Chemical Precipitation

Another well-known method of producing finely divided metals is by precipitation from solution, an example of which is the precipitation of finely divided tin from stannous chloride by scrap zinc in the manufacture of tin-coated paper for electrical condensers. In making this paper—known as Mansbridge paper—the tin is deposited on zinc in earthenware containers, periodically collected, washed, mixed with an adhesive, and spread on the paper. The paper is afterwards heavily calendered, with the result that a thin, electrically-continuous film of tin is formed on one side.

In most instances, metal precipitated by such means is formed in a spongy mass which can be pulverised to some extent by rubbing, but is not actually in a powdered form. It has recently been proposed to use aluminium powder in order to precipitate suitable metals from their salts[9]. Under these conditions a powder of the same grain size as the aluminium powder is said to be precipitated. It is necessary to add an "activating agent" to remove the oxide film from the aluminium, and for this purpose dilute solutions of mercury dichloride, hydrochloric acid, or alkaline chlorides are proposed.

Electro-Deposition as Powder

The common occurrence of metallic "fogs" in molten electrolytes and of spongy and non-adherent deposits when electro-plating from aqueous solutions have naturally encouraged many to attack the problem of depositing metals direct as powders. A large patent literature is in existence on the subject, and was recently reviewed by Rossman[16]. Many of the patents are best described under the librarian's classification of "curious." The more reasonable of them, however, make use of high current densities and rapid circulation of the electrolyte to produce a loosely adhering mass of powder; and in some instances this action is aided by the addition of certain colloids to the bath.

In recent years, considerable progress has been made in overcoming the difficulties of the process, and at the present time at least one metal powder—copper—is produced commercially by its means. Fig. 12 shows the appearance of this powder under the microscope, and illustrates the typical fern-like and nodular shapes met with. Automatic means have been patented for scraping the copper "trees' from the cathodes as fast as they are formed, and also for doing this in a non-oxidising atmosphere.

The principal application of copper powder has been in the manufacture of porous bearings. In making these, a mixture of 90 per cent. of powdered copper and 10 per cent. of powdered tin—usually with the addition of graphite—is pressed to the desired shape under about 3,000 kg./sq. cm., and heated to about 800° C. to sinter the particles together. Slight expansion occurs during this process, and the result is a strong and ductile product of which as much as half the volume is taken up by air pores. These are then filled with oil by a process of vacuum impregnation, and in this way an oil-containing self-lubricating bearing is produced.

Carbonyl Process

The last process in this classification—that depending on the decomposition of a gaseous compound—has only been employed since about 1927, and in practice is confined to the thermal decomposition of the metallic carbonyls—the most important of which are iron pentacarbonyl, $Fe(CO)_5$, and nickel carbonyl, $Ni(CO)_4$. Ironcarbonyl is a yellow liquid at room temperature and vaporises at 103° C. On heating further, the gas decomposes, yielding metallic iron and carbon monoxide. Nickel carbonyl is a gas at temperatures above 43° C. but, like iron carbonyl, splits up and deposits nickel on heating to higher temperatures.

The method employed for decomposing these carbonyls to yield a powder appears to be to introduce the carbonyl into a large hot container so that decomposition takes place in the hot free space and not in the neighbourhood of the walls[18]. Another method[19] which has been patented is to mix cool carbonyl vapour with a steam of hot inert gas in an enclosure, the walls of which are maintained at a temperature below that at which decomposition of the carbonyl occurs. In this way the carbonyl is prevented from depositing a film of metal on the walls of the container.

When the decomposition is properly carried out, the metal is obtained in the form of remarkably perfect spheres in sizes ranging from ½ to 5 microns. The beautifully regular appearance of the particles is shown in Fig. 13. It has been stated that each of the particles is a single crystal, but there is reason to believe that they have an "onion skin" structure, like Mond nickel shot, with annular discontinuities caused by differences in rate of decomposition and the inclusion of carbon.

The powders are virtually free from metallic impurities and sulphur, but are liable to contain small quantities of carbon and oxygen. Iron, nickel, and iron-nickel alloys are produced in powdered form by this process, and are used for magnetic cores and similar applications. The iron-nickel powders are preferably annealed to allow diffusion to occur and to ensure that they are in the condition of a uniform solid solution. Considerable attention has also been directed to the possibilities of pressing and sintering these carbonyl powders to produce finished articles or to yield an ingot which can later be forged or rolled in the usual manner[20]. The production of massive nickel may be taken as an example of this process. The powder, which contains small amounts of oxygen and carbon, is placed in a heat-resisting steel mould and either shaken for a short time or compressed. The container is then covered with a lid and heated to 1,200° C. for about 2 hours. During this time the oxygen and carbon combine and are driven off. It is preferable to work the sintered mass immediately after heating to consolidate the surface, after which reheating and further working can be carried out as desired. By rolling or forging in this way the density can be increased to 8.85. This process is said to result in the production of a metal with clean grain boundaries, and no inclusions or cavities.

These, and similar proposals made in America, have aroused considerable interest in the last two or three years[21]. It is claimed that by using powdered metals as a starting point and then pressing and sintering to a solid mass, the following advantages can be obtained:—

(1) The material is free from pipes and inclusions, and cropping is unncessary.
(2) Deoxidisers can be kept out of such metals as nickel.
(3) A purer product can in many cases be obtained.
(4) Alloys and metals can be produced which are otherwise unobtainable.
(5) Intimate mixtures of metals and non-metals can be formed.
(6) Bi-metals can be made by filling the mould with layers of different metal powders.

Up to the present, the characteristic which has proved of greatest value is the ability to produce material which can be made in no other way. The manufacture of ductile tungsten and molybdenum are outstanding instances of this. Other alloys which have been made by the methods of powder metallurgy are lead-copper, copper-chromium, copper-tungsten (for spot-welder electrodes), and copper-molybdenum. The claim that methods of powder metallurgy can give exceptionally pure metals requires careful consideration; it would seem that the possibility of appreciable amounts of oxide being entrapped in the sintering processes must not be overlooked. If this is avoided by conducting all operations in a reducing atmosphere, then it would seem necessary to consider the possible effect of gas which may be adsorbed at the particle surfaces. At present it is difficult to express an opinion as to how far and to what extent products made from sintered powdered metals are likely to replace those made by the more conventional methods of casting and working. For special purposes the method has great possibilities, and if in the future its use is extended plenty of processes capable of producing almost any metal or alloy in the form of powder will be available.

References

1. International Critical Tables, 1927, **2**, 331.

2. Sir Henry Bessemer, F.R.S. An Autobiography. *Engineering*, London, 1905.

3. E. Odernheimer. "Developments in Bronze Colour Manufacture." *Dinglers Polytech. J.*, 1896, **299**, 43-48: *J. Soc. Chem. Ind.*, 1896, **15**, 283-284.

4. Anon. "The Manufacture of Bronze Powder." *Met. Ind.* (*Lond.*), 1916, **9**, 165-167, 202-203, 225-227, 309-310, 365-366, 393-394, 449-450, 505-507.

5. Oliver Smalley. "The Manufacture of High-Grade Aluminium and Bronze Powder." *Met. Ind.* (*Lond.*), 1924, **24**, 273-274, 297-298, 445-446, 493-494, 569-570; **25**, 169, 369; 1925, **27**, 1, 93, 185, 283, 575.

6. Von Schenck. *Met. Ind.* (*N. Y.*), 1917, **15**, 77, 161, 200, 298.

7. Thorpe. "Dictionary of Applied Chemistry," **1**, 694-695.

8. Junius David Edwards. "Aluminium Bronze Powder and Aluminium Paint." Chemical Catalog Co., New York, 1927.

9. Anon. "Powdered and Granulated Aluminium." British Aluminium Co., Ltd. London, 1934.

10. E. Podszus. British Patent 183,134.
E. Kramer. British Patent 239,420, 278,999.

11. Buckner Speed and G. W. Elmen. "Magnetic Properties of Compressed Powdered Iron." *Trans. Amer. Inst. Elect. Eng.*, 1921, **40**, 1321-1359.

12. W. J. Shackleton and I. G. Barbour. "Compressed Powdered Permalloy." *Trans. Amer. Inst. Elec. Eng.*, 1928, **47** (2), 429-436. W. C. Ellis and Earle E. Schu-

macher "Magnetic Materials." *Metals and Alloys*, 1934, **5**, 269-276.

13. G. Tammann and K. L. Dreyer. "The Shape and Structure of Lead Shot." *Z. Metallkunde*, 1933, **25**, 64.

14. Colin J. Smithells. "Tungsten." Chapman and Hall, London, 1926.

15. G. Tammann and N. Nikitin. "The Pyrophoric Property of Metal Powders." *Z. Anorg. Chem.*, 1924, **135**, 201-204.

16. J. Rossmann. "Powdered Metals by Electrolytic Methods." *Met. Ind.* (*N. Y.*), 1932, **30**, 321-322, 396-397, 436, 468-469.

17. Anon. "'Oilite': An Oil-Containing Bearing Bronze." *Met. Ind.* (*Lond.*), 1933, **42**, 430-431.

18. I. G. Farbenindustrie. British Patent 244,895, 269,677, 284,087, 401,438.

19. General Electric Co., L. D. Goldsmith and J. F. Jackson. British Patent 300,691.

20. F. Duftschmid, L. Schlecht, W. Schubardt. "The Working-up of Carbonyl Iron by Sintering." *Stahl u. Eisen*, 1932, **52**, 845-849. G. Hamprecht and L. Schlecht. "On a New Process for the Technical Working of Nickel." *Metallwirtschaft*, 1933, **12**, 281-284.

21. Charles Hardy. "Manufacture and Use of Powdered Metals." *Metal Progress*, 1932, **22** (1), 32-37, 80. Charles Hardy. "Powder Metallurgy." *Met. Ind.* (*N. Y.*), 1932, **30**, 179-180. W. P. Sykes. "Powder Metallurgy as Illustrated by Tungsten." *Metal Progress*, 1934, **25**, 24-29.

Some Results of Tests on Coil Loaded Telephone Cables of The Copenhagen Telephone Company

By L. J. SALTOFT, B.Sc.

Assistant Chief Engineer, Copenhagen Telephone Company

IN THE year 1912, relatively early during the development of coil loading, the first coil loaded cables in Denmark were installed by the Copenhagen Telephone Company on the routes Copenhagen-Elsinore and Copenhagen-Holte. The following year another loaded cable was laid from Copenhagen to Roskilde and the Copenhagen-Holte cable was extended to Hillerød (Fig. 1). All these cables were constructed as quadded cables according to the Dieselhorst-Martin system; but as it was possible to insert the phantom coils later, and as the phantom circuits were not needed at that time, only the side coils were installed. In 1923 a cable was laid between Copenhagen and Frederikssund, in which the heavy gauge wires were loaded with both side coils and phantom coils during installation, while the smaller gauge wires were loaded with side coils only.

Owing to a great increase in traffic more loaded cables were required at that time, and it became necessary for the Copenhagen Telephone Company to make decisions regarding future requirements, particularly whether the phantom circuit could be dropped in order to obtain the benefits of the more flexible paired cables for the relatively short distances involved.

First of all, the motor traffic in Denmark, to an increasing degree, has caused many and extensive widenings and alterations of the main roads; and, since the main telephone cables naturally follow the roads mentioned, this has often necessitated relaying the telephone cables on relatively long routes. In the case of cable installed and balanced for phantom working, special precautions may be required to maintain the jointing scheme or to rebalance when moving the cable.

In order to show how much influence relaying of the road may have on a phantom loaded cable which has been balanced, the above mentioned Copenhagen-Frederikssund cable may be taken as an example. The total length is about 40 km. with a loading coil spacing of about 2.2 km. In the centre of the cable are placed 20 quads of 1.2 mm. wire and around these are placed .8 mm. pairs, the number of which varies along the route. The 20 quads are loaded for phantom working and go straight through from Copenhagen to Frederikssund without branching off. After the cable had been in operation for some years it was moved on account of widening of various sections of the road in which it was placed. The resulting changes in capacity unbalances without any precautions or rebalancing are given in the table below:

Route	Length of Cable Moved	Change in Phantom to Side Capacity Unbalance	
		Average	Maximum
Coil 4 — Coil 5	664 m.	76 m.m.f.	380 m.m.f.
Herløv Cable hut—Coil 6	1,125 m.	43 m.m.f.	420 m.m.f.
Coil 6 — Coil 7	2,181 m.	50 m.m.f.	330 m.m.f.
Coil 7 — Coil 8	918 m.	59 m.m.f.	207 m.m.f.
Coil 8 — Coil 9	618 m.	58 m.m.f.	330 m.m.f.
Coil 12 — Coil 13	560 m.	69 m.m.f.	400 m.m.f.
Coil 15 — Coil 16	600 m.	106 m.m.f.	560 m.m.f.

The many relatively small rural telephone exchanges on Sealand, about 400 altogether, are situated comparatively close to one another, with the result that the main cables must have rather many branching-off points, as will appear from Fig. 1. Those exchanges which have direct connection with the loaded cables are indicated

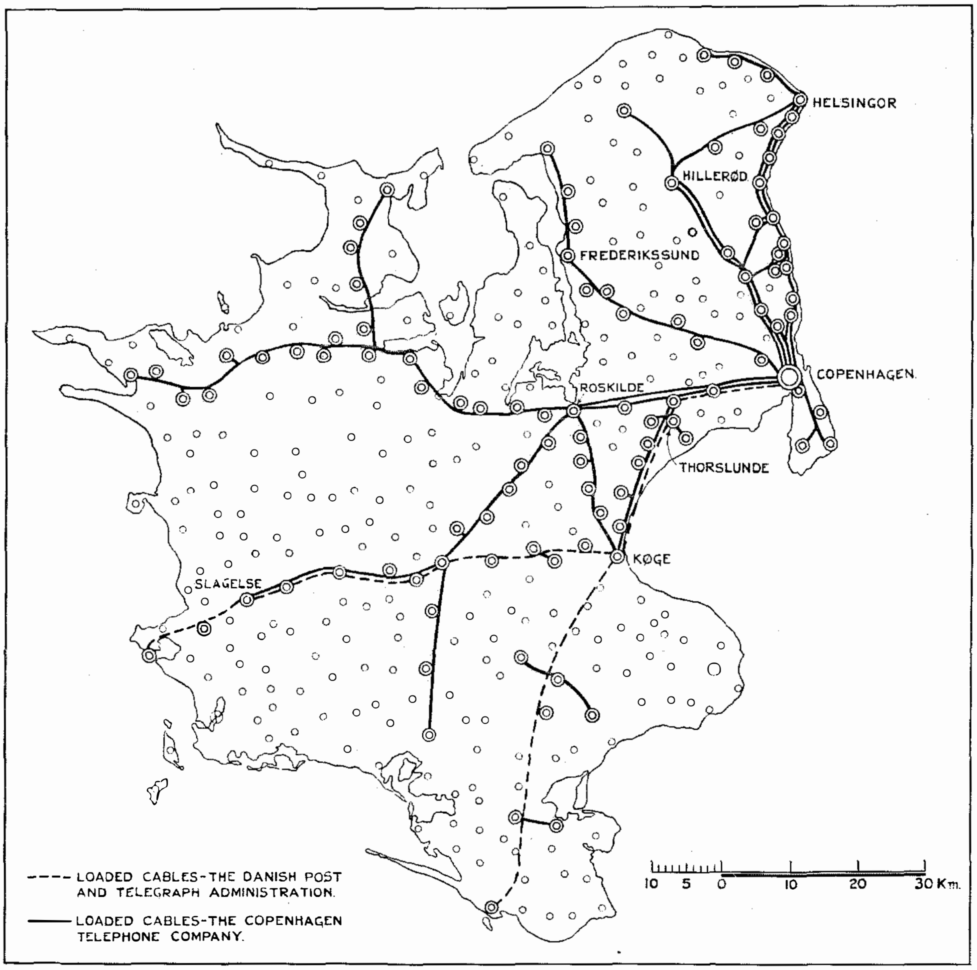


Figure 1—Loaded Cables of The Danish Post and Telegraph Administration and The Copenhagen Telephone Company.

by a double circle. This distribution of junctions and trunk connections in comparatively small bundles, often containing unequal numbers of circuits, in itself decreases the possibility for phantom working, which normally is 50%, to about 30%. Under these conditions, the economy of phantom loaded cables is less than usually expected.

On account of the above mentioned reasons it was decided to construct all new cables as pair cables, thus making no provision for future phantom working. The question then arose as to whether the Danish cable industry represented by the Northern Cable & Wire Works, Ltd., which for a number of years had been manufacturing subscribers cable satisfactorily, would be able to manufacture coil loaded cables. Negotiations resulted in collaboration between the Northern Cable & Wire Works and the International Standard Electric Corporation regarding delivery of coil loaded cables, whereby the Danish cable factory delivered the cables, whereas Standard Electric delivered the necessary loading equipment and placed at the Cable factory's disposal its wide experience in the construction of long distance cables. In competition with several foreign cable factories, it appeared that the Danish Cable factory was able to hold its own with regard to prices as well as quality.

The first coil loaded cable manufactured by the Northern Cable & Wire Works was delivered in the year 1923, and the collaboration between the two firms has since resulted in the delivery of a large number of long distance cables.

In order to increase the crosstalk attenuation without systematic reduction of the capacity unbalances, the cables are jointed according to predetermined jointing schedules in such a way that each pair changes its position in the cable cross-section from manufacturing length to manufacturing length. The aim of this procedure is to avoid the possibility of two pairs being adjacent for more than one manufacturing length and thus distribute the capacity unbalances originating from the manufacturing processes evenly on all pairs in the cable. Fig. 2 shows such a random splicing schedule and Fig. 3, the corresponding cable profile for a section of the coil loaded Thorslunde-Køge cable.

UP	DOWN	UP	DOWN	UP	DOWN
● 1	10	28	27	55	79
▨ 2	22	29	16	▨ 56	48
● 3	39	30	44	● 57	33
4	59	31	71	58	55
5	11	32	28	59	75
6	23	33	4	60	49
7	43	34	17	61	34
▨ 8	54	35	63	62	64
● 9	67	▨ 36	45	63	76
10	12	● 37	5	64	35
11	24	38	18	65	50
12	40	39	29	66	▨ 56
13	● 1	40	72	67	65
14	68	41	6	68	77
15	13	42	46	69	▨ 36
16	25	43	19	70	51
17	41	44	30	71	● 57
18	60	45	7	72	78
19	69	46	73	73	● 37
▨ 20	14	47	▨ 20	74	52
● 21	26	48	31	75	66
22	42	49	▨ 8	76	58
23	62	50	47	77	38
24	▨ 2	51	● 21	78	53
25	15	52	74	79	61
26	70	53	● 9	▨ 80	▨ 80
27	● 3	54	32		

Figure 2—Random Splicing Schedule.

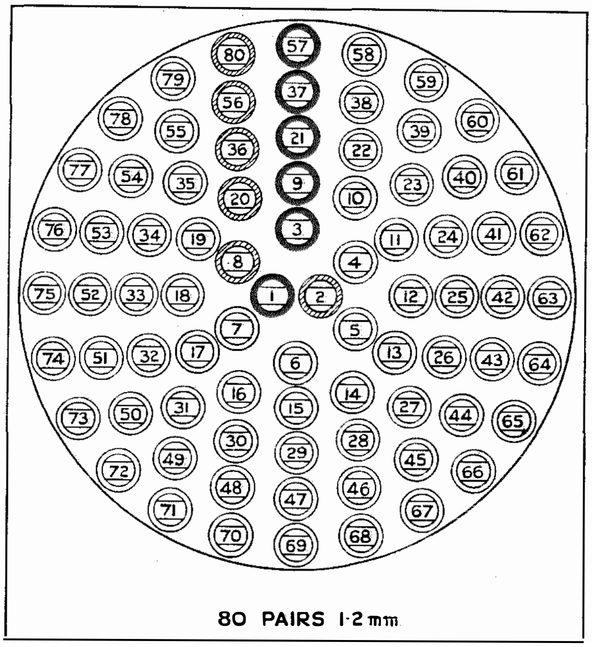


Figure 3—Cable Profile—Coil Loaded Thorslunde-Køge Cable.

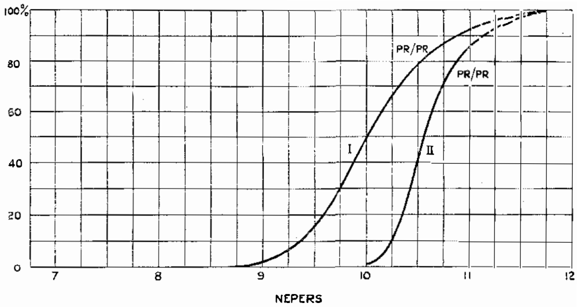


Figure 4—Results of Crosstalk Measurements at Speech Frequencies.

The hatched and the filled out circles and rings in Figs. 2 and 3, respectively, indicate the tracer wires in each layer. As each pair, both in the up direction and the down direction, is provided with a numbered label as soon as the lead is stripped off the ends and the pairs spread out, it is comparatively easy for the jointer to carry out the work according to the random splicing schedule.

It is obvious that, when this method is employed, no difficulty is met with if later road widenings make it necessary to place the cable

TABLE I

Route	Cable			Loading Coils						
	d mm.	Ohm/ km.	µf./km.	S m.	mh. 800 p:s	mh. 1,800 p:s	R Ohm	R 800 p:s	R 1,800 p:s	Ohm/ Amp.
Roskilde-Slagelse 1923	1.2	14.8	0.0382	2,200	174.2		7.0			
Thorslunde-Køge 1934	1.2	14.7	0.0345	1,710	139.0	140.0	4.20	5.20	8.10	600

in a new position in the road and rejoint it according to the random schedule without impairing the overall crosstalk characteristics of the cable. As no measurements are involved, the cost incurred by the above mentioned operation need scarcely be more than the cost of the jointing work itself.

As examples, in Tables I and II are given the electrical data for two such coil loaded cables installed in 1923 and 1934, respectively:

As these tables show, the cable installed in 1923 has a loading coil spacing of 2,200 m., while the 1934 cable was installed according to the newer systems with a loading coil spacing of 1,700 m. and a cut-off frequency of 3,400 p:s.

In Fig. 4, the results of the crosstalk measurements at frequencies corresponding to speech are plotted in the form of curves showing frequency of occurrence. Curves I and II indicate the results for the above mentioned cables of 1923 and 1934, respectively. The curves show that great improvements in manufacture have taken place during the intervening years, the average crosstalk attenuation having been increased from 10.1 to 10.8 népers and the minimum crosstalk attenuation from 8.6 to 10.0 népers.

TABLE II

Route	The Completed Plant					
	MΩ/km	Néper/ km. 800 p:s	Z 800 p:s	f_0	Cross-talk Average	Cross-talk Min.
Roskilde-Slagelse 1923	30,000	0.0117	1,530	2,600	10.1	8.6
Thorslunde-Køge 1934	79,400	0.0111	1,550	3,450	10.8	10.0

Since the results have been satisfactory and proved suitable for the conditions under which the Copenhagen Telephone Company carries on its work, the cooperation with the Danish cable industry represented by the Northern Cable & Wire Works and with the International Standard Electric Corporation has been continued through the years with the result that 80% of the present number of loaded pair kilometers, about 70,750, have been delivered as the product of a Danish industry.

Description des Installations Téléphoniques des Chemins de Fer de L'Etat Dites de la "Gare Saint-Lazare" à Paris

par **A. DAMOISEAUX, C. de VRIENDT, et R. BOUCHER**
Le Matériel Téléphonique, Paris, France

LES installations téléphoniques des chemins de fer de l'Etat ont pour but de faciliter les communications de tous genres nécessitées par l'exploitation du réseau de chemins de fer qui forme un des monopoles de l'Etat Français et qui couvre la partie occidentale de la France, comprise entre les côtes de l'Océan Atlantique et de la Manche, et deux lignes qui seraient tracées l'une de Paris à Bordeaux et l'autre de Paris à Dieppe. Cette partie de la France comprend les importantes provinces de Normandie, de Bretagne et du Sud-Ouest; elle est desservie par un réseau très étendu de chemins de fer, dont les lignes principales sont celles de:

Paris à Dieppe;
Paris à Rouen et le Hâvre;
Paris à Granville et Saint-Malo;
Paris à Chartres, Le Mans, Rennes, Brest;
Paris à Chartres, Angers, Nantes;
Paris à Saumur, La Rochelle, Rochefort-sur-mer;
Paris à Saumur, Niort, Bordeaux.

Les installations téléphoniques de la gare Saint-Lazare relient entr'eux les services du réseau de chemins de fer qui constituent la Direction Générale, et dont les principaux sont:

Le Conseil d'Administration, la Direction, l'Exploitation, le Matériel et la Traction, les Voies, Bâtiments et Constructions Nouvelles, le Personnel, les Services Sociaux, Sanitaires et Hospitaliers, la Police Générale du réseau, etc.; à ces départements généraux s'adjoignent les nombreuses subdivisions et dépendances nécessaires au service immédiat des grandes gares de Paris (Saint-Lazare SL, Montparnasse MP et Invalides) et des nombreuses gares des environs de Paris, les magasins, les ateliers, les dépôts de matériel et de combustibles, etc.

La plupart de ces services et dépendances sont desservis par des postes réunis en de nombreux petits bureaux centraux appelés "groupes" ou "standards" (gares, dépôts, ateliers, bureaux techniques ou administratifs, laboratoires, magasins, etc.) reliés entr'eux et aux grandes gares dont ils dépendent, par des jonctions généralement à double sens, appelées jonctions "privées"; ces installations réalisées progressivement par extensions et raccordements successifs, constituent un réseau dans lequel la variété et la complexité des méthodes d'opération ne permettent pas d'obtenir dans toutes les circonstances la rapidité et la sécurité nécessaires à une utilisation réellement efficace.

Les relations du chemins de fer avec les grands organismes de l'Etat et avec la population sont assurées par le reliement des principaux groupements de postes du chemins de fer avec les bureaux centraux du réseau téléphonique de Paris, monopole de l'Administration des P.T.T. et par des jonctions spéciales reliant entr'eux les groupes de postes du chemin de fer.

L'Administration des chemins de fer de l'Etat est considérée par l'Administration des P.T.T. de l'Etat comme un abonné ordinaire à lignes groupées, dites lignes d'abonnement ou lignes P.T.T.; chacune de ces lignes donne à l'abonné la disposition d'un poste normal ou d'abonnement. D'autres postes des chemins de fer, en surplus des postes d'abonnement et appelés postes "supplémentaires" peuvent jouir de l'accés au réseau de l'Etat ou P.T.T., moyennant le paiement d'une redevance spéciale pour chacun d'eux.

Par extension, le terme "supplémentaire" a été appliqué non seulement à tous les postes d'abonnement et de surplus pouvant correspondre avec le réseau P.T.T., mais encore à la totalité du trafic de ces postes avec le réseau P.T.T. et à toutes les parties des installations de l'abonné, tableaux, commutateurs, lignes, jonctions, etc., pouvant être mises en communication avec le réseau P.T.T.

On trouve ainsi dans le réseau téléphonique du chemin de fer des postes "privées" pouvant communiquer librement avec tous les autres postes du chemin de fer, mais auxquels toute relation avec le réseau public des P.T.T. est interdite et doit même être rendue irréalisable; des postes "supplémentaires" pouvant communiquer non seulement avec tous les autres postes du chemin de fer, mais encore avec le réseau des P.T.T.; les communications échangées entre ces postes et le réseau P.T.T. sont soumises à la même taxation que les communications des postes normaux d'abonnés du réseau P.T.T.

Une distinction semblable est faite pour les jonctions reliant entr'eux les groupes de postes du chemin de fer:

Les jonctions "privées" entre deux groupes ou standards ne peuvent écouler que le trafic des postes privés et des postes supplémentaires entr'eux, à l'exclusion de tout reliement avec le réseau P.T.T.

Les jonctions "supplémentaires" entre deux groupes ou standards sont réservées au trafic des postes "supplémentaires," tant pour le service privé que pour le service avec le réseau P.T.T.

Les principaux groupes du chemin de fer, et tout au moins ceux qui comprennent des postes supplémentaires, sont reliés aux bureaux centraux du réseau des P.T.T. par des lignes d'abonnement ou lignes P.T.T., divisées elles-mêmes en:

> Lignes spécialisées A à service restreint; (appels du CF vers P.T.T.:)
> lignes spécialisées B; (appels P.T.T. vers CF)
> lignes mixtes à service général (utilisées dans les deux sens, et pour appels CF vers régional, interurbain, etc.)
> lignes interurbaines (entre le chemin de fer et le bureau interurbain des P.T.T.)

Les jonctions supplémentaires entre deux groupes ou standards CF ne paraissent justifiées que si l'un des groupes, bien que contenant des postes supplémentaires, n'avait pas de reliement direct par lignes P.T.T. avec le réseau P.T.T.; en réalité, tous les groupes CF sont pourvus de lignes directes P.T.T.; des jonctions privées seraient donc suffisantes. Mais les jonctions privées, dès qu'elles franchissent dans leur parcours une partie du domaine public, donnent lieu au profit des P.T.T., à une redevance supérieure à celle qui est due pour des jonctions supplémentaires de même parcours. Le CF tire parti de cet avantage économique en installant chaque fois qu'il est possible des jonctions supplémentaires, qui peuvent écouler la totalité du trafic des postes supplémentaires, lesquels ont également accès aux jonctions privées, et des jonctions privées, ces dernières étant les seules accessibles aux postes privés.

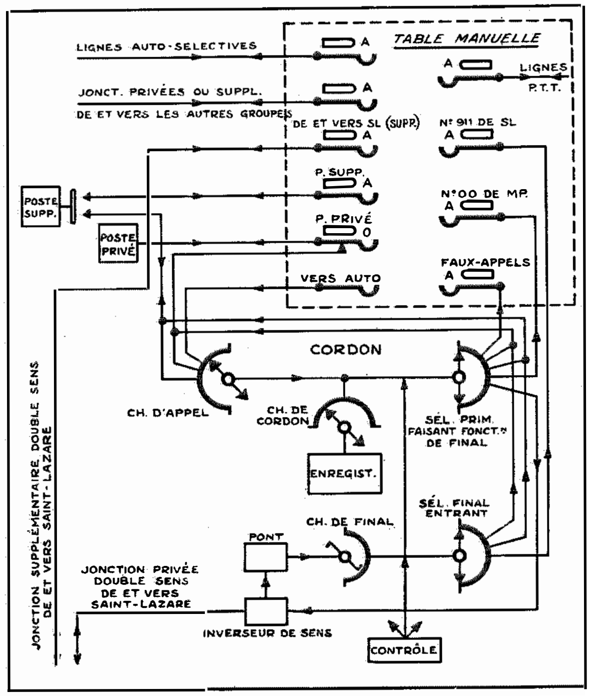


Figure 1—Groupe de Montparnasse—Diagramme de Jonction.

La réorganisation des services téléphoniques des chemins de fer de l'Etat a été entreprise par "Le Matériel Téléphonique" pour la partie comprenant les groupes de la gare Saint-Lazare et de la gare Montparnasse à Paris; sans rien modifier aux autres installations existantes, cette réorganisation a pour but de transformer le réseau actuel très disparate et très imparfait, en un réseau homogène, équipé en système Rotary 7.D, avec chercheurs-sélecteurs à un seul mouvement, enregistreurs et mécanisme d'entraînement; lorsque ce réseau homogène sera terminé, tous les postes du chemin de fer seront pourvus d'un numérotage uniforme permettant à un poste quelconque d'atteindre automatiquement un autre poste quelconque par une seule méthode opératoire identique, en supprimant toute intervention manuelle tant au départ qu'à l'arrivée, et toute subdivision de l'appel avec répétition du signal de transmission ou d'envoi.

1$^{\text{ère}}$ PARTIE

GARE MONTPARNASSE

L'importance capitale des communications téléphoniques entre les postes d'un réseau de chemin de fer à grand trafic exige que ces communications, dans toutes les circonstances qui peuvent se présenter, soient établies avec rapidité, certitude et sécurité; il semble qu'un bon moyen d'exposer clairement les méthodes adoptées pour la réalisation des installations des gares Saint-Lazare et Montparnasse soit d'en analyser successivement tous les éléments; c'est le programme qui sera suivi dans cet article, dans lequel il est fait usage des abréviations suivantes:

SL: Saint-Lazare;
MP: Montparnasse;
PTT: Réseau Téléphonique de l'Etat, dans la Région Parisienne;
CF: Réseau particulier des chemins de fer de l'Etat.

Les services intérieurs de la gare MP sont assurés par 45 postes privés et 45 postes supplémentaires; la gare MP est reliée à la gare SL par 4 jonctions privées et 2 jonctions supplémentaires, au réseau P.T.T. par des lignes P.T.T. aboutissant au bureau central automatique (Rotary 7.A) "Littré", aux autres groupes ou standards du CF par des jonctions privées et des jonctions supplémentaires.

Le service de la gare MP elle-même a été seul englobé dans la transformation actuelle; il est assuré par un équipement automatique complet en relation directe avec le groupe de la gare SL; une table manuelle assure le service de la gare MP avec le réseau P.T.T. et avec les autres groupes CF.

Postes privés avec lampes d'occupation—

Chacun des 45 postes privés est relié à l'automatique seulement, mais il est représenté à la table manuelle par une lampe d'occupation et un jack individuel; cette lampe s'allume aussitôt et reste allumée aussi longtemps que le poste est occupé comme demandeur ou comme demandé.

Le poste privé n'a pas de lampe d'appel à la table manuelle; il ne peut appeler l'opératrice que par l'automatique, en envoyant le N° 00 qui lui est assigné et qui ne doit être utilisé que par les postes MP; par contre, même lorsqu'il est occupé, il peut être appelé à tout moment par l'opératrice, en service privé seulement, pour un appel émanant d'un autre poste MP privé ou supplémentaire, ou parvenant d'un autre groupe par une jonction privée.

Les postes privées MP ont accès par les sélecteurs primaires (faisant fonction de finals) des cordons automatiques:

aux postes privés et aux postes supplémentaires MP, par l'envoi du numéro de 3 chiffres du poste demandé;
aux postes privés et aux postes supplémentaires SL, par l'envoi du numéro de 3 chiffres du poste demandé, l'appel utilisant automatiquement une jonction privée à double sens MP-SL;
à l'opératrice MP, par l'envoi du numéro 00 réservé à cette opératrice pour les postes privés et les postes supplémentaires MP seulement.

Postes supplémentaires à double ligne—

Le poste supplémentaire peut être mis en communication avec les lignes P.T.T. et avec les jonctions supplémentaires; il est relié au bureau central MP par deux lignes, à l'une ou à l'autre desquelles il est rattaché par la manoeuvre des clés dont il est pourvu, la ligne laissée libre restant sur sonnerie.

La première ligne est la ligne privée, reliée exclusivement à l'automatique comme la ligne d'un poste privé, mais sans lampe d'occupation ni jack à la table manuelle; la ligne privée donne au poste supplémentaire les mêmes facilités qu'au poste privé; le poste supplémentaire a donc accès automatique complet aux postes privés et supplémentaires MP et SL, par l'envoi du numéro de 3 chiffres du poste demandé, et à l'opératrice MP par l'envoi du N° 00.

La deuxième ligne est la ligne supplémentaire, qui relie le poste à la table manuelle où elle est pourvue d'une lampe d'appel et d'un jack individuels; tout appel émis par le poste sur cette ligne ne peut être desservi que par l'opératrice MP, à destination d'une ligne P.T.T. ou d'une jonction vers un autre groupe CF.

Les dispositifs de la table manuelle sont tels que les lignes des postes privés ne peuvent pas être reliées aux lignes P.T.T. ni aux jonctions supplémentaires; par contre, aucune restriction n'existe pour les postes supplémentaires.

Le diagramme de jonction de la fig. 1 représente dans son état actuel l'équipement automatique du groupe MP. Cet équipement comprend:

9 cordons formés chacun d'un chercheur

d'appel et d'un sélecteur primaire faisant fonction de sélecteur final; les lignes des postes privés et les lignes privées des postes supplémentaires sont multiplées à la fois dans les arcs des chercheurs d'appel et des sélecteurs primaires; les 9 cordons sont desservis par 3 enregistreurs avec chercheurs de cordon.

En même temps que les lignes des postes, 3 lignes provenant de la table manuelle, où elles sont pourvues de jacks individuels, sont multiplées dans les arcs des chercheurs d'appel, tandis que trois autres lignes, aboutissant à la table manuelle où elles sont pourvues de lampes d'appel et de jacks individuels sont multiplées dans les arcs des sélecteurs primaires; c'est la première disponsible de ces trois dernières lignes qui est atteinte lorsque le demandeur de MP envoie le N° 00 pour appeler l'opératrice MP. Enfin, dans l'arc des sélecteurs primaires des cordons sont multiplées les jonctions privées à double sens MP-SL; la première disponible de ces jonctions est prise automatiquement par un appel d'un poste MP envoyant le numéro de 3 chiffres d'un poste SL.

Jonctions privées à double sens MP-SL—

Ces jonctions écoulent le trafic entre les postes privés et les postes supplémentaires des deux groupes et ne peuvent pas être utilisées pour le trafic émanant ou à destination du réseau P.T.T.

Chacune des quatre jonctions privées actuellement équipées est pourvue d'organes d'inversion de sens ou d'aiguillage, d'alimentation et de discrimination et se termine à un chercheur de sélecteur final; les nombres des jonctions privées, qui peuvent atteindre 6, et des sélecteurs finals entrants étant très faibles, ne justifieraient qu'un seul contrôle ce qui serait insuffisant pour assurer la rapidité et la sécurité désirables; aussi à sa partie entrante, la jonction se termine aux balais d'un commutateur pas-à-pas qui recherche dans son arc un sélecteur final disponible dans une section actuelle de sélecteurs finals dont le contrôle est lui-même disponible.

Ultérieurement, lorsque le nombre des postes du groupe MP dépassera 90, il sera nécessaire de faire intervenir des sélecteurs secondaires et des sélecteurs finals; la jonction aboutira aux balais d'un sélecteur secondaire qui sera raccordé à un contrôle secondaire par un chercheur de jonction; ce chercheur de jonction sera le commutateur pas-à-pas utilisé momentanément comme distributeur de sélecteur et de contrôle finals.

Dans l'état actuel, tout appel parvenant de SL par une jonction privée recherche en premier lieu un sélecteur final entrant dont le contrôle est disponible; dans les arcs des sélecteurs finals entrants ainsi accessibles aux jonctions privées sont multiplées les lignes des postes privées, les lignes privées des postes supplémentaires et trois lignes aboutissant à la table manuelle où elles sont pourvues de lampes d'appel et de jacks individuels; ces lignes sont réservées aux appels émanant des postes ou des opératrices SL à destination de l'opératrice MP, appelée automatiquement par l'envoi du N° 911 par le poste demandeur.

Au-delà de leur aiguillage, les jonctions privées sont multiplées dans les arcs des sélecteurs primaires des cordons automatiques et peuvent ainsi écouler le trafic dans le sens MP-SL.

Jonctions supplémentaires à double sens MP-SL—

Ces jonctions écoulent principalement le trafic des postes supplémentaires MP et SL entr'eux; elles peuvent en outre écouler le trafic de ces postes supplémentaires avec le réseau P.T.T., mais ne peuvent en aucun cas être reliées aux postes privés de ces deux groupes.

Un poste supplémentaire quelconque MP, après s'être fait relier par l'opératrice MP à une jonction supplémentaire MP-SL, peut ensuite appeler, sans aucune autre intervention de l'opératrice MP, un poste supplémentaire quelconque SL, en envoyant au moyen du cadran d'appel le numéro de 3 chiffres de ce poste.

Chacune des deux jonctions équipées actuellement aboutit directement à la table manuelle MP où elle se termine par une lampe d'appel et un jack individuels; elle peut être mise en communication directe, par un cordon manuel, avec la ligne supplémentaire d'un poste supplémentaire quelconque MP, ainsi qu'avec une jonction supplémentaire vers un autre groupe rattaché à MP ou avec une ligne P.T.T. reliant la table manuelle MP au réseau P.T.T.

La disposition des organes de la table manuelle MP (fiches, jacks, clés, etc.) interdit toute mise en communication des postes privés avec les lignes P.T.T. et les jonctions supplémentaires.

Appel direct des opératrices SL par les jonctions supplémentaires—

Chacune des jonctions supplémentaires qui relient MP à SL est pourvue à la table manuelle MP, d'un dispositif d'appel direct qui permet à l'opératrice MP, par le seul enfoncement d'une clé, de créer à SL un appel signalé par le scintillement de la lampe d'occupation de la jonction; en service normal, cette lampe s'allume et reste allumée aussitôt et aussi longtemps que la jonction est occupée. Le dispositif d'appel direct transforme les jonctions supplémentaires qui aboutissent à SL en lignes d'ordre et facilite considérablement le service des opératrices des groupes distants, chaque fois que ces opératrices doivent recourir à l'intervention de leurs collègues de SL; il s'applique non seulement aux jonctions supplémentaires MP-SL, mais encore aux jonctions supplémentaires provenant des autres groupes distants.

Autres liaisons du groupe MP—

Les lignes P.T.T. de la gare MP (lignes groupées) reliant la gare MP au bureau urbain automatique (Rotary 7.A) "Littré" du réseau P.T.T., les jonctions privées et supplémentaires entre le groupe MP et les autres groupes CF, les lignes autosélectives équipées suivant le système "train dispatching" mais servant exclusivement au service téléphonique comme des lignes partagées ou "party lines" à appels directs entre deux postes quelconques de la même ligne, aboutissent exclusivement à la table manuelle MP où elles sont desservies par des procédés purement manuels ou semi-automatiques, adaptés, à l'équipement manuel ou automatique du groupe distant.

Faux-appels—

Les dispositifs permettant de déceler les faux-appels sont les mêmes que ceux qui sont décrits dans la deuxième partie de cet article.

2ème PARTIE

GARE SAINT-LAZARE

Equipement et Service Privé

Les vastes bâtiments de la gare Saint-Lazare à Paris contiennent non seulement les bureaux et les dépendances du chemin de fer dans la circonscription ou l'arrondissement dont elle est le centre, mais encore la plupart des bureaux de la Direction Générale des Chemins de Fer de l'Etat pour toute l'étendue du réseau. Elle est pourvue d'un bureau central téléphonique comprenant une partie automatique et une partie semi-automatique; ce bureau est lui-même relié au réseau téléphonique P.T.T. par des lignes P.T.T. spécialisées A, spécialisées B, mixtes et interurbaines, et aux nombreux petits centraux desservant les gares voisines, les dépôts, les ateliers, les magasins, etc., par des jonctions privées et par des jonctions supplémentaires.

Parmi les lignes et jonctions, la plupart sont entièrement métalliques à deux fils sans retour commun ni prise de terre; quelques-unes sont des circuits fantômes ou des circuits à courant porteur; les jonctions privées et les jonctions supplémentaires sont à double sens.

1. Equipement Automatique—(Fig. 2)

L'équipement automatique dessert exclusivement le trafic privé du chemin de fer et ne peut en aucun cas intervenir dans la mise en communication d'un poste privé ou d'un poste supplémentaire avec une ligne P.T.T. ou une jonction supplémentaire, ni inversément.

Postes privés—Les postes privés n'ont pas droit à la mise en communication avec le réseau P.T.T.; leur nombre qui peut être porté à 466 est actuellement de 320.

Les lignes des postes privés les relient au bureau automatique, sans aucune communication directe avec la table manuelle; elles sont divisées en groupes de 100 et sont multiplées dans les arcs des chercheurs de ligne et des sélecteurs finals; des cordons, composés chacun d'un chercheur d'appel et d'un sélecteur primaire et accessibles à des enregistreurs avec chercheur de cordon, assurent les communications demandées par les postes privés.

Les sélecteurs primaires des cordons automatiques ont accès sous le contrôle des enregistreurs:

- aux sélecteurs finals des postes privés SL et des postes supplémentaires SL;
- aux jonctions à double sens de et vers la gare Montparnasse, cette gare constituant le seul groupe distant actuellement englobé dans la transformation des installations;
- aux sélecteurs finals des jonctions privées, des lignes autosélectives et des opératrices SL.

Un poste privé SL peut ainsi atteindre directement:

un poste privé SL ou un poste supplémentaire SL, par l'envoi du numéro de 3 chiffres du poste demandé;

un poste privé MP ou un poste supplémentaire MP par sa ligne privée, par l'envoi du numéro de 3 chiffres du poste demandé; la communication occupe automatiquement une jonction privé disponible à double sens SL-MP;

une opératrice MP, par l'envoi du numéro 911 utilisable par les postes SL seulement;

une opératrice SL, par l'envoi du numéro 00 utilisable par les postes SL seulement;

l'opératrice d'un groupe manuel ou automatique distant relié par jonction privée à SL, par l'envoi du numéro de 3 chiffres de ce groupe;

une ligne autosélective, par l'envoi du numéro de 3 chiffres de la ligne demandée, l'appel faisant intervenir une opératrice SL, qui s'informe du numéro du poste désiré et qui complète la mise en communication.

Au point de vue du service privé, les deux catégories de postes supplémentaires ne diffèrent pas entr'elles; leurs lignes divisées en groupes de 100 au répartiteur général, sont pourvues à leur entrée au bureau central d'un aiguillage constitué par un groupe de relais; au-delà des aiguillages, elles sont desservies par des chercheurs de ligne qui leur sont réservés; les cher-

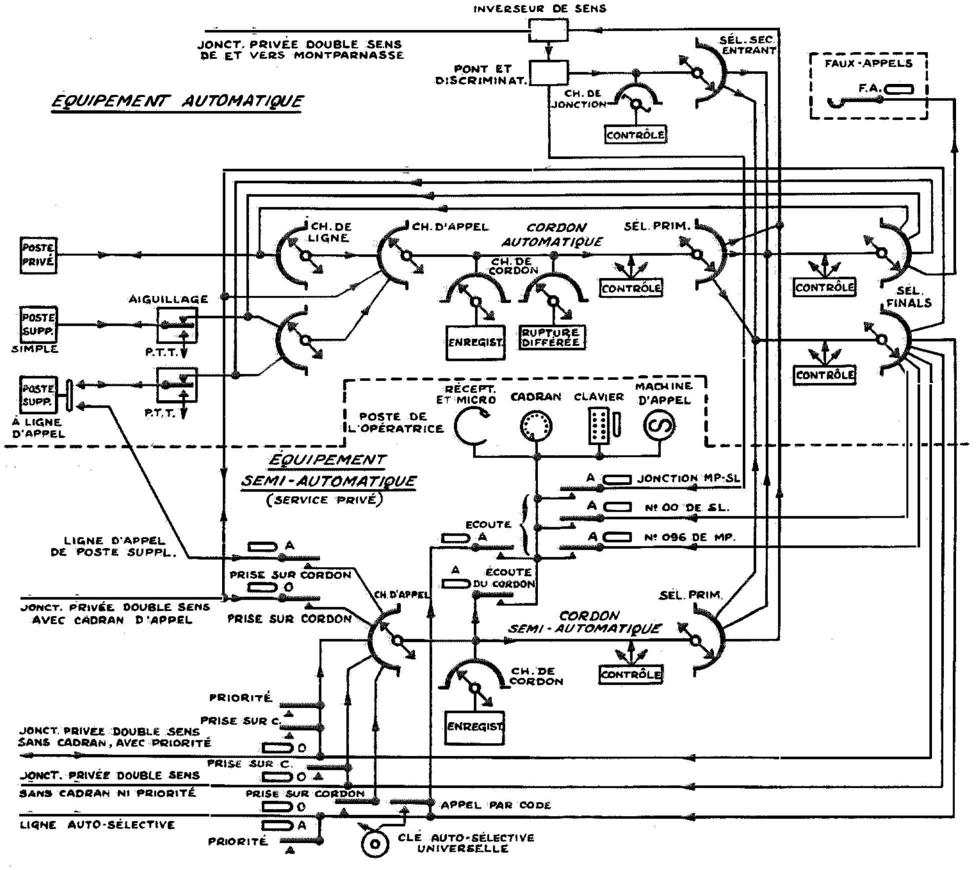


Figure 2—Diagramme de Jonction du Groupe Saint-Lazare—Service Privé.

Postes supplémentaires—Les postes supplémentaires SL qui ont droit à la mise en communication avec le réseau P.T.T. sont au nombre de 370; ces 370 postes sont reliés normalement à l'equipement automatique, mais 80 d'entr'eux disposent en outre chacun d'une ligne spéciale d'appel individuel le reliant à l'équipement semi-automatique.

cheurs de ligne des postes supplémentaires utilisent les mêmes cordons, les mêmes enregistreurs et les mêmes sélecteurs finals que les chercheurs de ligne des postes privés.

Les lignes des postes supplémentaires sont multiplées dans les arcs des sélecteurs finals, comme les lignes des postes privés, et dans les arcs des chercheurs de ligne des postes supplémentaires; elles sont en outre multiplées dans les arcs des chercheurs P.T.T. faisant partie de l'équipement "supplémentaire" ou P.T.T. Les postes supplémentaires ont ainsi, pour le service privé, les mêmes facilités que les postes privés.

Dans sa position normale, qu'il conserve aussi longtemps qu'une ligne P.T.T. ou une jonction supplémentaire ne doit pas intervenir, l'aiguillage de poste supplémentaire maintient la ligne de ce poste en communication directe et exclusive avec l'équipement automatique.

Jonctions privées à double sens avec cadran d'appel—

Les jonctions privées à double sens avec cadran d'appel relient le groupe SL à des groupes distants dans lesquels il est fait usage d'un cadran d'appel soit au poste demandeur, soit à la table manuelle du groupe auquel ce demandeur appartient. Ces jonctions sont multiplées d'une part dans les arcs des chercheurs d'appel des cordons automatiques, d'autre part dans les arcs des sélecteurs finals des jonctions; elles sont représentées à la table manuelle SL par une lampe d'occupation et par un jeu de clés individuels; la lampe d'occupation s'allume aussitôt et reste allumée aussi longtemps que la jonction est occupée comme appelante ou comme demandée.

Jonctions privées à double sens SL-MP—

Ces jonctions présentent la particularité de relier entr'eux les deux premiers groupes équipés de l'ensemble homogène que pourrait constituer ultérieurement le réseau téléphonique des chemins de fer de l'Etat, tout au moins pour les circonscriptions Saint-Lazare, Montparnasse et Batignolles.

La jonction privée à double sens SL-MP est pourvue, à son entrée à SL, d'un inverseur de sens et d'un pont avec discriminateur, au-delà desquels elle aboutit d'une part, pour le trafic entrant de Montparnasse, à un sélecteur secondaire entrant avec contrôle à chercheur de jonction, et d'autre part, pour le trafic de SL vers MP, dans les arcs des sélecteurs primaires des cordons automatiques et des cordons semi-automatiques.

Les sélecteurs secondaires entrants des jonctions ont accès dans leur arc aux mêmes sélecteurs finals que les sélecteurs primaires des cordons automatiques, et ultérieurement aux jonctions privées à double sens entre SL et les autres groupes CF équipés en système 7.D.

Le discriminateur de la jonction SL-MP intervient dans le cas suivant: un poste MP veut atteindre un poste d'un groupe distant relié à SL et équipé actuellement en système automatique autre que le système 7.D; il envoie, à cet effet, de MP, le numéro de 3 chiffres attribué au groupe de destination et occupe une jonction MP-SL, le sélecteur secondaire entrant de la jonction, un sélecteur final des jonctions, et une jonction privée à double sens SL-groupe distant. La capacité de numérotage étant épuisée pour atteindre ainsi le bureau central du groupe distant, le demandeur ne peut envoyer lui-même au moyen de son cadran le numéro demandé dans le groupe de destination. La lampe d'occupation de la jonction SL-groupe distant s'allume à la table manuelle SL, mais le discriminateur de la jonction y allume en même temps, en la faisant scintiller, la lampe individuelle d'appel de la jonction MP-SL; l'opératrice SL intervient en actionnant la clé de la jonction, s'informe du numéro désiré et envoie ce numéro par cadran; en même temps, elle "garde" la jonction MP-SL et la ligne appelante pendant l'envoi et la sélection du numéro demandé.

Jonctions privées à double sens sans cadran d'appel, avec ou sans priorité—

Ces jonctions n'ont pas accès directément aux cordons automatiques; pour les appels qu'elles émettent à destination de SL, elles sont desservies par les cordons semi-automatiques faisant partie de l'équipement semi-automatique SL décrit dans un chapitre ultérieur; par contre, pour les

---

Faux-appels—Quelle que soit la cause d'un faux-appel sur la ligne d'un poste privé, d'un poste supplémentaire ou d'une jonction privée aboutissant au bureau automatique, la ligne ou la jonction défectueuse est reportée sur le dispositif de faux-appels accessible aux sélecteurs finals d'un des groupes (le moins chargé) de postes privés et de postes supplémentaires.

appels qui leur sont destinés, elles sont accessibles par les sélecteurs finals SL des jonctions privées. Elles sont pourvues à la table manuelle SL de lampes d'occupation et de jeux de clés individuels.

Lignes auto-sélectives—Les lignes auto-sélectives sont des lignes privées qui desservent chacune une série de postes équipés en système "dispatching" mais utilisés exclusivement pour le service téléphonique; les appels, émis par ces postes aussi bien que les appels qui leur sont destinés, font intervenir l'opératrice SL qui complète la mise en communication dans l'un ou l'autre sens; le système d'équipement permet aux postes de la même ligne de communiquer entr'eux sans aucune intervention intermédiaire.

Rupture différée des communications—

La rupture différée présente une importance considérable quand on tient compte du fait que parmi les nombreux groupes distants reliés à SL par des jonctions privées, les uns sont dits "bien desservis" parce qu'un opérateur spécial toujours présent assure au moment opportun la rupture des communications et la libération des organes et des jonctions, tandis que les autres sont dits "mal desservis" parce que leur opérateur est chargé en même temps d'autres fonctions telles par exemple que la délivrance et le récolement des billets, l'enregistrement des bagages, le télégraphe, etc. Des jonctions et des organes pourraient donc être maintenus occupés après la fin des conversations.

Pour éviter ce défaut, les cordons automatiques sont accompagnés de quelques circuits de rupture différée composés chacun d'un groupe de relais et d'un chercheur de cordon; tout cordon maintenu par une communication dans laquelle le demandé a raccroché tandis que le demandeur ne raccroche pas, est recherché par les circuits de rupture différée et est libéré après un délai déterminé; la jonction privée, bien qu'elle reste engagée au point où on a négligé de la libérer, ne devient pas appelante, mais est bouclée sur elle-même et ne redeviendra disponible qu'après l'exécution des manoeuvres normales (retrait de fiche, relèvement de clés, raccrochage, etc.) de rupture et de libération.

2. *Equipement Semi-Automatique (Service Privé—(Fig. 2)*

L'équipement semi-automatique de la gare Saint-Lazare intervient dans le service privé pour établir ou compléter les mises en communication dans les deux sens, des postes privés et des postes supplémentaires SL et MP d'une part, avec les autres postes et groupes du CF, d'autre part, en utilisant les jonctions privées de toutes catégories reliant ces autres postes et groupes à SL; il intervient également pour établir les communications émanant ou à destination des postes des lignes auto-sélectives reliées à SL.

L'équipement semi-automatique se compose de deux parties:

a) Une table manuelle à quatre positions d'opératrice, à laquelle sont raccordées toutes les lignes et jonctions pouvant ou devant recourir à l'intervention des opératrices; les positions sont équipées exclusivement de clés et de lampes, l'Administration du CF de l'Etat rejetant formellement tout emploi de cordons manuels, de fiches et de jacks pour ses installations nouvelles. Les lignes d'appel des postes supplémentaires à double ligne sont réparties également entre les positions, tandis que les jonctions et les lignes auto-sélectives sont multiplées sur les 4 positions;

b) Des cordons semi-automatiques, constitués comme des cordons automatiques et comprenant chacun un chercheur d'appel et un sélecteur primaire; ces cordons, desservis par des enregistreurs avec chercheurs de cordon, sont attribués en nombres égaux à chacune des positions d'opératrice. Leurs sélecteurs primaires ont accès aux mêmes sélecteurs finals de poste et de jonction que les sélecteurs primaires des cordons de l'équipement automatique.

Lignes d'appel des postes supplémentaires SL à double ligne—

Ces lignes, dont le nombre actuel de 80 peut-être porté à 100, sont réparties à raison de 20 par position d'opératrice. Chaque ligne possède à la position à laquelle elle est attribuée une lampe d'appel et une clé de "prise sur cordon"; au-delà de la clé, la ligne est multiplée dans les arcs des chercheurs d'appel des cordons de la position.

Les lignes d'appel individuel des postes supplémentaires SL ont pour but principal de permettre aux usagers de ces postes de confier aux opératrices le soin d'établir les communications qu'ils veulent obtenir.

Le scintillement de la lampe de la ligne signale l'arrivée d'un appel; l'opératrice, en actionnant la clé de prise sur cordon de la ligne, rend la ligne appelante dans les arcs des chercheurs d'appel des cordons de sa position. Le cordon qui s'engage avec la ligne appelante allume par scintillement sa lampe d'appel; l'opératrice actionne la clé d'écoute de ce cordon, s'informe de la demande et établit ensuite la communication désirée.

Jonctions privées à double sens avec cadran d'appel—

Ces jonctions relient à SL de nombreux groupes manuels et quelques groupes automatiques (en systèmes pas-à-pas), comprenant de 30 à 50 postes et distants de 6 à 15 Km; l'équipement de ces groupes a été établi pour leur capacité propre, sans aucune prévision d'interconnexion automatique entre leurs postes et les postes d'autres groupes similaires.

Les jonctions privées avec cadran d'appel sont considérées à leur arrivée à SL comme des lignes simples de postes privés; elles sont multiplées directement dans les arcs des chercheurs d'appel et des sélecteurs finals de jonction de l'équipement automatique; elles ont donc accès et sont accessibles sans aucune intervention manuelle des opératrices SL, aux postes privés SL et MP, aux postes supplémentaires SL et MP, aux jonctions privées de toutes catégories et aux lignes auto-sélectives. Chaque jonction privée avec cadran d'appel est en outre représentée par multiplage à chacune des positions de la table manuelle SL, par une lampe d'occupation et une clé de prise sur cordon. La lampe d'occupation s'allume aussitôt et reste allumée aussi longtemps que la jonction est occupée.

Lorsque la jonction est disponible, et est demandée par l'intermédiaire de l'opératrice, celle-ci, par la clé de prise sur cordon, la relie à un de ses cordons sur lequel elle envoie le courant de sonnerie par la clé générale de sonnerie de sa position; à la réponse du poste demandé, elle "rappelle" le poste demandeur par le même cordon, au moyen du clavier et d'un enregistreur. Il convient d'insister quelque peu sur ce mode de mise en communication, dont le principe a servi de base à l'élaboration des moyens mis en oeuvre dans le service des lignes P.T.T. et des jonctions supplémentaires. L'opératrice prend à sa charge la communication qui lui est demandée, et la renverse de sens: du demandé, elle fait le demandeur en le reliant à un de ses cordons comme s'il était réellement le demandeur; on dit que l'opératrice, en actionnant la clé de prise de cordon de la jonction, "crée un appel sur la jonction"; en fait, elle fait apparaître la jonction demandée comme si cette jonction était appelante, et se met en relation avec l'opératrice distante pour obtenir le poste demandé; dès que celui-ci répond, il se trouve relié au cordon semi-automatique de l'opératrice SL comme s'il était lui-même appelant. L'opératrice établit ensuite la mise en communication comme si le demandeur vrai était demandé par la jonction.

Jonctions privées à double sens, sans cadran d'appel, avec priorité—

Ces jonctions assurent un service très important, en reliant à SL des groupes comprenant de 50 à 120 postes, situés à des distances de 125 à 400 kilomètres. Parmi ces groupes, on peut citer notamment les gares de Rouen—136 Km, Le Mans—211 Km, Caen—239 Km, Thouars—326 Km et Rennes—374 Km, qui figurent parmi les plus importantes du réseau des chemins de fer de l'Etat. Ces jonctions, par lesquelles aucun envoi par cadran ne peut être fait actuellement sont multiplées directement dans les arcs des chercheurs d'appel des cordons semi-automatiques et dans les arcs des sélecteurs finals de jonction de l'équipement automatique; dès que l'Administration des CF le jugera utile, elles seront munies de cadrans d'appel utilisant le courant alternatif à 50 périodes pour l'envoi des impulsions d'appel, ce qui permettra d'établir des communications directes entièrement automatiques de poste à poste, entre les groupements dépendant de Saint-Lazare, de Rouen, du Hâvre et des autres villes importantes du réseau des chemins de fer.

Pour tous les appels qu'elles amènent, ces jonctions sont desservies par les cordons semi-automatiques; le cordon semi-automatique qui s'engage avec la jonction appelante allume sa lampe d'appel, qui provoque l'intervention de l'opératrice SL par la clé d'écoute de cordon. Après s'être informée du numéro demandé, l'opératrice SL complète la mise en communication par clavier et enregistreur; la communication est assurée pendant toute sa durée, par le cordon semi-automatique et un des sélecteurs finals de poste ou de jonction communs à l'équipement automatique et à l'équipement semi-automatique.

Les appels à destination des groupements desservis par les jonctions sont établis par les cordons automatiques ou par les cordons semi-automatiques et mettent le poste demandeur en relation avec l'opératrice du groupement demandé, sans aucune intervention de la table manuelle SL; chacune des jonctions est représentée à chacune des 4 positions de la table manuelle SL par une lampe d'occupation et par une clé de prise sur cordon.

L'intensité et la nature du trafic assuré par les jonctions sans cadran avec priorité exigent qu'un demandeur qualifié de SL ou MP puisse obtenir à bref délai une communication urgente ou importante lorsqu'il constate que ses appels automatiques normaux aboutissent au signal d'occupation. Chaque jonction est pourvue d'une clé de priorité, que l'opératrice actionne lorsqu'elle en est requise par le poste demandeur, qui a envoyé le N° 00 ou le N° 096 suivant qu'il appartient au groupe SL ou au groupe MP. La clé de priorité éteint la lampe d'occupation de la jonction à la position à laquelle elle a été enfoncée, mais laisse allumées les lampes d'occupation de la jonction aux autres positions. D'autre part, la jonction dès sa prochaine libération, deviendra automatiquement appelante à la position qui en a pris la priorité. Entretemps, l'enfoncement des clés de priorité aux autres positions n'a aucun effet ni sur la jonction, ni sur ses lampes d'occupation, ni sur la priorité déjà établie; autrement dit, la prise de priorité n'est effective que pour la position à laquelle la clé de priorité a été enfoncée la première, et pour la durée seulement de l'engagement de la jonction par l'appel pour lequel cette priorité a été requise.

Jonctions privées à double sens, sans cadran et sans priorité—

Ces jonctions relient au groupe SL d'autres groupes de 30 à 50 postes situés à des distances qui atteignent 60 Km; elles sont équipées et fonctionnent, sauf en ce qui concerne la priorité, exactement comme les jonctions sans cadran avec priorité: elles sont multiplées directement dans les arcs des chercheurs d'appel des cordons semi-automatiques et dans les arcs des sélecteurs finals de jonction communs à l'équipement automatique et à l'équipement semi-automatique.

Elles sont multiplées à la table manuelle, à chacune des positions de laquelle elles sont représentées par une lampe d'occupation et par une clé de prise sur cordon.

Un appel provenant d'une jonction allume les lampes d'occupation et provoque l'engagement de la jonction avec un cordon dont la lampe d'appel scintille. L'opératrice intervient par la clé d'écoute du cordon et établit ensuite la communication au moyen de son clavier et d'un enregistreur.

Un appel destiné à un poste du groupe distant occupe la jonction soit par l'équipement automatique, soit par l'équipement semi-automatique, et parvient à l'opératrice du groupe distant. Il convient de rappeler que dans l'annuaire téléphonique des chemins de fer, et pour tous les groupes non encore équipés en système Rotary 7.D, le numéro du groupe seulement est mentionné, et non les numéros individuels des postes du groupe.

Lignes auto-sélectives—

Ces lignes dont la longueur varie de 30 à 170 Km, et qui desservent chacune de 4 à 10 gares ou postes importants pouvant communiquer directement entr'eux par leur ligne commune, sont pourvues à chacune des positions de la table manuelle d'une lampe d'occupation, d'une lampe d'appel, d'une clé de prise sur cordon, et d'une clé d'écoute; quelques-unes des lignes auto-sélectives sont en outre pourvues d'une clé de priorité.

Les lignes auto-sélectives sont multiplées d'une part dans les arcs des chercheurs d'appel des cordons semi-automatiques, et d'autre part dans les arcs des sélecteurs finals de jonction communs à l'équipement automatique et à l'équipement semi-automatique.

Un appel émis par un poste de la ligne auto-sélective allume à la table manuelle les lampes d'appel de la ligne seulement et les fait scintiller; par la clé de prise sur cordon de la ligne, l'opératrice reçoit la demande au moyen d'un de ses cordons semi-automatiques et complète la mise en communication par clavier et enregistreur.

Un appel à destination d'un poste d'une ligne auto-sélective donne lieu à l'envoi du numéro de la ligne (et non du poste désiré) et occupe par un sélecteur final de jonction le branchement sortant de la ligne, dont il allume simultanément en permanence les lampes d'occupation et par scintillement les lampes d'appel; l'opératrice actionne la clé d'écoute de la jonction et reçoit l'indication du poste désiré, qu'elle appelle par code en manoeuvrant la clé universelle autosélective de sa position, après avoir renversé la clé d'écoute de la jonction; aucun organe de l'équipement semi-automatique proprement dit ne participe donc à l'établissement de la communication. La priorité appliquée aux lignes auto-sélectives donne les mêmes facilités qu'aux jonctions sans cadran avec priorité.

Jonctions privées à double sens SL-MP—

Ces jonctions sont représentées aux positions de la table manuelle SL par une lampe d'appel et une clé d'écoute. La lampe d'appel signale et la clé d'écoute relie à l'opératrice SL tout appel émis par un poste MP à destination d'un autre groupe distant équipé en système automatique (pas-à-pas) mais non encore incorporé dans la transformation en Rotary 7.D.

Les organes aiguilleurs de la jonction à son entrée à SL, commandés par l'enregistreur du bureau d'origine de l'appel MP, font aboutir directement l'appel à la ligne du poste demandé si celui-ci fait partie d'un groupe équipé en système Rotary 7.D; si le demandé fait partie d'un groupe équipé en système automatique pas-à-pas, l'appel occupe une jonction vers le groupe automatique distant; la lampe d'appel de la jonction scintille à la table manuelle SL; l'opératrice se porte en écoute, s'informe du numéro du poste demandé et envoie ce numéro par cadran; elle se retire ensuite de la communication. Le demandeur reçoit le signal de sonnerie ou le signal d'occupation; la rupture et la libération sont placées sous le contrôle exclusif du demandeur.

Diagramme de jonction—

La fig. 2 représente le diagramme de jonction assurant le service privé automatique et semi-automatique du groupe SL. Pour des raisons de clarté, on a séparé dans les sélecteurs finals les postes privés et les postes supplémentaires des jonctions privées et des postes d'opératrice; il doit être bien entendu que le mode de sélection contrôlée utilisé dans le système Rotary 7.D permet d'attribuer à volonté les broches des arcs des sélecteurs finals à des lignes individuelles, à des jonctions de toutes catégories, aux postes d'opératrice et aux circuits de faux-appel.

Le diagramme ne fait aucune mention des lignes P.T.T. ni des jonctions supplémentaires: il fait ressortir clairement l'impossibilité de toute mise en relation d'un poste privé avec une ligne P.T.T. ou une jonction supplémentaire et inversément.

3ème PARTIE

GARE SAINT-LAZARE

Equipément et Service "Supplémentaires"

L'intensité du trafic de la gare Saint-Lazare avec le réseau P.T.T. nécessite actuellement 35 lignes: 16 lignes spécialisées A à service restreint, 16 lignes spécialisées B, 2 lignes mixtes à service général, ces nombres pouvant être portés respectivement à 23, 23 et 3; de plus, une ligne spéciale interurbaine relie la gare Saint-Lazare au bureau central interurbain; toutes ces lignes aboutissent à un bureau central automatique ou manuel du réseau P.T.T. et sont appelées "lignes d'abonnement" ou "lignes P.T.T."

Les lignes P.T.T. sont concentrées sur un commutateur automatique; mais les appels provenant du réseau P.T.T. à destination des postes supplémentaires parviennent à une opératrice, chargée principalement de diriger les appels vers leur destination, l'abonné ou l'usager moyen des P.T.T. ne connaissant pas, dans la plupart des cas, l'organisation intérieure des services du chemin de fer: bien que son organisation téléphonique comprenne pour la gare Saint-Lazare seulement plusieurs centaines de postes et de jonctions de toutes catégories, l'Administration des C.F. de l'Etat, ne figure dans l'annuaire général du réseau P.T.T. que sous quelques numéros seulement.

Un demandeur quelconque de réseau P.T.T., pour atteindre "l'Administration des C.F. de l'Etat" épuise la capacité de numérotage ou de désignation verbale et se trouve dans l'impossibilité d'appeler encore par un ou par plusieurs numéros successifs de 2, 3 ou même 4 chiffres, le poste CF avec lequel il désire correspondre.

L'opératrice CF, en recevant une demande amenée par une ligne P.T.T. à destination d'un poste supplémentaire CF, provoque le reliement de la ligne P.T.T. appelante à la ligne du poste CF demandé ou qu'elle croit le mieux qualifié pour recevoir la communication; en cas de besoin, elle relie la ligne P.T.T. appelante à une jonction "supplémentaire" disponible vers le groupe CF distant qui contient le poste demandé.

Dans le sens inverse, les communications émanant des postes supplémentaires CF à destination des abonnés du réseau P.T.T. peuvent être établies sans aucune intervention de l'opératrice CF, par le reliement de la ligne du poste CF demandeur à la première ligne P.T.T. disponible; en cas de besoin, l'appel utilise une jonction supplémentaire disponible entre le groupe CF d'origine et le groupe distant dans lequel les lignes P.T.T. se terminent.

Les dispositifs mis en oeuvre pour assurer conformément aux réglements en vigueur, et par des tables sans fiches ni cordons manuels le service supplémentaire dans les installations des CF de l'État à la gare Saint-Lazare sont exposés ci-dessous.

1. Service des Lignes P.T.T.—(Fig. 3)

Appel émis par un poste supplémentaire CF à destination d'un abonné du réseau P.T.T.

a) Le demandeur, qui est nécessairement titulaire d'un poste supplémentaire SL, effectue lui-même les opérations d'envoi du numéro demandé.

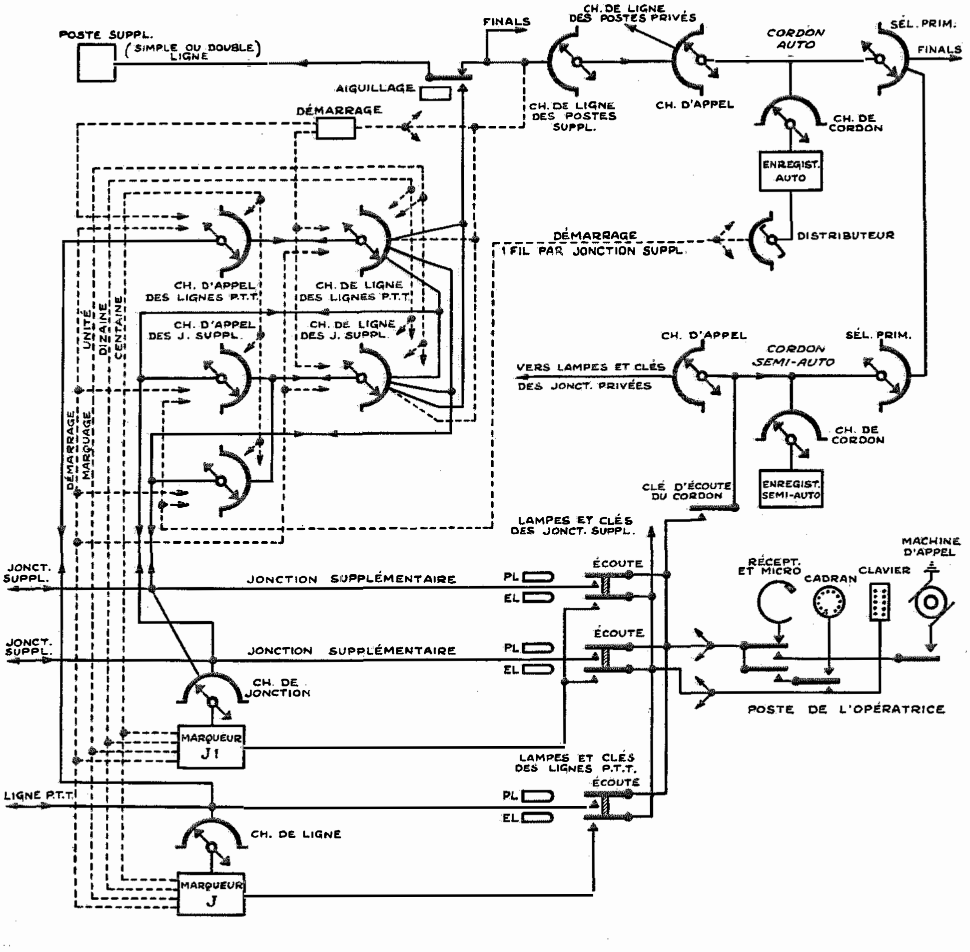


Figure 3—Diagramme de Jonction de L'Équipement "Supplémentaire" du Groupe Saint-Lazare. Lignes P.T.T. et Jonctions Supplémentaires.

Le demandeur, relié normalement à l'équipement automatique SL, envoie le numéro de deux chiffres 01 réservé au réseau P.T.T. Au reçu de ce numéro, l'enregistreur rend la ligne du demandeur appelante dans les arcs de chercheurs "supplémentaires" qui terminent les lignes P.T.T. à leur entrée à SL.

Les nombres des postes supplémentaires CF (équipés 370; prévus 470) et des lignes P.T.T. (équipées 34; prévues 50) nécessitent deux étages de chercheurs: des chercheurs de ligne, par groupe de 100 postes et jonctions supplémentaires, et des chercheurs d'appel individuels par ligne P.T.T.

La ligne du poste demandeur, rendue par l'enregistreur appelante dans la centaine dont elle fait partie, est recherchée par les chercheurs de ligne de cette centaine; les chercheurs d'appel de toutes les lignes P.T.T. disponibles sont mis en action, à la recherche du chercheur de ligne qui s'engage avec la ligne du poste supplémentaire demandeur.

La rencontre et l'engagement de la ligne du poste supplémentaire demandeur par les chercheurs supplémentaires de ligne et d'appel actionnent l'aiguillage de la ligne; en fonctionnant, l'aiguillage déconnecte la ligne du poste demandeur des broches des arcs des chercheurs de ligne de l'équipement automatique privé; les organes intervenus de cet équipement sont aussitôt libérés.

L'aiguillage est indispensable pour satisfaire à la condition imposée par les réglements des P.T.T., qu'aucune partie de l'équipement privé ne demeure en dérivation sur une communication avec le réseau P.T.T.

Dès qu'il est en relation avec le bureau central P.T.T., (signal de transmission ou annonce de l'opératrice suivant le cas) le poste supplémentaire SL envoie par son cadran ou énonce verbalement le numéro de l'abonné P.T.T. avec lequel il désire correspondre.

La communication est établie sans aucune intervention de l'opératrice SL; la ligne P.T.T. occupée est signalée par l'allumage de ses lampes d'occupation à toutes les positions d'opératrice sur lesquelles cette ligne est multiplée.

b) Le demandeur, titulaire d'un poste supplémentaire SL, charge l'opératrice SL d'établir la communication.

Si le demandeur appartient à l'un des groupes SL ou MP, il obtient l'opératrice SL en envoyant au moyen de son cadran le numéro assigné à cette opératrice; il peut obtenir directement l'opératrice SL s'il utilise un poste SL pourvu d'une ligne d'appel individuel (poste supplémentaire SL à double ligne).

Si le demandeur appartient à un autre groupe non équipé en système Rotary 7.D, il ne peut que faire intervenir l'opératrice de son groupe; celle-ci se met en relation avec l'opératrice SL par appel direct sur une jonction supplémentaire disponible.

L'opératrice SL, informée de la demande et du numéro de poste demandeur, crée, par la clé d'écoute dont chaque ligne P.T.T. est pourvue à la table manuelle, un appel sur une ligne P.T.T. spécialisée A ou mixte disponible, en reliant son poste à cette ligne; au reçu du signal de transmission ou de l'annonce de l'opératrice P.T.T., elle obtient par cadran ou verbalement, suivant le cas, le poste P.T.T. demandé, qui par le fait même devient le poste demandeur; la ligne P.T.T. utilisée et son chercheur d'appel sont d'autre part associés à un des enregistreurs marqueurs J accessibles aux lignes P.T.T.; cet enregistreur est lui-même relié au clavier par lequel l'opératrice envoie le numéro du poste supplémentaire demandeur.

L'enregistreur marqueur J ne provoque aucune sélection: au reçu du numéro du poste supplémentaire SL demandeur, il marque la centaine dont le demandeur fait partie comme seule existante dans l'arc du chercheur d'appel de la ligne P.T.T.; ce chercheur d'appel se relie aussitôt au premier chercheur de ligne qu'il atteint dans la centaine marquée. L'enregistreur J rend à ce moment la ligne du demandeur "appelante" dans les arcs de tous les chercheurs de ligne de la centaine, ce qui provoque la recherche de cette ligne, son engagement par le chercheur de ligne atteint par le chercheur d'appel et finalement son reliement à la ligne P.T.T. utilisée par l'opératrice pour atteindre le poste P.T.T. demandé.

Si la ligne du poste supplémentaire SL demandeur est libre au moment où elle est atteinte, son aiguillage est actionné et le courant d'appel lui est envoyé par l'équipement du chercheur d'appel; la réponse du demandeur SL met ce dernier en relation avec le poste P.T.T. qu'il a demandé.

L'opératrice SL et son clavier ont été libérés aussitôt après l'envoi du numéro du poste supplémentaire SL demandeur.

Si la ligne du poste supplémentaire SL demandeur est occupée au moment où elle est atteinte par la ligne P.T.T., la rencontre n'a aucun effet sur l'aiguillage et le courant d'appel n'est pas envoyé; la lampe d'occupation de la ligne P.T.T. vacille à la fréquence du signal d'occupation. L'opératrice SL intervient en actionnant la clé d'écoute de la ligne P.T.T.

Dans le cas où l'occupation résulte d'une communication "locale" ou "privée" en cours, l'opératrice ne reçoit aucun signal, mais se trouve en écoute sur cette communication et peut offrir la communication P.T.T.

Dans le cas où l'occupation résulte d'une communication "P.T.T." ou "supplémentaire" en cours, l'opératrice reçoit un signal d'occupation interdictif et n'a aucune action sur cette communication; mais elle a toujours la ressource d'appeler le poste supplémentaire SL demandeur par sa ligne individuelle d'appel, s'il en possède une, et d'informer ce poste que la communication P.T.T. qu'il a demandée est établie. Les lignes individuelles d'appel, qui sont réservées aux postes principaux de l'organisation téléphonique du CF, donnent à ceux-ci la possibilité d'être atteints dans toutes les circonstances qui peuvent se présenter.

Appel émis par un abonné du réseau P.T.T. à destination d'un poste supplémentaire CF—

L'appel est signalé aux opératrices SL par le scintillement des lampes d'appel dont la ligne P.T.T. est pourvue aux positions de la table semi-automatique sur lesquelles elle est multiplée. En abaissant la clé d'écoute de cette ligne, une opératrice SL se met en relation avec le demandeur et provoque le reliement de la ligne P.T.T. à un des enregistreurs marqueurs J associés aux lignes P.T.T.; elle envoie par clavier le numéro demandé à cet enregistreur, qui marque la ligne demandée dans les arcs du chercheur d'appel de la ligne P.T.T. et des chercheurs de ligne du groupe de 100 lignes et jonctions supplémentaires dont le poste demandé fait partie; la communication s'établit exactement comme si elle avait été demandée à l'opératrice SL par le poste supplémentaire SL demandé.

Succession des appels constituant le trafic "supplémentaire" avec les lignes P.T.T.—

Les appels qui constituent le trafic "supplémentaire" avec les lignes P.T.T. se divisent en deux catégories:

a) *Appels entrants ou sortants faisant intervenir l'opératrice SL—*

Ces appels ne peuvent être desservis que successivement, même s'ils se présentent simultanément. La succession est assurée par le mode d'interconnexion des 4 enregistreurs-marqueurs J: un enregistreur-marqueur J ne peut entrer en action et ne peut actionner le chercheur d'appel de la seule ligne P.T.T. à laquelle il est momentanément relié et qui a été "prise" par l'opératrice SL, qu'après la réception du 1er chiffre du numéro qui lui est envoyé par le clavier de l'opératrice; cette réception n'est elle-même accomplie qu'au moment où la touche de 1er chiffre se relève aprés avoir été enfoncée. Non seulement, la probabilité du relèvement simultané des deux touches de 1er chiffre de deux claviers est extrêmement faible, mais encore une épreuve de priorité est imposée à l'enregistreur-marqueur J, avant qu'il puisse influencer le chercheur d'appel auquel il est relié. Si l'opératrice A, en envoyant un numéro, maintient enfoncée la touche de 1er chiffre de son clavier tandis que l'opératrice B plus rapide enfonce et laisse se relever entretemps la touche de 1er chiffre de son clavier, l'enregistreur-marqueur engagé par l'opératrice B prendra la priorité sur l'enregistreur-marqueur engagé par l'opératrice A; si même les deux réceptions sont exactement simultanées, les deux enregistreurs passeront simultanément à la position de marquage mais subiront une épreuve éliminatoire de mise en action des chercheurs d'appel auxquels ils sont reliés.

b) *Appels sortants émis directement par les postes supplémentaires—*

Ces appels provoquent la recherche de la ligne du poste demandeur par les chercheurs d'appel et de ligne des P.T.T., mais ne font pas intervenir les marqueurs J. Aucun mélange n'est à craindre pour ces appels qui ont la même direction commune, le réseau P.T.T.

2. *Service des Jonctions Supplementaires—(Fig. 3)*

Les jonctions supplémentaires sont équipées de la même façon que les lignes P.T.T.: chacune d'elles aboutit aux balais d'un chercheur d'appel individuel ayant accès dans son arc à des chercheurs de ligne disposés par groupe de 100 postes supplémentaires et jonctions supplémentaires;

elles sont accessibles en commun à des enregistreurs-marqueurs J_1 avec chercheurs de cordon, similaires aux enregistreurs-marqueurs J des lignes P.T.T.

Les enregistreurs-marqueurs J_1 desservent indifféremment les appels émanant des jonctions supplémentaires, pour lesquels l'envoi du numéro demandé est fait par cadran au poste demandeur distant, et les appels pour lesquels l'envoi du numéro demandé est fait par clavier, par l'opératrice SL.

Les jonctions supplémentaires sont multiplées en totalité à toutes les positions de la table semi-automatique, et sont pourvues à chaque position d'un jeu de clés et de lampes.

Appel émanant d'une jonction supplémentaire à destination d'un poste supplémentaire SL—

Le numéro du poste demandé est envoyé par cadran, ou est demandé verbalement à l'opératrice SL.

Dans le premier cas, envoi par cadran, l'enregistreur-marqueur J_1 reçoit le numéro demandé et marque la ligne correspondante comme appelante dans les arcs du chercheur d'appel de la jonction et des chercheurs de ligne disponibles de la centaine qui la contient; il met en action le chercheur d'appel et les chercheurs de ligne.

Dans le deuxième cas, intervention de l'opératrice SL, l'opératrice SL envoie par clavier à l'enregistreur J_1 le numéro demandé; les opérations se poursuivent comme dans le premier cas.

Appel émanant d'une jonction supplémentaire à destination d'un abonné du réseau P.T.T.—

Le demandeur, qui est nécessairement un poste supplémentaire CF, envoie le N° 01 à l'enregistreur J_1, qui marque la jonction comme appelante dans les arcs des chercheurs de ligne P.T.T. de la centaine qui la contient; les chercheurs P.T.T. de ligne de cette centaine et tous les chercheurs d'appel des lignes P.T.T. disponibles recherchent la jonction supplémentaire appelante.

Appel émanant d'un poste supplémentaire à destination d'une jonction supplémentaire—

a) L'appel est émis au cadran par un poste supplémentaire SL.

L'enregistreur automatique, à la réception du numéro de trois chiffres de la direction de destination, marque la ligne du poste supplémentaire demandeur comme appelante dans les arcs des chercheurs de ligne de la centaine qui la contient et dans les arcs des chercheurs d'appel des jonctions disponibles dans le groupe de jonctions de la direction demandée seulement. Les opérations se poursuivent ensuite de la manière précédemment décrite.

b) Le demandeur charge l'opératrice SL d'établir la communication.

L'opératrice procède comme pour les appels à

TABLEAU DE NUMÉROTAGE DES GROUPES "SAINT-LAZARE" et "MONTPARNASSE" DES CHEMINS DE FER DE L'ETAT

Le numérotage général est à 3 chiffres et comprend les numéros de la série 000 à 999; il sera porté ultérieurement à 4 chiffres, de 0000 à 9999.

1—GROUPE SAINT-LAZARE

Postes supplémentaires	**120 à 499**
Postes privés	**500 à 839**
Opératrices appelées de Saint-Lazare	**00**
appelées de Montparnasse	**096**
Réseau de l'Etat ou P.T.T.	**01**
Jonctions privées sans cadran avec priorité (grands circuits vers Caen, Rouen, Rennes, Thouars, le Mans, etc.)	**020 à 027**
Jonctions privées sans cadran, sans priorité (petits circuits vers Mantes, Versailles, Achères, etc.)	**035 à 040**
Circuits autosélectifs (équipés en train despatching, vers Dieppe, Mantes, Serquigny, etc.)	**045 à 050**
Jonctions privées avec cadran d'appel (Saint-Cloud, Puteaux, Clichy, etc.)	**055 à 085**
Jonctions supplémentaires (Ministère des Travaux Publics, Sénat, Chambre des Députés, etc.)	**100 à 117**
Faux-appels. Les circuits de faux-appel occupent dans les sélecteurs finals l'emplacement du numéro	**777**
Dérangements	**800**
Service d'alarme, d'incendie, etc	**500**

2—GROUPE MONTPARNASSE

Postes (privés et supplémentaires)	**900 à 909 et 920 à 999**
Opératrices appelées de Montparnasse par l'envoi du N° 00	**911, 912, 913 des sélecteurs finals locaux**
appelées de Saint-Lazare par l'envoi du N° 911	**911, 912 des sélecteurs finals entrants**
Opératrices de Saint-Lazare	**096**

Le groupe Montparnasse étant établi pour une capacité maximum de 100 lignes, toutes les directions, jonctions, postes, etc., occupent un jeu de broches dans l'arc des sélecteurs finals.

destination des lignes P.T.T.; elle choisit une jonction disponible dans la direction demandée, obtient le poste demandé, et envoie par son clavier le numéro du poste supplémentaire SL demandeur; le chercheur d'appel de la jonction supplémentaire, et les chercheurs de ligne de la centaine qui contient la ligne du demandeur, recherchent cette ligne et la relient à la jonction choisie par l'opératrice.

c) L'appel émane d'une jonction supplémentaire et est envoyé par cadran.

Par suite de son engagement avec le demandeur, la jonction supplémentaire appelante se relie à un enregistreur J_1 qui reçoit les impulsions du numéro demandé envoyées par cadran; il marque aussitôt la direction demandée comme appelante dans les arcs des chercheurs de ligne disponibles de cette direction seulement. La mise en communication s'établit par les chercheurs comme dans les cas précédents.

Succession des appels constituant le trafic des jonctions supplémentaires—

Les jonctions supplémentaires desservent des directions distinctes; leur nombre est actuellement 18 et peut être porté à 30, chacune des directions pouvant avoir un nombre quelconque de jonctions; il est donc de toute nécessité d'assurer la succession des appels de façon que seuls soient mis en action les chercheurs d'appel des jonctions de la direction demandée. Cette succession est obtenue par l'adjonction à chacun des enregistreurs automatiques, d'un distributeur, ces distributeurs étant conjugués entr'eux de la façon suivante:

Le distributeur est un commutateur pas-à-pas à 11 positions, la première marquée N est la position normale; les dix autres sont marqueés de 1 à 10. Dès que l'enregistreur s'engage avec une ligne appelante, son distributeur est mis en action et tente de gagner sa position 10 où il s'arrête, s'il l'atteint, et où il complète les connexions qui permettent à l'enregistreur de commander les organes de sélection auxquels il est relié; mais le distributeur ne peut franchir aucune des positions intermédiaires si un autre enregistreur a déjà amené son distributeur à sa position 10. Si donc la position 10 est occupée par un distributeur, un autre enregistreur ne pourra amener son distributeur qu'à sa position 9 où il attendra que l'appel précédent soit écoulé par l'enregistreur qui le dessert; un 3ème enregistreur intervenant entre temps arrêtera son distributeur à sa position 8 et ainsi de suite; 10 appels occupant simultanément 10 des 14 enregistreurs automatiques amèneront donc les distributeurs dans leurs positions 1 à 10, et seront écoulés successivement, tous les distributeurs en attente avançant d'un pas vers la position 10 qu'un seul d'entr'eux peut occuper pour la durée de la sélection seulement.

Le marquage des jonctions dans la direction demandée par chacun des appels s'effectue par un seul faisceau de 30 fils correspondant d'une part aux 30 jonctions supplémentaires prévues et communs d'autre part aux 14 enregistreurs de l'équipement automatique.

La rapidité du marquage et de la recherche de la ligne du poste supplémentaire SL demandeur n'occasionne aucun retard appréciable dans les mises en communication, même pendant les moments de grande activité.

The Application of Voice Frequency Signalling to C. L. R. Service in Belgium

By G. E. H. MÖNNIG
Ingenieur en Chef—Directeur Adjoint, Circonscription Téléphonique, Brussels, Belgium

THE existing C.L.R. equipment in Belgium utilises the 50 cycle signalling system. The outgoing equipment, as shown in Fig. 1, comprises outgoing connecting circuits (jack finders and direction selectors), register choosers, and register circuits of the key sending type. The outgoing connecting circuit contains a 50 cycle receiving unit designed to receive the following signals sent from the distant exchange:

(*a*) start send,
(*b*) end of selection,
(*c*) wanted party removes receiver,
(*d*) wanted party restores receiver.

Between the toll line repeating coil and the automatic equipment, a relay group is connected which transforms the direct current impulses into alternating current impulses of 50 p:s which are sent to the distant exchange.

The incoming 50 cycle equipment comprises connecting circuits (line finders and first group selector), register choosers, and a group of local register circuits. The 50 cycle receiving equipment is located in the incoming line circuits and transforms the received alternating current impulses into direct current and transfers them to the incoming cord circuits. The impulses received are as follows:

(*a*) calling signal,
(*b*) dial impulses,
(*c*) releasing signal.

The following description outlines the application of voice frequency signalling to C.L.R. service utilising the 50 cycle signalling system. The voice frequency signalling system employed is the two-frequency system which, as the name implies, uses alternating currents of two frequencies within the speech range, namely: 600 and 750 p:s. From the point of view of switching facilities, this system possesses the same advantages as the four-frequency signalling system from which it is, in fact, derived and it is suitable for all the various types of telephone circuits. Ordinary telephone relays in combination with vacuum tubes and a system of filters are used instead of voice frequency relays. The extremities of the telephone circuits are connected to signalling panels which receive, amplify, and rectify the voice frequency currents and pass them on to the automatic equipment as regular d-c signals.[1]

Signalling Panel

The signalling panel is shown schematically in Fig. 2. The toll line terminates as usual on a repeating coil and between this coil and the local automatic equipment, a combined hybrid coil and input transformer is connected, preventing voice currents originating on the office side from reaching the signalling equipment. The windings of this hybrid coil are arranged to present a high impedance towards the local side and a low impedance towards the line side. The signalling panel introduces but a small additional transmission loss which has been kept to extremely low limits and is of the order of 0.5 db. The received signalling currents, the level of which can be adjusted by a potentiometer, are amplified by the first tube V_1 and passed on to the second tube V_2 which functions as a limiting amplifier.

The amplified currents then pass through a filter circuit with a band width of approximately 550-800 p:s. The filter comprises three inductances L_1, L_2, and L_3 and three condensers C_1, C_2, and C_3. The filtered current is then rectified by a dry rectifier of the bridge type and is once more filtered by the low frequency filter circuit impedances L_4 L_5, and L_6 and the three condensers C_4, C_5, and C_6 which pass a band be-

---

[1] "Automatic Long Distance Switching, Impulse Transmission," by S. Van Mierlo and T. S. Skillman, M.A., *Electrical Communication*, January, 1934.
"The Four Frequency Signalling System," by T. S. Skillman, M.A., *Electrical Communication*, July, 1930.

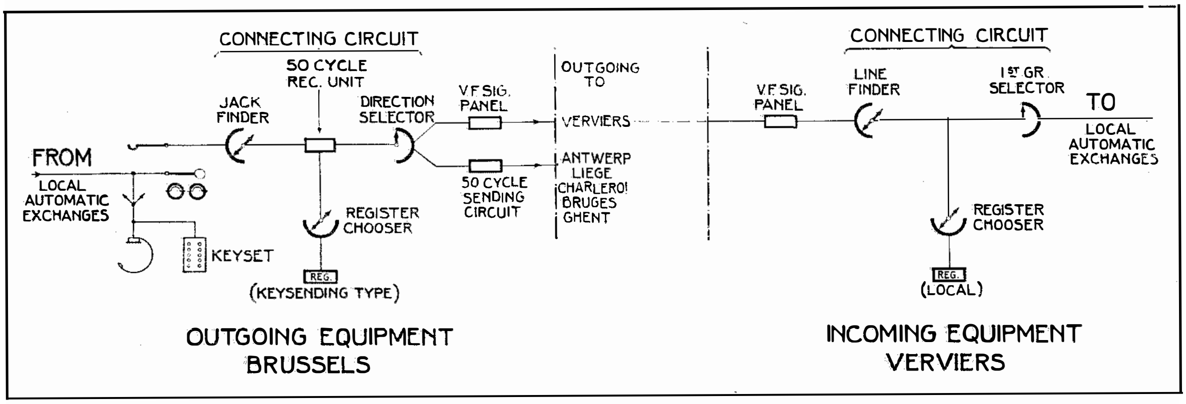


Figure 1—Schematic of C.L.R. Equipment in Belgium Utilising the 50 Cycle Signalling System.

tween 100 and 200 p:s. The output from the low frequency filter reaches the third tube V_3 through a transformer and the plate circuit of this last tube includes an ordinary telephone type relay IR shunted by a condenser. This relay responds to the variations of plate current and in this manner the voice frequency signals are transmitted to the automatic equipment in the form of direct current impulses.

Application of Voice Frequency Signalling

To apply voice frequency signalling to the existing C.L.R. equipment, it was sufficient to replace the 50 cycle units in the toll lines by the 600/750 p:s signalling panels. The outgoing connecting circuits, however, required a small modification to disable the 50 cycle receiving units, which they include, and to arrange the third wire to receive d-c signals from the voice frequency panels. The outgoing end of each toll line is equipped with a voice frequency signalling panel and a relay group. The incoming end is similarly equipped but the relay group is of a slightly different design. In addition to the line equipment, each exchange is provided with a voice frequency generator and one reserve machine, together with arrangements for routine testing.

Establishment of a Connection

The establishment of a connection is made in exactly the same manner as with the existing 50 cycle signalling system. The C.L.R. operator engages a jack circuit, an outgoing connecting circuit, and a register. By means of her key set, she conveys the exchange prefix and wanted party's number to the register which then controls the selection of the connecting circuit selector. This selector seizes a free toll line in the wanted direction and the calling impulse is then despatched. At the distant exchange, the finders of free connecting circuits rotate to find the calling line. When the line is found, a register is connected and a signal is sent back to the outgoing exchange, indicating that the sending register may send the series of impulses representing the number of the called subscriber.

When the selection of the wanted party is completed, a second impulse is sent to the outgoing exchange, causing the supervisory lamp of the operator's cord circuit to light. At the same time, the calling subscriber and the operator hear ringing tone or busy tone. When the wanted subscriber replies, a third impulse is sent back to the outgoing exchange, causing the supervisory lamp to be extinguished and indicating to the operator the beginning of conversation and the fact that the time meter may be started.

At the end of a conversation, both parties restore their receivers and both supervisory lamps flash. The restoration of the wanted party's receiver causes a train of impulses to be sent back to the outgoing exchange to which the supervisory relay and lamp respond.

The operator takes down the plug and the outgoing connecting circuit is thereby released. A long releasing impulse is sent from the outgoing end of the toll line to the distant exchange, causing the equipment there to be released.

Security of System

Practical tests on one receiving unit to determine the frequencies simultaneously transmitted by the filter circuits gave the following results, which must, however, be considered as only approximate as they were carried out by the use of oscillators not accurately calibrated. If a frequency of 700 p:s was sent, the signalling panel operated correctly only if the second frequency was between the limits of 545 and 570 p:s. The resultant frequency then varied between 130 and 155 p:s. When sending a frequency of 730 p:s, the second frequency had to be between the limits of 540 and 600 and, in this case, the resultant frequency varied between 130 and 190. Finally, if the first frequency was 750, the second could be between 560 and 610 with a resultant frequency between 140 and 190.

Thus the resultant frequencies which were capable of correctly operating the impulsing relay of the signalling panel lay between 130 and 190, these being derived from combinations of frequencies of average value of 575 and 725. These limits are well inside the specified values of minimum 550 and 800 for the first filter, and 100 and 200 for the second filter.

On the first tests made by the Régie, it was possible to produce a release of the circuit by sending a musical tone for about 500 milliseconds. It was, however, considered that in practice such frequencies would not be present in ordinary speech long enough to cause the release, and the delay figure of 500 milliseconds was left unchanged.

In the opposite direction, incoming end to outgoing end, it is not possible to cause a release since the connection is held by the operator, but it was found that in certain cases speech frequency currents affected the supervisory lamp. This trouble was eliminated by doubling the backward impulses, i.e., instead of sending a single impulse of fixed duration, two impulses with a certain definite spacing were used and this method proved quite satisfactory. Further tests were made over a 100 k.m. cable and one line repeater. A large number of communications were established during the tests without the slightest difficulty. The transmission of impulses was made without error and without omission, the supervisory signals were properly received and no false release produced by speech or otherwise was observed.

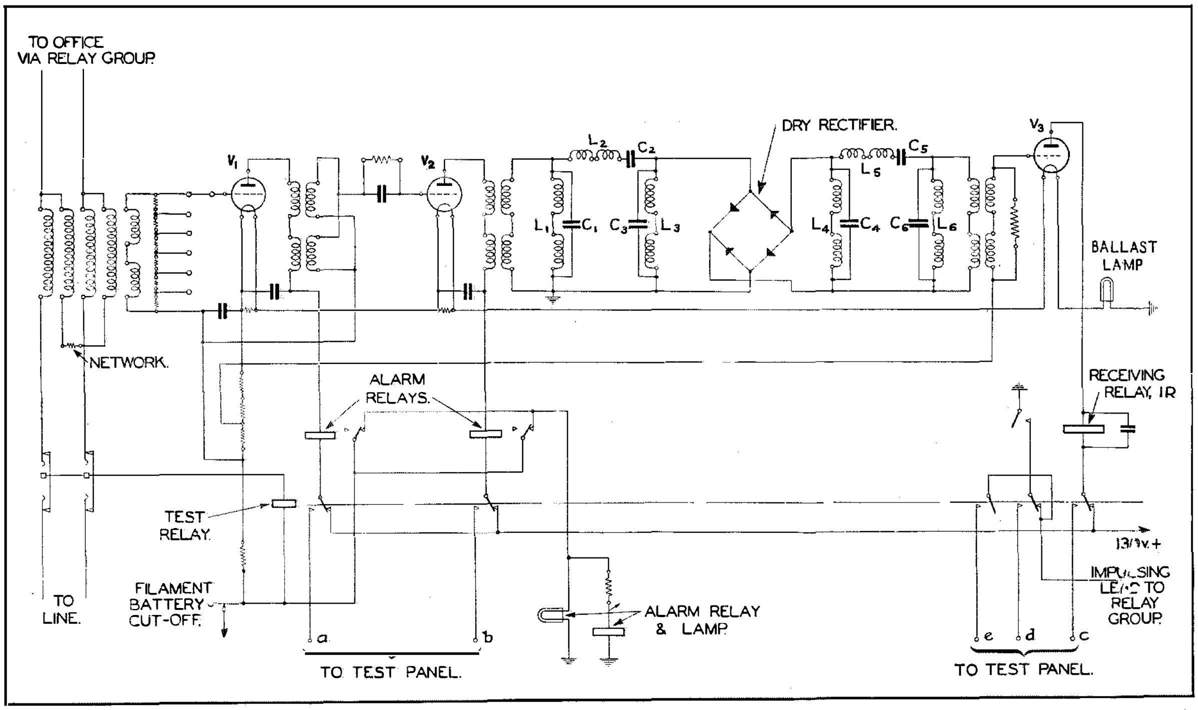
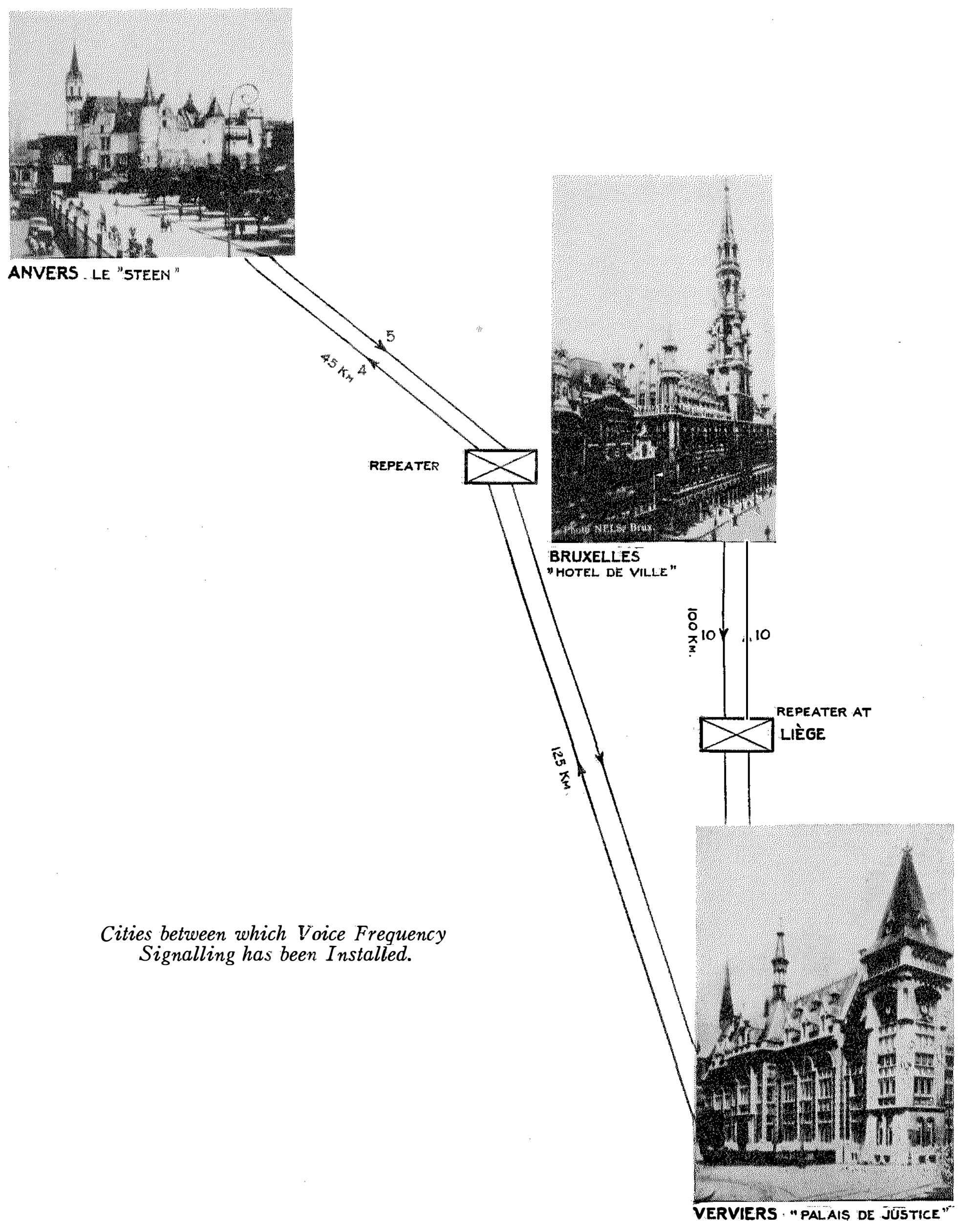


Figure 2—Schematic of Voice Frequency Signalling Panel.

Following these most favourable tests, the new system was adopted and towards the end of December, 1934 two-frequency signalling was put in service between Brussels and Verviers.

The most favourable testimony that one can give to the system is the statement that right from its inauguration it has given the same results in practice as the 50 cycle system which has been in operation for three years.

Comparison of the results of service observations on the two systems indicates that they are practically the same except for a small difference in the percentage of busy connections which is an effect not influenced by the signalling system:



Cities between which Voice Frequency Signalling has been Installed.

	Verviers Two Voice Freq.	Antwerp, Charleroi, Ghent, Liège 50 p:s
Effective calls	77.9%	75.5%
Busy	12.8	14.8
No answer	6.4	6.6
Incomplete calls	1.9	2.1
Errors due to operator	0.5	0.4
Errors due to subscriber	0.1 0.9	0.2 0.9
Errors due to machines	0.3	0.3
Interrupted connections	—	—
Fault signal	0.1	0.04

Up to the present, no interrupted communications have been observed and no release caused by speech currents have been reported by the personnel responsible for the maintenance of the C.L.R. equipment.

In view of the fact that the voice frequency signalling system has only been in service for some months, it is too early to say anything definite about faults which may affect operation, but from what can be seen, it appears that troubles will not be more numerous than with the 50 cycle system.

Recent Telecommunication Developments of Interest

A SERIES of low voltage hot cathode mercury vapour rectifiers has been developed by Les Laboratoires L.M.T., Paris, suitable for d-c supplies up to 500 volts and 120 amperes. The series consists of types designed specially for the following applications:

(a) General Industrial Use.
(b) Battery Charging.
(c) Floating Batteries.
(d) Charging and Floating Batteries.
(e) Arc Welding or Cinema Arc Projector Supply.

These types can be supplied for the following power ratings:

24 Volts and 48 Volts........40, 60, and 120 amperes.
110 Volts and 220 Volts...10, 15, 40, 60, and 120 amperes.

The efficiency of this series of H.C.M.V. rectifiers is superior to that of dry oxide rectifiers or rotating machines.

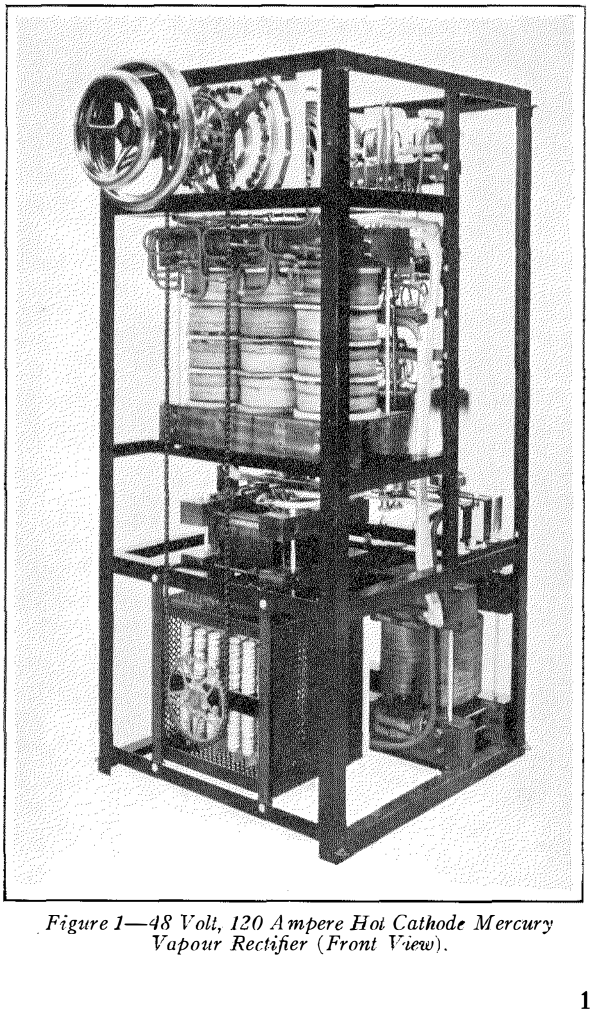


Figure 1—48 Volt, 120 Ampere Hot Cathode Mercury Vapour Rectifier (Front View).

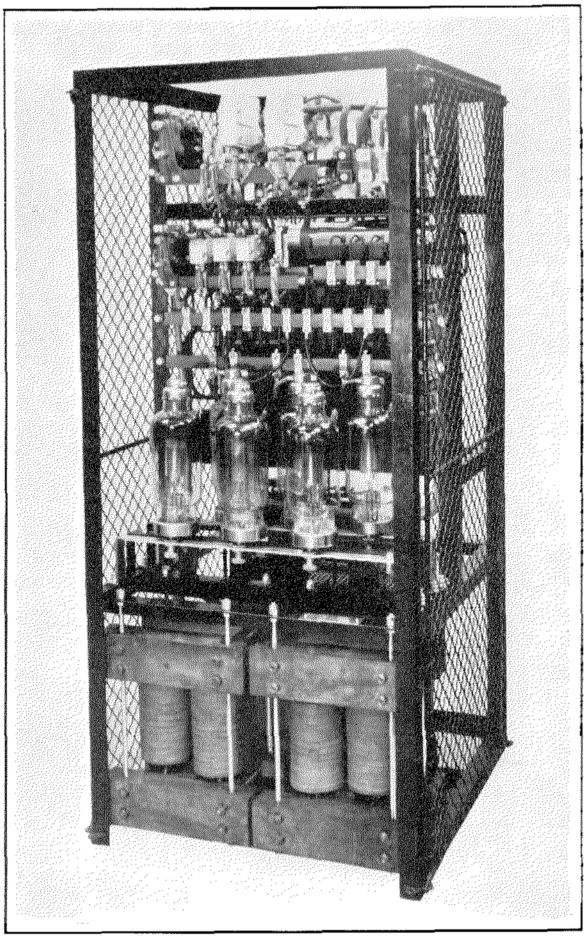


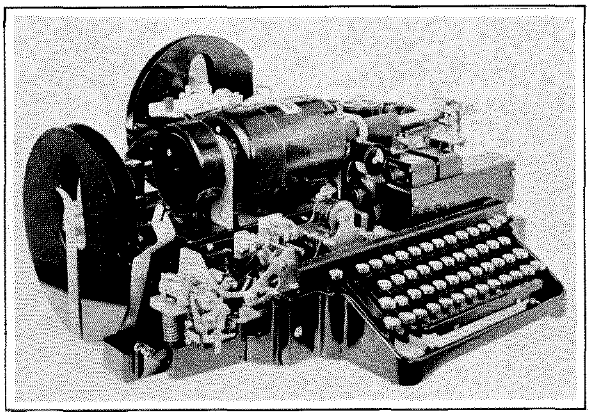
Figure 2—48 Volt, 120 Ampere Hot Cathode Mercury Vapour Rectifier (Rear View).

The illustrations represent a 48 volt, 120 ampere rectifier supplied for floating a 2,000 ampere, 48 volt telephone battery to take care of the night traffic on the exchange, the unit being arranged for direct mounting behind one of the panels of the exchange power board.

◆ ◆ ◆

A TAPE perforating attachment for a commercial teleprinter keyboard, described in the July, 1934 issue of *Electrical Communication*, has been developed by Creed and Company, Ltd., London. The attachment is fitted to the left-hand side of the keyboard, as shown in the illustration, and is designed so that the last character perforated is immediately visible.

The punch block is mechanically operated from a ratchet-clutch driven cam. The selection of the punches and the release of the cam are effected through the existing keyboard storage and case insertion mechanism, and therefore full use is made of these important features when preparing perforated tape.



The attachment may be switched in and out of use by the operation of a lever, and if no local record is required when perforating tape, the keyboard transmitter can be cut out. In the latter case the perforator cam is released from the code shaft of the transfer unit instead of from the transmitter shaft, and the maximum average speed at which the keyboard can be operated is thereby increased from the normal speed of 420 characters to 840 characters per minute.

◆ ◆ ◆

THE TA.101 Magnetic Brake has been developed by the Bell Telephone Manufacturing Company as a simple and practical tool for testing small fractional horsepower motors such as are extensively used in rotary type automatic telephone exchanges.

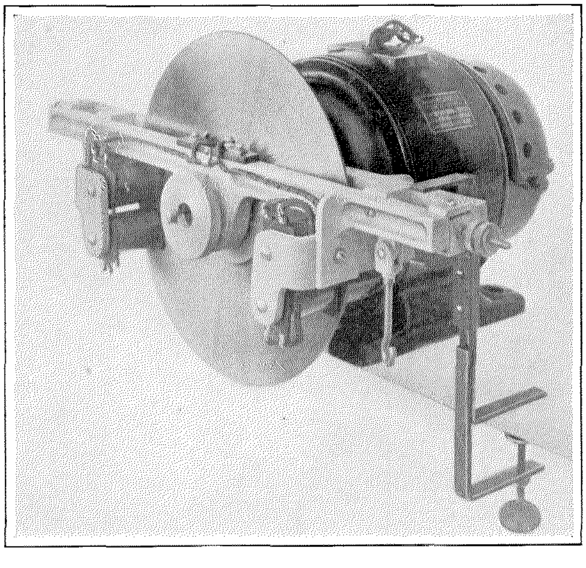
The brake consists of a copper disc which is mounted on a yoke in an aluminium casting by means of two double row ball bearings and in the airgap of two electromagnets which are also fixed on the yoke. The yoke is provided at both ends with threaded levers fitted with knurled nuts and locknuts, which serve as balancing weights to maintain the yoke horizontally when the torque is zero. A pair of hooks on which the loading weight is to be attached is also fitted to the yoke.

The whole assembly can be mounted on the shaft of the motor to be tested by means of a spring chuck, and a series of spring bushings is supplied with each brake, thus permitting the brake to be fixed on shafts from .375 inch to .525 inch in thickness.

The electromagnets can be excited from any d-c supply system of 48 volts or higher, and the field intensity required to counterbalance the torque of the loading weight attached to one of the hooks can be adjusted by means of a separate series resistance. Balance in operation is obtained when the retarding torque of the magnetic field equals the moment exerted about the shaft axes by the loading weight, the yoke then being maintained in the horizontal position. The angular motion of the yoke may be limited by two stops fixed to the frame of the motor or to some other fixed point, as required in each particular case.

The motor load is defined by its speed and by the energy absorbed by the brake at each revolution of the disc. The determination of the motor load is simplified by the fact that the dimensioning of the system is such as to make the energy absorbed at each revolution of the disc numerically equal to the loading weight.

The design of the brake is shown in the accompanying illustration and is suitable for testing motors up to $\frac{1}{4}$ HP. The current consumption of the electromagnets is about 0.4 amp. for $\frac{1}{8}$ HP. load at 1,000 r.p.m.



Licensee Companies

BELL TELEPHONE MANUFACTURING COMPANY .... *Antwerp, Belgium*
Branches: Brussels.
BELL TELEPHONE MANUFACTURING COMPANY .... *Berne, Switzerland*
BELL TELEPHONE MANUFACTURING COMPANY .... *The Hague, Holland*

CHINA ELECTRIC COMPANY, LIMITED .... *Shanghai, China*
Branches: Canton, Hankow, Hongkong, Peiping, Tientsin.

COMPAÑÍA RADIO AEREA MARITIMA ESPAÑOLA .... *Madrid, Spain*

COMPAÑÍA STANDARD ELECTRIC ARGENTINA .... *Buenos Aires, Argentina*

CREED & COMPANY, LIMITED .... *Croydon, England*

INTERNATIONAL MARINE RADIO COMPANY, LIMITED .... *London, England*

INTERNATIONAL STANDARD ELECTRIC CORPORATION, *Branch Office,*
Rio de Janeiro, Brazil

JUGOSLAVIAN STANDARD ELECTRIC COMPANY, LIMITED .... *Belgrade, Jugoslavia*

KOLSTER-BRANDES, LIMITED .... *Sidcup, England*

LE MATÉRIEL TÉLÉPHONIQUE .... *Paris, France*
Branch: Rabat, Morocco.

NIPPON DENKI KABUSHIKI KAISHA .... *Tokyo, Japan*
Branches: Osaka, Dairen, Taihoku.

SOCIÉTÉ ANONYME LES TÉLÉIMPRIMEURS .... *Paris, France*

STANDARD ELECTRIC AKTIESELSKAB .... *Copenhagen, Denmark*

STANDARD ELECTRIC COMPANY W POLSCE SKA Z O. O .... *Warsaw, Poland*

STANDARD ELECTRIC DOMS A SPOL .... *Prague, Czechoslovakia*
Branch: Bratislava.

STANDARD ELECTRICA ROMANA S/A .... *Bucharest, Rumania*

STANDARD ELÉCTRICA, S.A .... *Madrid, Spain*
Branches: Barcelona, Santander.

STANDARD ELECTRICA, S.A .... *Lisbon, Portugal*

STANDARD ELEKTRIZITATS-GESELLSCHAFT, A.G .... *Berlin, Germany*

STANDARD ELETTRICA ITALIANA .... *Milan, Italy*
Branch: Rome.

STANDARD TELEFON-OG KABELFABRIK A/S .... *Oslo, Norway*

STANDARD TELEPHONES AND CABLES, LIMITED .... *London, England*
Branches: Birmingham, Glasgow, Leeds, Manchester, Dublin,
Cairo, Johannesburg, Calcutta.

STANDARD TELEPHONES AND CABLES (AUSTRALASIA), LIMITED ..... *Sydney, Australia*
Branches: Melbourne; Wellington, New Zealand.

STANDARD VILLAMOSSÁGI RÉSZVÉNY TÁRSASÁG .... *Budapest, Hungary*

SUMITOMO ELECTRIC WIRE & CABLE WORKS, LIMITED .... *Osaka, Japan*

VEREINIGTE TELEPHON-UND TELEGRAPHENFABRIKS AKTIEN-GESELLSCHAFT,
CZEIJA, NISSL & CO .... *Vienna, Austria*

Sales Offices and Agencies Throughout the World

Printed in U. S. A.