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Editorial

PLANNING AHEAD

The Editorial in our last issue indicated the general direction of our planning for the future without detailed reference to any specific feature. In order to implement such plans, which have reference to both the production and research organizations, it is imperative to ensure, as far as possible, that sufficient well-trained technicians and craftsmen are available.

The specialized knowledge required in the telecommunications industry must, perforce, be supplementary to that acquired from a general education, and in order to provide every facility for those leaving school or college to gain this special knowledge, the Company operates a comprehensive training scheme in the works.

The idea is not new, there having been kindred schemes in a variety of industries for a great many years, but there is a vast difference between the training required today and that of the apprentice of, say, twenty years ago.

That the standard of technical education will have to be progressively higher as the years pass, in order to meet the requirements of this scientific age, there can be no doubt, also it seems certain that the professional will tend to become still more a specialist than he is today, a circumstance which is bound to be considered when planning the curriculum of an industrial training scheme, if the maximum benefit is to be ensured for both the company and the individual.

In this issue of the Bulletin will be found an article entitled " Education and Training for the Telephone Industry " which, while making sufficient reference to our own works scheme to show that it is an important section of the factory organization, is primarily a general approach to the subject and deals with certain fundamental concomitant problems of common interest.

Phonogram and Telephone-Telegram Automatic Distribution at Newcastle

ON the 12th June 1949, a new type of equipment, replacing the existing double-tier ancillary-working switchboard used for handling phonogram and telephone-telegram traffic, was brought into service for field trial at Newcastle-upon-Tyne by the British Post Office, the manufacture, installation and testing of the equipment being entrusted to the Company.

Phonograms and telephone-telegrams are defined as follows :—

A phonogram is a telegram which is transmitted by telephone from a telephone subscriber to the post office.

A telephone-telegram is a telegram which is transmitted by telephone between two post offices.

With the standard system it is not always possible for the operator to answer calls in the order of their arrival at the position, as her attention may be directed to the writing or despatching of a message and not to the lamp jacks, thus some calls have a waiting time much longer than the average. The new scheme has been developed to ensure that calls received at the phonogram equipment are automatically routed singly and in chronological order to free operators' positions on a cyclic basis.

Sudden peaks of traffic which occur during the day are catered for automatically by increasing the number of staffed positions to which incoming calls have access. During sustained seasonal increases in traffic or for exceptionally busy periods the chief supervisor can further augment the number of incoming positions, as will be explained. By this means, very long

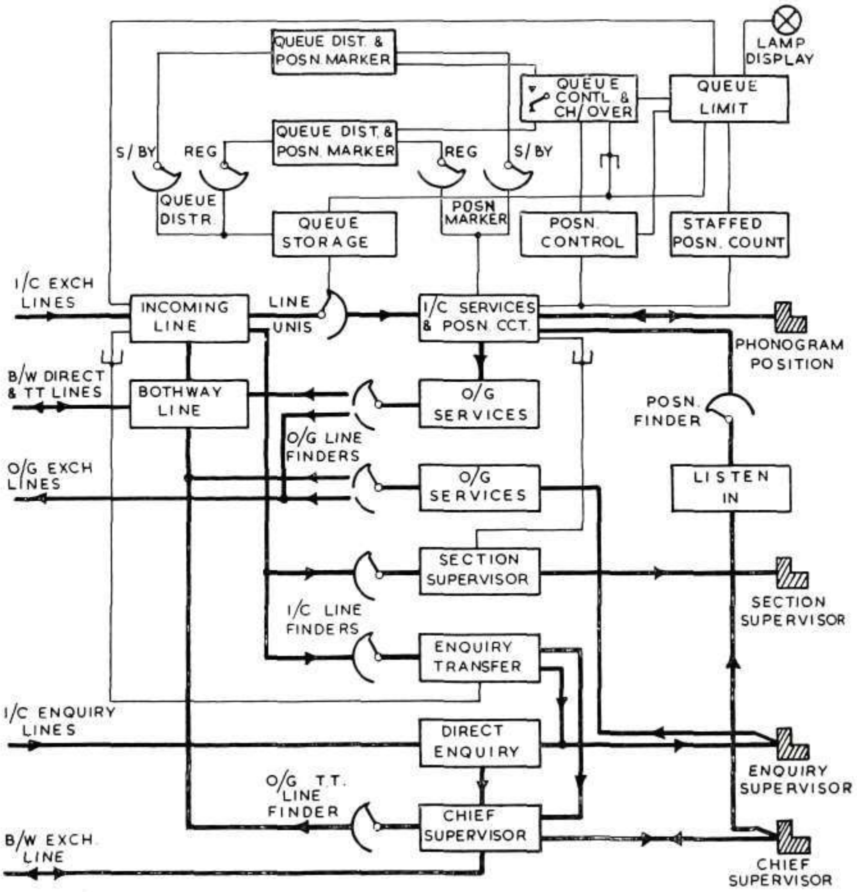


Fig. 1—Phonogram and Telephone-Telegram Automatic Distribution Scheme.

waiting time is eliminated, and due to the flexibility of the scheme a reduction in the average time taken to answer incoming calls is assured.

By the use of automatic switching, plugs, cords and multiple jacks as provided for the present standard system become unnecessary, but the opportunity of incorporating in the new equipment the latest features of cordless switchboard design could not be fully exploited for the field trial, as the maximum possible use was made of the existing positions, therefore the illustrations shown are not necessarily indicative of the design which would be followed in the case of a completely new installation.

Fig. 1 shows in block schematic form the items of equipment, comprising relay sets and switches, provided for incoming call queueing and automatic distribution, outgoing calls, transfer of calls, etc.

The operating positions are divided into three separate groups, i.e. incoming, bothway and outgoing. Bothway positions are normally used for outgoing working but when temporary increases in traffic result in all the incoming positions being engaged, the calls are automatically routed to free bothway positions.

To meet seasonal traffic when the increase is sustained, e.g. Christmas, Easter and race-meeting days, the operation of a master key under the control of the chief supervisor converts all bothway to incoming positions.

During exceptionally busy periods, outgoing positions also may be allocated to incoming working, the changeover in this case being effected, at the supervisor's discretion, by the operation of a key associated with each position. It will be seen, therefore, that it is possible to arrange for every operator to answer incoming calls.

When a free position is not available, incoming calls are queued in the order of their arrival and are distributed in that order direct to the headsets of the operators as the latter become free. Busy tone is returned to the caller when the queue is filled. 50-point switches are used for the line uniselectors associated with the incoming line relay sets, the first 15 outlets being allocated to queue positions and the remaining 35 to operators' positions, which were arranged initially as 10 incoming, 15 bothway and 10 outgoing.

The queue capacity can be adjusted manually by the supervisor (or automatically by means of terminal strappings) up to the maximum of 15, to suit variations in the number of operators allotted for incoming service.

The removal or insertion of an operator's headset plug causes a staffed position count relay set to function ; the number of incoming staffed positions is counted and the total is displayed at the chief supervisor's desk.

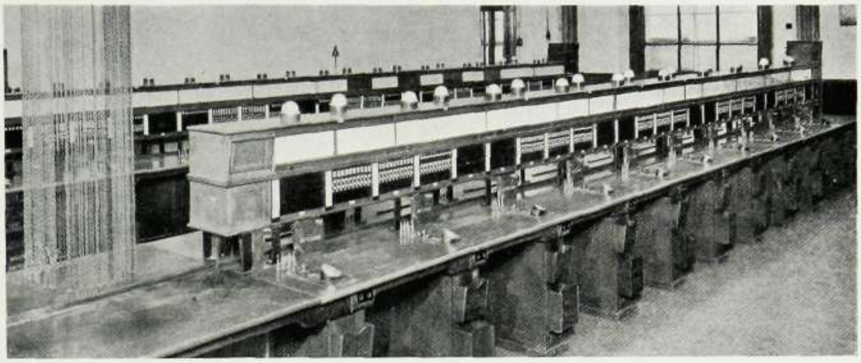
The chief supervisor has two lamp displays, one giving an indication of the size of the queue and a "queue full" condition, and the other indicating the number of incoming staffed positions, as previously stated. An audible alarm functions when the queue limit is reached.

Each phonogram operator has a display column as seen in Fig. 2. Alternate columns contain strips of 10 lamps, five of which represent the first five queue positions, another is allocated to "over 5" queue positions, while another registers a "queue full" condition.

At the top of each display column is a dome-shaped opal containing two lamps. One is green and glows on an incoming call ; if, however, on completion of the call the operator fails to throw the position release key within 15 seconds after the clear down of the calling subscriber, the steady glow of the lamp changes to a flashing signal. The other lamp, a red one, glows when the position is engaged on an outgoing call.

The relay sets and associated equipment are mounted on four 10 ft. 6 in. x 4 ft. 6 in. 2000-type apparatus racks as shown in Fig. 3, and are built from standard components as used in automatic telephone practice.

The power supply is 50 volts.



Old Scheme — Ancillary Working.

New Scheme — Automatic Distribution.

Fig. 2—Phonogram Positions. Newcastle.

CIRCUIT NOTES.

A subscriber wishing to send a telegram by telephone, i.e. to make a phonogram call, dials, or is connected by an operator to, the directory number specified for this service. In the present case the call is routed through the Newcastle automatic telephone exchange via an outgoing relay set and over a two-wire junction to an incoming line relay set (Fig. 1) in the phonogram equipment located at Newcastle Head Post Office.

The incoming line circuit responds to the calling condition and if a free queue position is available the line uniselector steps to find this position. The testing relay operates in series with a relay in the particular queue storage circuit, and ringing tone is connected to the line.

When a phonogram position becomes free to accept a queued call, the queue distributor and position marker equipment marks the particular incoming services relay set which, in turn, marks the line uniselector associated with the free position. The distributor also discharges the call from the storage relay set, this action allowing the line uniselector to hunt for, and find, the marked outlet.

If the queue is unoccupied and an operator is free to accept the call, it will enter the storage equipment but will be immediately discharged ; if fully occupied, busy tone is connected to the caller.

If the phonogram operator desires to transfer the call to the section supervisor's position, the appropriate key on the operator's position is depressed and the call is routed via the incoming line finder and section supervisor's relay set. If the services of the phonogram operator are then no longer required, the section supervisor operates a release key to disconnect the phonogram operator from the transferred call, allowing further incoming traffic to

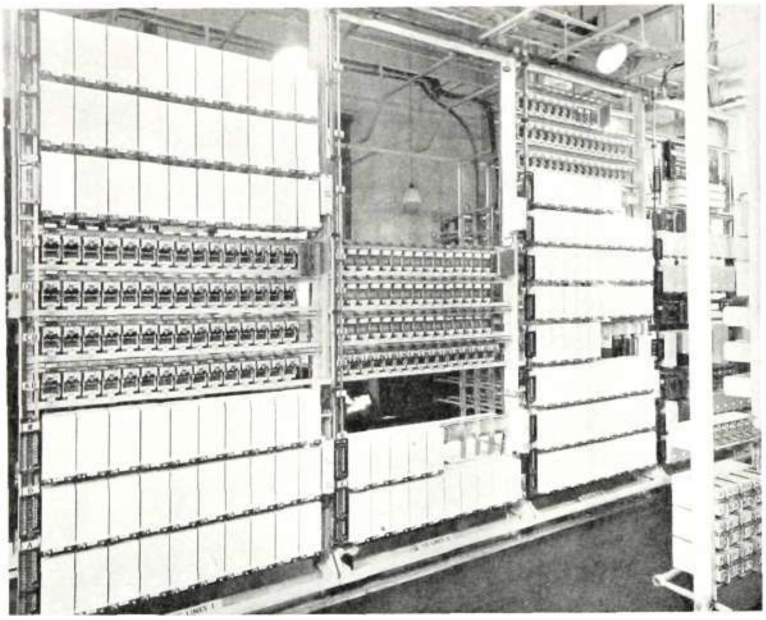


Fig. 3—Phonogram Automatic Distribution Apparatus Racks. Newcastle.

be accepted. Similarly, the phonogram operator may transfer the call to the enquiry supervisor who can, if necessary, extend it to the chief supervisor. Busy tone is returned should the section or enquiry supervisor be engaged.

If it becomes necessary to release a call, it is transferred from the operator to the section supervisor, who then utilizes a "forced release" key to clear the call from both positions. If after this the incoming line relay set is held beyond a predetermined period, audible and visual indication is given on the rack equipment.

Outgoing calls may be routed over the exchange network or to direct T.T. circuits by the operation of the appropriate key on the position. By actuating the exchange outgoing key the operator is connected to an outgoing services relay set and causes the associated line finder to hunt over a common group of exchange lines for a free outlet. Busy tone is returned if all lines are engaged.

A telephone telegram circuit is similarly obtained, the operation of the direct T.T. outgoing key establishing a connection to the outgoing services relay set and enabling the operator to dial the prearranged code for the T.T. line which is reached via the bothway line relay set. Standard tones indicate the condition of the called line.

Should the common control equipment, i.e., the queue distributor and position marker relay set, fail to function correctly, automatic changeover to standby equipment is provided. On taking over, the latter is automatically positioned to agree with the setting of the regular equipment. Facilities for manual changeover are also given for test and maintenance purposes.

Meters provided for each incoming line relay set register each call and record the time taken to answer, while other meters connected to the incoming operator's position circuit, register each call and its duration.

Battery testing arrangements using high-speed relays are employed throughout for the uniselector testing and switching circuits.

Efficiency of the System.

The new equipment is satisfactorily dealing with an average of 20,000 calls per week, and statistics obtained from meter readings when the Christmas 1949 seasonal messages were being handled demonstrate the flexibility of the arrangements for meeting sudden or prolonged peaks in traffic. The very long delays in answering some incoming calls, experienced with the former system, have been eliminated, while the average time of answer has been lessened.

An added advantage is that the employment of cordless-type positions reduces the amount of construction above desk level, thereby improving operating conditions and assisting supervision.

We are indebted to the Engineer-in-Chief of the British Post Office for permission to publish this article, and for the use of photographs

Education and Training for the Telephone Industry

ONE of the results of the development continually taking place in manufacturing processes is an ever increasing demand on the educational standards of those who operate and control them. It is thought, therefore, that a short examination of some of the problems involved in education and training for industry may prove of general interest.

The approach of industry to education is necessarily more utilitarian than that of the educationist, for industry survives only by its ability to pay its way. If the following pages appear to stress unduly the importance of merely technical ability, it should be remembered that the possession of this ability does not exclude the attainment of a broader culture, and that it is useless to learn to live unless one learns also to earn a living.

The telephone manufacturing industry is remarkable for the immense variety of technical skills of which it makes use. The productive departments of our own works, for example, include machine shops for turning, milling, drilling, gear cutting, grinding and presswork ; an extensive toolroom ; heat treatment, bakelite moulding, crystal cutting, cabinet-making and wood-finishing departments ; shops engaged on framework erection, plating, enamelling and paint production ; coil winding, wiring and cabling shops, and assembly departments of many kinds.

Training for the telephone industry must take account of this diversity and attempt to relate the practical arts of the workshop to the basic science which underlies them all. Some of these arts have been built up empirically over many years, and the fact that those who now work with their hands do not always appreciate the need for fundamental knowledge is no reason for denying to succeeding generations the power which it alone can give.

It is useful at the outset to examine the mass of knowledge upon which industry depends, and Fig. 1 is an attempt to illustrate in diagrammatic fashion some of the relations which the various parts of this mass bear to one another. At the bottom is the basic knowledge of mathematics and the physical sciences—the "solid ground of nature"—taught in our schools and universities. To it must be added the ability to express oneself clearly in English, not always a strong point in members of the science faculties.

It is at once the strength and the weakness of basic scientific knowledge that it deals

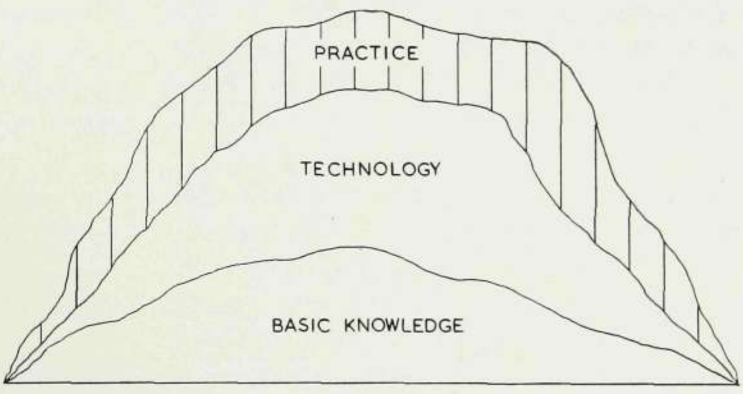


Fig 1.—Industrial Knowledge.

with general principles rather than particular cases ; the strength because only so can an approach be made to fundamentals, and the weakness because it renders impossible any attempt to take into account all the innumerable variable factors that influence practical results.

Forming a crust at the top of the mass of industrial knowledge, and divided into more or less watertight compartments, are the workshop arts and practical " know how " to which reference has already been made. They are concerned not with general principles but with particular cases, and since particular cases seldom exhibit the ideal simplicity assumed in theoretical discussions, their dependence upon the bottom layer of basic knowledge, absolute though it may be, is not always apparent.

An important function of education for industry is to relate these two extremes ; to show the man in the workshop that practice *is* based on theory, and the man with the basic knowledge that theory is not complete until it has accounted for *all* the practical results. Only in this way can practice be given a firm foundation and theory be freed from the gibe that anyone can design something that no one can make.

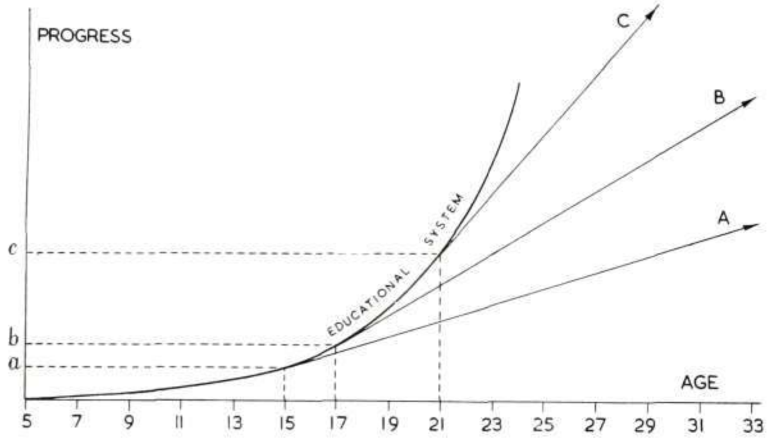


Fig. 2—Individual Progress.

The link is the technologist, the man who is able to translate the findings of the scientist and to wring from them the practical results which are the *raison d'être* of industry. There is therefore a middle layer in the diagram : the mass of technology which relates theory to practice and, no less important, the practice of one department to that of another. Without it the thin crust of practice has no support, and all the basic knowledge in the world cannot prevent collapse.

With this picture of industrial requirements in mind, it is possible to examine the educational system as it affects our own industry. One or two points of interest are illustrated in Fig. 2, which is intended to relate the progress of the individual to his increasing age and widening education.

At the age of five the child is caught up in the educational system and, even in these days of self-expression, is encouraged to follow a prescribed path, indicated in the diagram by the heavy curve, until he finally leaves school. If he leaves when he is fifteen years old, and the system has succeeded in carrying him with it, his progress up to this time is represented by the value *a*, and he is flung off like a drop of water from a wheel in the direction A. The educational system that he has left can do nothing afterwards to change this direction.

If, on the other hand, his ability and good fortune are such that he has reached a grammar or public school, he will normally remain until he passes a recognized school-leaving examination at, say, seventeen. His progress at this time will be represented by the value b. It is not, however, the small difference between b and a—the extra knowledge gained during the extra years at school—that is of primary importance. What matters is the marked change in outlook brought about by wisely directed education during these formative years. As a direct result of this change he is flung from the educational system in the direction B, and the effect upon his future and (for the two things go together) his value to industry is out of all proportion to his slight initial gain.

The boy who goes on from school to a university has still further opportunities. Provided that he is capable of making use of them, his progress at, say, 21, may be measured by the value c and his subsequent direction by C. Other things being equal, he will progress further and more rapidly than those who have not had his advantages.

A point to be considered, but one which this is not the place to pursue, is that outlook and direction are dependent upon the individual and the home no less than upon the school. In earlier times those who had the best education commonly came from the most cultured homes, but the progress towards equality of educational opportunity has made it possible to achieve some academic success, particularly in science, without much cultural background.

It must not be supposed that a boy who begins his industrial life in the direction B or C may not by lack of effort allow his course to droop below that of A. It is, indeed, all too easy for him to lose his initial advantage through failure to maintain direction when left to his own resources. On the other hand, one who sets out in the direction A may rise to B or C. It will not be easy, but a wise industry will do all that it can to help him. In particular it will encourage him to maintain contact with the educational system by attending evening classes. When possible, and if it seems likely that he will make good use of them, it will allow him to attend day classes during working hours.

We may now enquire into the use made of the output of the schools, and into the ways in which our own industry attempts to further the education of its employees after they begin to earn their living. Let it be said first of all that there is no prejudice against those who leave school at an early age ; provided that they make up what they lack there are no artificial barriers to restrict their progress. It is futile, on the other hand, to ignore the wide differences in ability and outlook which undoubtedly exist in those leaving school.

What can an employer do to assist young people entering his service to make the most of their educational opportunities without interfering unduly with the useful production upon which both employer and employed depend ? In the days of the small master craftsmen, apprentices enjoyed advantages which were denied to many of their successors, but conditions have changed greatly during the last twenty or thirty years and most large companies now have an organized training system for their junior employees. Our own apprenticeship scheme dates back for twenty years and after considerable development it now offers what we believe to be a satisfactory solution of the industrial training problem.

Like most modern training schemes, it provides for the release of junior employees whose work is of sufficient merit in order that they may attend day classes in their chosen subjects. It is reasonable that an employer who makes this concession should have some control over the subjects studied, and in our own case it is expected that the apprentice will attend classes likely to assist

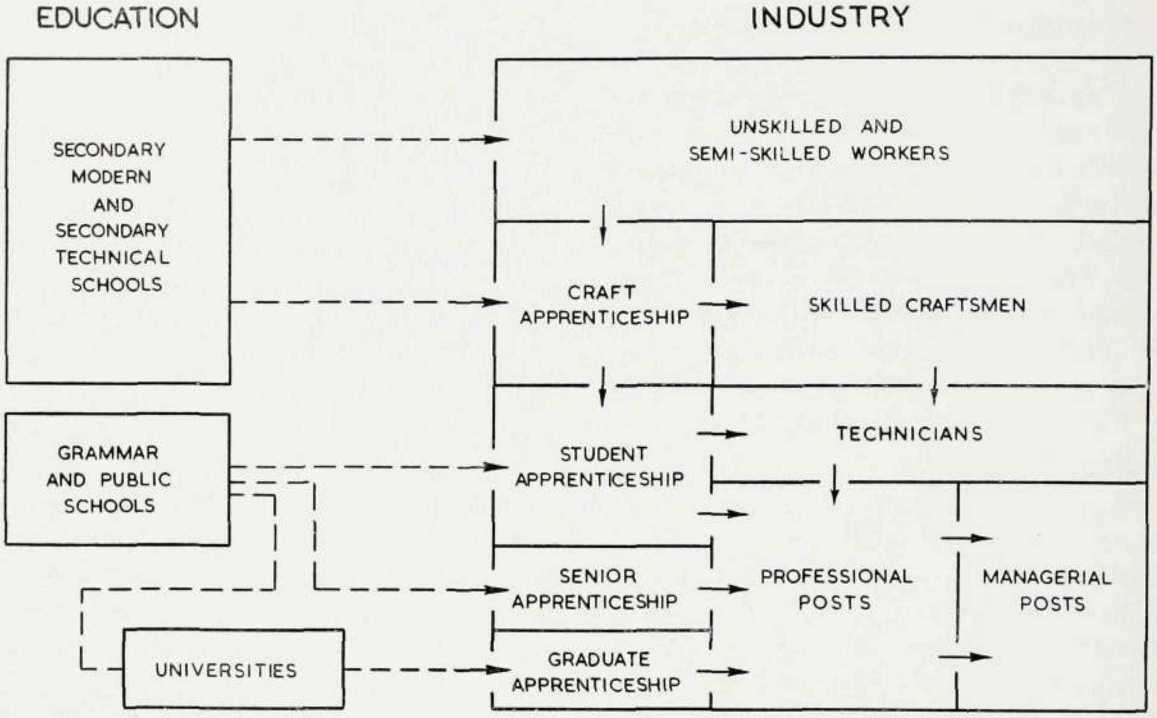


Fig. 3—Typical Training Scheme.

him in making progress in the telephone manufacturing industry. He may study, for example, for a national certificate in electrical or mechanical engineering, or for an external degree in engineering or the physical sciences.

The decision regarding the type of school attended during the later years of school life rests largely with the educational authorities. Most boys and girls find their way to secondary modern or secondary technical schools and enter industry at the age of fifteen, but those considered capable of benefiting from a more academic curriculum obtain places in grammar schools. Most of the latter enter industry or begin to train for one of the professions at about seventeen years of age, but a few may continue a general or specialized education at one of the universities and enter industry as graduates. The effect of these varying periods of education has already been noticed. A well-conceived industrial training scheme must make special provision for entrants of each class, placing no artificial obstacles in their paths yet never failing to recognize their essential differences in outlook.

The problems involved have received much study in the telephone industry, and Fig. 3 outlines, by way of example, the methods adopted to meet them in our own works. The majority of young workpeople of the craft grades come from the secondary modern and secondary technical schools. A preliminary sifting separates (but not irrevocably) those who are unlikely to achieve more than a semi-skilled status, and these are absorbed into works and office departments where there may be demands for their services. The remainder are interviewed and tested in a training centre attached to the works, and if considered suitable are offered probationary craft apprenticeships.

The craft apprentice spends his first three or four months in the training centre, where he is given opportunities to handle many of our products and to develop any ability he may have to practise mechanical and electrical crafts, draughtsmanship and clerical work. During this time he is carefully watched, and provided that his progress is satisfactory he is then moved to a department in which he can make the most of his special aptitudes. If necessary he may pass through more than one department in order to gain experience in cognate kinds of work. Eventually he will become a skilled craftsman and be recognized as such both within our own industry and outside it.

The boy or girl who has had a grammar school or public school education ought to have acquired that difference in outlook which fits him for the wider training necessary if in due course he is to become a qualified engineer or other professional worker. Pupils of this kind are accepted as student-apprentices, the entry standard being approximately that required for matriculation in a university.

The student-apprentice spends at least six months in the training centre, during which he is given an intensive theoretical and practical course in the fundamentals of the industry. He is required to attend technical-college classes on one day and at least two evenings each week and to make satisfactory progress during each session. Lectures intended to relate his technical-college studies to the special problems of the telephone industry are given in the training centre. A further series of special lectures by senior members of the staff helps the apprentice to gain a comprehensive picture of the organization as a whole.

After his initial period in the training centre, the student-apprentice spends the remainder of his first three years in an extensive tour of the works, gaining experience in many different departments and gradually acquiring a broad view of the industry which will stand him in good stead later on. He then settles down in the department in which he is most likely to prove of value, but he normally remains an apprentice for a further two years, making five years in all.

Student-apprentices who successfully complete their course usually obtain posts either as technicians or as professional engineers. The distinction between these classes is not always easy to draw, but it may be said that to achieve professional status it is necessary nowadays to obtain either a university degree or corporate membership of one of the chartered institutions. The technician must not be identified with the technological layer in Fig. 1, for many highly qualified professional men find their proper place in that important sphere.

A craft apprentice who shows special ability and acquires the necessary educational background is eligible for consideration as a student-apprentice. At a later stage some skilled craftsmen find their way into the ranks of the technicians, and in a similar manner the more capable technicians may obtain professional posts. The professional men, in their turn, particularly if they prove to have administrative ability, may qualify for managerial positions.

Some pupils at grammar and public schools remain until they reach an educational standard approximating to that of an intermediate degree examination, and a senior apprenticeship class is provided for these cases. Similarly, there is a graduate apprenticeship class for those who obtain degrees by full-time work at a university. Senior and graduate apprentices should in due course reach one of the professional grades.

Enough has probably been said to show that industry, and our own telephone industry in particular, is alive to the importance of making the most of the entrants it receives, and of doing what it can to further their education in the interests of themselves, of the industry they enter, and of those whom that industry serves. It remains to the educational authorities to provide the best possible material, and to recognize that the acquirement of technical skill is itself a worthy object of education and in no way incompatible with the gradual development of a liberal culture.

5 Plus 20
Sub-Attended P.A.B.X.

RAPID and efficient telecommunication is one of the essentials of modern times. It is as necessary within the business organization as it is in the public telephone network and is being achieved by increased automatization, but even when private and public exchanges are automatic the fullest benefit is not experienced if connections from the former to the latter have to be established through a local manual switchboard.

This disadvantage is obviated in the sub-attended P.A.B.X. which is completely automatic and incorporates the following facilities :—

(1) Access to the public exchange is obtained by dialling a single digit.

(2) Extensions can be completely or partially barred exchange facilities.

(3) Incoming exchange calls may be answered by any one of any number of designated extensions.

(4) Extensions with full facilities can originate, answer, or transfer exchange calls.

(5) An extension engaged on an exchange call can consult another extension without releasing the external connection.

(6) A transferred exchange call can be further transferred to any other extension having exchange facilities.

Design and Rack Layout.

Critical design, together with the use of twin type relays and 25-point British Post Office type uniselectors, has made it possible to produce this equipment, incorporating every essential facility, at a competitive price.

Employment of the twin relay, performing the functions of two standard relays but occupying the space of one, has enabled the equipment to be mounted on a rack of unusually small dimensions, the height being only five feet and the width approximately two feet six inches. The potentialities of the uniselector as a switching mechanism have been fully utilized, so that the P.A.B.X. has a maximum capacity of 25 lines. Of these, up to twenty are used

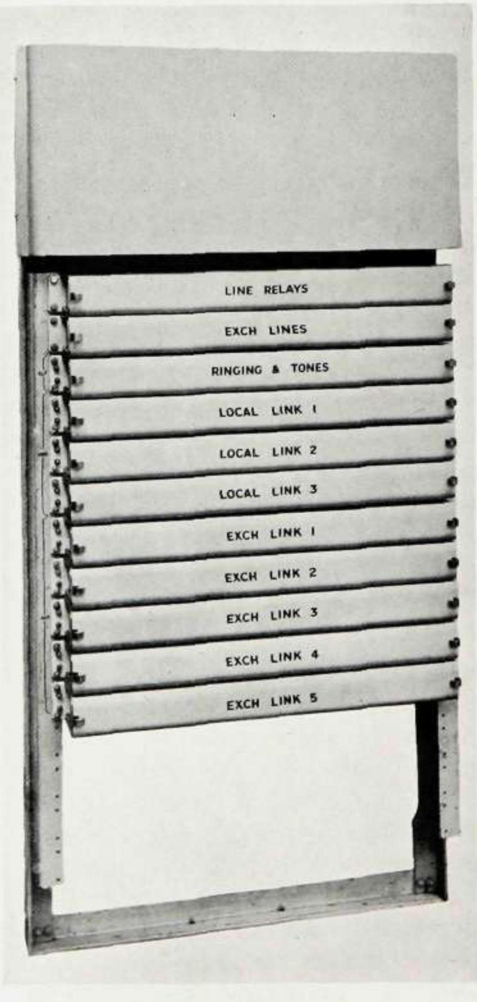


Fig. 1. 5 + 20 P.A.B.X. Equipment Rack.

for internal extensions and any number of the remaining five for the circuits giving access to the public exchange (exchange links).

The connecting circuits for internal calls (local links) are equipped as required, the standard rack, illustrated in Fig. 1, accommodating a maximum of three, but where the traffic loading is exceptionally high special provision can be made to equip extra links.

NUMBERING SCHEME.

The extensions are numbered in three groups, as follows, the prefix digit, or digits, determining the group :—

01 to 09 inclusive	..	(9 numbers)
11 to 19 ,,	..	(9 ,,)
001 and 002	..	(2 ,,)

EXTENSION INSTRUMENTS.

Extension instruments are provided with a push button for use in connection with consultation or transferred calls. Instruments for extensions without exchange facilities need not have a push button.

OPERATION.

In the following description, an extension dealing with a public exchange call is termed an " exchange " extension.

Internal Call.—The extension lifts the handset and when connected to a local link receives dial tone. After dialling the number required, ringing tone is received if the line is free, or busy tone if engaged. When the call is established, the first extension to replace the handset at the conclusion of conversation releases the connection.

Outgoing Exchange Call.—The preliminary digit 9 is dialled and connection to the public exchange line is immediately established.

If all lines are engaged, busy tone is received, but, if the extension cares to wait, connection is automatically made when a line becomes free.

Should a barred extension attempt to make an external call, busy tone is received.

Incoming Exchange Call.—Attention is drawn to an incoming exchange call by the ringing of a special bell, or bells, positioned within hearing of all designated extensions. The first of these extensions to answer the call is connected automatically to the exchange line concerned. Under no circumstances can an incoming call be answered by a barred extension or by dialling the digit 9.

Consultation Call and Transfer.—An extension engaged on an exchange call and wishing to consult another extension, momentarily operates the button on the instrument. This " holds " the exchange line and connects the exchange extension to a local link, thereby enabling the wanted number to be dialled.

When the called party replies, the exchange extension can either complete the transfer simply by replacing his handset or, after having finished the consultation, which incidentally cannot be overheard on the exchange line, can release the local link and resume the original exchange call by again operating the button.

Should the wanted extension be engaged on an internal call, busy tone is received by the exchange extension but an intrusion tone is superimposed upon the conversation of the local call to give warning that an exchange extension is calling. On hearing the tone, both local extensions should replace their handsets, when the one required will be automatically rung and, on answering, will be connected to the exchange extension.

If the wanted extension is engaged on an exchange call, " number unobtainable " tone

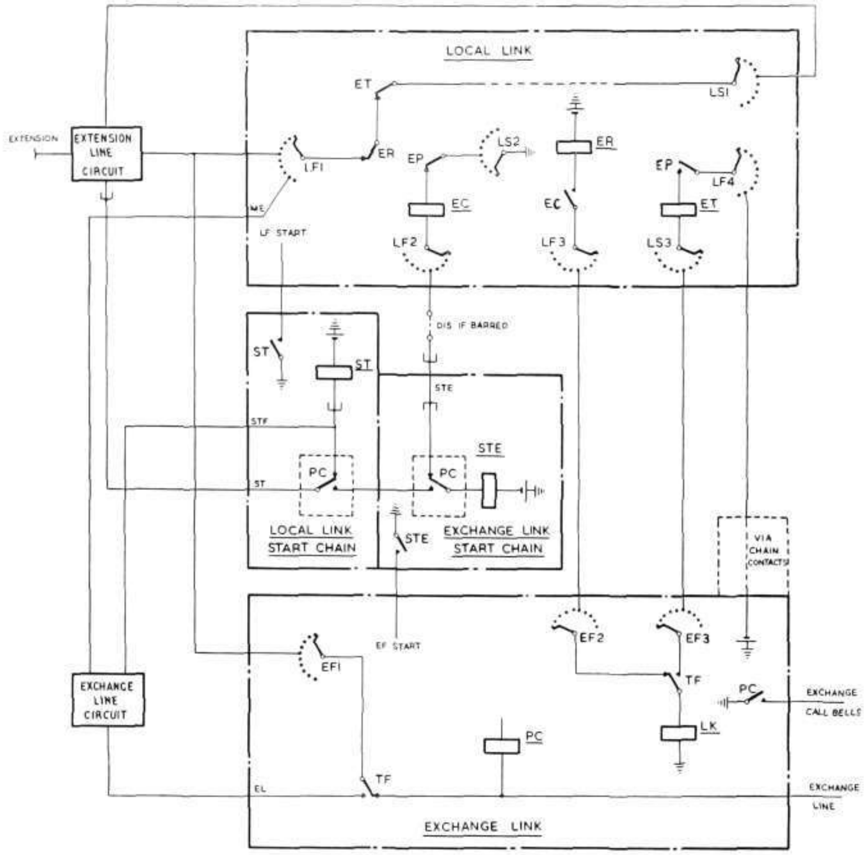


Fig. 2—Skeleton Circuit. 5 + 20 P.A.B.X. System.

is received by the exchange extension and the intrusion tone is not connected.

Circuit Arrangement.

In Fig. 2 the circuit of the P.A.B.X. is reproduced in simple skeleton form so that the association of the elements can be readily appreciated.

Internal Call.—When the handset is lifted, the extension line circuit responds to the loop and connects earth to the ST lead of the common local link start chain. A free local link is selected and its line finder (LF) searches for the calling line. When connection is made, dial tone is heard and the calling extension dials the wanted number. The dialled impulses position the connector switch (LS) and the local call is completed over the link LF1 to LS1.

Outgoing Exchange Call.—A local link is obtained and the extension dials the preliminary digit 9 to position the connector switch. From bank LS2 of this switch, earth is connected to the exchange link start chain, through relay EC and bank LF2 of the line finder. (The inclusion of this bank allows a pair of terminals for each extension to be placed in the STE lead so that any extension can be barred exchange calls by omitting the strap between the two terminals).

A free exchange link is selected and its finder switch searches on bank EF2 for the local link marked on bank LF3 of the line finder by the operation of relay EC. When contact is made, relays LK and ER operate to break the drive circuit of the EF switch, and to release the local link, respectively.

The exchange link is now connected to the calling extension via bank EF1 and the external call can be made.

Incoming Exchange Call.—Ringing current from the public exchange operates relay PC which closes the circuit for the special exchange call bells, and switches the ST lead through to relay STE in the chain associated with the exchange link through which the call has been received. The first designated extension to answer causes the relay to operate and the EF switch of the link to search for the line circuit concerned.

Consultation Call.—Operation of the instrument button by the exchange extension causes contact TF in the exchange link to complete a connection over the EL lead to the associated exchange line circuit. The latter is similar to the extension line circuit and, over the STF lead, selects a free local link which searches for the contact on bank LF1 to which the particular ME lead is wired. When the two circuits are connected, relay contact EP opens to prevent the irregular seizure of another exchange link over banks LS2 and LF2 should the digit 9 be dialled. The exchange extension can now dial the wanted number and, at the end of the consultation, another operation of the push button releases the local link and reconnects the exchange line.

Transfer.—To effect a transfer, the exchange extension establishes connection to the desired party, as for a consultation call, and then replaces the handset, thereby causing battery to be connected to a contact in the LF4 bank of all local links. This contact occupies the same relative position as the contact in the LF1 bank to which the ME lead of the particular exchange link is connected.

Chained contacts ensure that only one exchange link at a time is able to mark its associated contacts in the LF4 banks, consequently, in only one local link is the LS3 wiper at battery potential.

Bank LS3 is wired to bank EF3 in such a manner that contacts in each, representing the same extension, are connected, and it is arranged that the EF switch of the exchange link searches over bank EF3 to find the contact marked by battery.

When the circuit is established relay LK operates to break the drive and the EF switch is thus stopped on the contact, on bank EF1, connected to the extension line circuit marked by the LS switch of the local link.

Relay ET operates in series with relay LK to release the local link ; relay TF in the exchange link is released and the exchange line is thereby transferred to the second extension. The latter may make a consultation call to a third extension and if necessary transfer the exchange call once again.

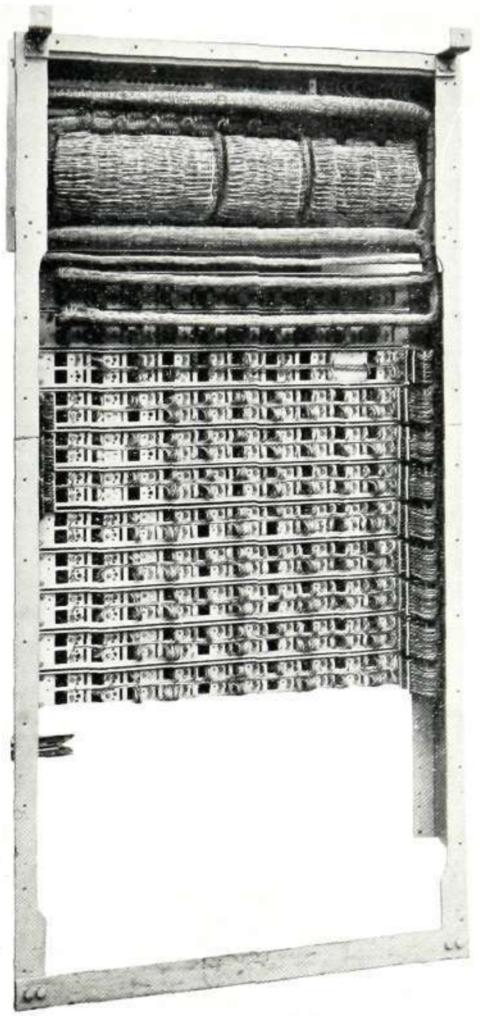


Fig. 3—Rear View of Rack showing Plug and Jack Connections on Relay Plates.

MISCELLANEOUS CIRCUIT DETAILS.

Test Line.—The incoming line from extension 01 passes through a test jack, thus permitting this number to be used for test purposes.

Mains Failure.—Normally, power for the P.A.B.X. is obtained from the mains via a rectifier unit which is convenient and requires little or no attention. In the event of a mains failure the internal system will be temporarily put out of action but all exchange lines are automatically connected to selected extension instruments so that contact with the public exchange system is maintained.

Unused Numbers.—Should an incorrect prefix digit, or digits, be dialled, busy tone is returned.

Tones.

The ringing current and low-frequency ring and dial tones are generated by a vibrator-convertor of a type commonly employed in P.A.B.X. equipment, while the higher frequency tones are obtained from a self-interrupting relay.

The busy and intrusion tones are of the same frequency as the continuous N.U. tone but are interrupted at different periodicities, in order to give a distinctive character to each tone.

Voltage and Line Limits.

The equipment will function over a range of from 46 to 52 volts, and with extension line loop resistances up to a maximum of 500 ohms.

Instruments fitted with the transfer press button require an earth connection which may be obtainable near the instrument, but, if this is not possible, earth potential can be supplied from the P.A.B.X. equipment over a third conductor, the resistance of which should not exceed 250 ohms.

Equipment.

The equipment is mounted, as illustrated in Fig. 1, on a rack of angle-iron construction which has two brackets at the top rear (Fig. 3) for supporting it from the wall, close proximity to the wall being made possible by the fact that all the equipment is readily accessible from the front.

The relays are strip mounted and, with the exception of those on the two topmost plates, are wired to plugs which mate with

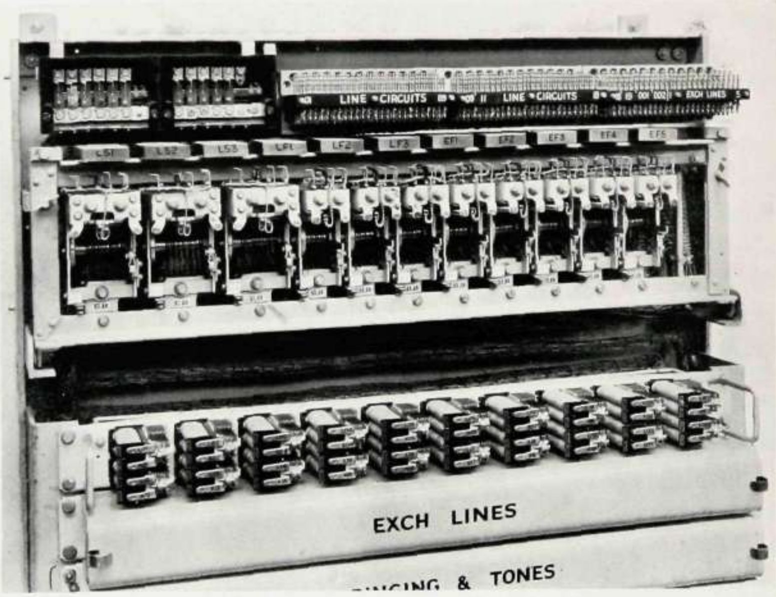


Fig. 4. View of Uniselector Equipment with cover removed.

jacks terminating the rack wiring, thus plates of relays can be easily removed for attention.

An enlarged view of the upper portion of the rack equipment is shown in Fig. 4 from which it may be seen that the switches are mounted on a hinged shelf fastened by two thumb screws and are grouped to facilitate straight multiple wiring.

Above the switches are two fuse panels, and three terminal blocks for the connection of external cables. Facilities for barring exchange calls from extensions, and for cross-connecting to suit various public systems are also given on these blocks.

Maintenance is simplified by the straightforward design of the circuit and by the accessibility and comparatively robust construction of the components, which are protected by front and rear dust covers. These advantages, combined with compactness, low cost and the fact that tropical finishes are provided throughout, make this P.A.B.X. equipment well worthy of consideration for use in small business organizations anywhere in the world.

Timber in the Telephone Industry

IN spite of the increasing use of plastics and other substitutes for wood, the wood-cabinet-making department of a telephone works is still a very important part of the production organization.

The main reasons for the continued use of wood are its economic and technical advantages ; for example, from an economic point of view, it lends itself readily to the manufacture of single units or small quantities of equipment at relatively low cost, particularly in designs of intricate shape, because ordinary hand tools can be employed instead of the costly machines and special tools which are indispensable with some materials, irrespective of the number of parts being made. On the other hand, there is probably less difficulty in arranging for mass production with timber than with any other basic material, because of the versatility of the machines normally used in the cabinet shop. It is not generally necessary to provide special tools or devices.

The physical beauty of well-finished timber is universally appreciated. It is pleasing to the senses of sight and touch and can be made to enhance the most delicate furnishings, therefore it is not surprising that its popularity for telephone switchboards is undiminished.

The world's supply of some raw materials is by no means inexhaustible and timber is one of the few examples of a replaceable substance. Well-planned schemes of re-afforestation are ensuring continuity of future supplies.

PRESENT DAY USES.

The use of hardwoods in the construction of manual positions for main telephone exchanges has continued since the earliest days of the industry and although challenged by metal and other materials, timber has generally maintained its position in this field. High grade Honduras or similar types of mahogany have proved to be extremely stable and have given excellent service over long periods. In some instances other timbers which lend themselves more readily to light colour schemes have been used and there is little doubt that improved techniques in seasoning and stabilizing processes will result in reliable long-term service from beech and similar woods. An excellent feature in the design of main exchange switchboards is the employment of internal steel frameworks, enabling relatively short lengths and widths of timber to be used for the individual sections, thus ensuring maximum dimensional stability.

Undoubtedly one of the principal reasons for the continued use of timber as the main constructive material for private switchboards is the wide varieties of size and form required to meet individual needs. Conditions of service may be relatively arduous and protection against extreme variations in climatic conditions must be given, but, should the surface deteriorate after long use, woodwork can be refinished locally at fairly low cost. It will be seen later, however, that interesting developments in wood laminates offer new advantages for this class of work.

There is a general tendency for small items of apparatus previously made in timber to be replaced by plastic or other non-conducting materials. The higher standards demanded for insulation have resulted in the gradual elimination of timber for terminal blocks, connection strips etc. Certain woods have reasonable insulating properties but very careful selection and testing are essential when this point is of importance.

Battery boxes and ladders of various kinds are examples of miscellaneous equipment where the preference for timber has so far been maintained. In the case of ladders, lightness and strength, combined with reasonable electrical insulation, are features which have resisted tendencies toward the replacement of wood by metallic materials and, in addition, wooden surfaces are not cold to the touch and have good frictional properties which reduce the danger of accidents.

Timber is, of course, used in connection with all classes of telephone equipment in the ultimate packing stage. The construction of packing cases for some of the more delicate equipment might almost be termed an art, as adequate strength and resistance to shock and moisture penetration must be achieved at reasonable cost. For the main cases, soft woods and timber laminates are used almost exclusively, as most of the alternative materials do not possess the necessary mechanical properties, while processed and dried wood wool is widely employed as a shock-resistant inner packing.

The extent to which timber is used in the Company's works may be judged from the following quantities for the year 1949 :

Hard woods for cabinet work
36,500 cu. ft.

Soft wood for packing
50,000 cu. ft.

Plywood laminates for packing
420,000 sq. ft.

SELECTION OF TIMBER.

For many years during which timber of various types was in plentiful supply, the selection of suitable varieties was a relatively simple matter. In the telephone industry a measure of standardization was achieved, so that good quality Honduras mahogany was generally employed for the construction of switchboards for use in temperate climates. For tropical work, selected teak held an unchallenged position and gave unrivalled service in hot damp climates owing to its resistance to moisture, fungus and insect attack.

Under present conditions, it is not possible to obtain regular supplies of these desirable woods, but fortunately authorities in the timber trade, and the Forest Products Research Laboratory, have studied the problem of finding suitable alternatives and, while some of these differ in appearance from the mahogany and teak which they replace, they nevertheless possess the requisite technical features. In the following descriptions of the more important of the alternative timbers, indication is given of their behaviour under seasoning and machining processes but it is stressed that great care is always taken in selecting timbers for specific purposes.

AGBA. (*Gossweilerodendron balsamiferum*). This timber has proved to be a very satisfactory alternative both for mahogany and teak. Whilst it is rather lighter in density, it possesses very good mechanical properties, being at the most only 15% less in compressive and shear strength. It is highly resistant to fungus and termite attack. Further points of importance are that it responds very well to kiln seasoning processes, is available in substantial lengths and widths and will accept a good polish by normal finishing methods.

DOUSSIE.—This is a species of Afzelia which grows generally throughout tropical West Africa and a shipment would probably consist of two or three species classified under the general name of Apa. These varieties are similar in character, but the most noticeable difference is that of weight, which ranges from 40 to 55 lb. per cu. ft. The lighter woods have proved to be the most suitable for switchboard manufacture.

Under bending and compression tests, Doussie has been found to possess strength about 20% above that of oak. The timber is mahogany coloured and has a characteristic grain structure of considerable beauty, although it is unlike that of mahogany or teak, either of which it can replace.

IROKO (*Chlorophora excelsa*).—This timber is an excellent substitute for teak, being similar in appearance and having durability with equivalent strength. It has the additional advantage that the shrinkage ratio is very small, and it is not liable to warp, shake or check during, or subsequent to, kilning. From the machinist's point of view, a possible disadvantage is that sometimes a hard calcareous deposit is found in the interior of the log and this may cause difficulty in working.

TRUE AFRICAN MAHOGANIES.—These comprise various species of Khaya, whilst other species with very similar characteristics and appearance are normally distributed under their own names and are typified by Gedu Nohor, Sapele, Makore, Guarea and Andiroba (Crabwood). The African mahoganies are normally identified by the districts and seaports of their origin, i.e. Lagos mahogany, Benin mahogany, Sekondi mahogany and Gold Coast mahogany, and this serves as a guide to their general properties.

Thus, broadly speaking, Lagos is consistently of fine texture with good machining and finishing qualities, and Benin is similar, but a harder and stronger wood. Sekondi and Grand Basam (another one of the group) are usually softer timbers of more open texture, whilst Gold Coast mahogany has been known to vary over very wide limits and is generally more uncertain from many points of view. In comparison with American mahoganies, the African substitutes are equivalent in many respects, but are more liable to variation.

SAPELE (*Entandrophragma cylindricum*) and ASSIE (*Entandrophragma Utile*) are West African timbers with striking and attractive figuring and are in demand for cutting into veneers. They are prone to warping and twisting during seasoning unless radially sawn, but nevertheless constitute valuable additions to the mahogany range.

MAKORE (*Mimusops Heckelii*), ANDIROBA and AFRICAN WALNUT (*Lavoa Klaineana*) are lesser known woods which are becoming more popular for cabinet work but are

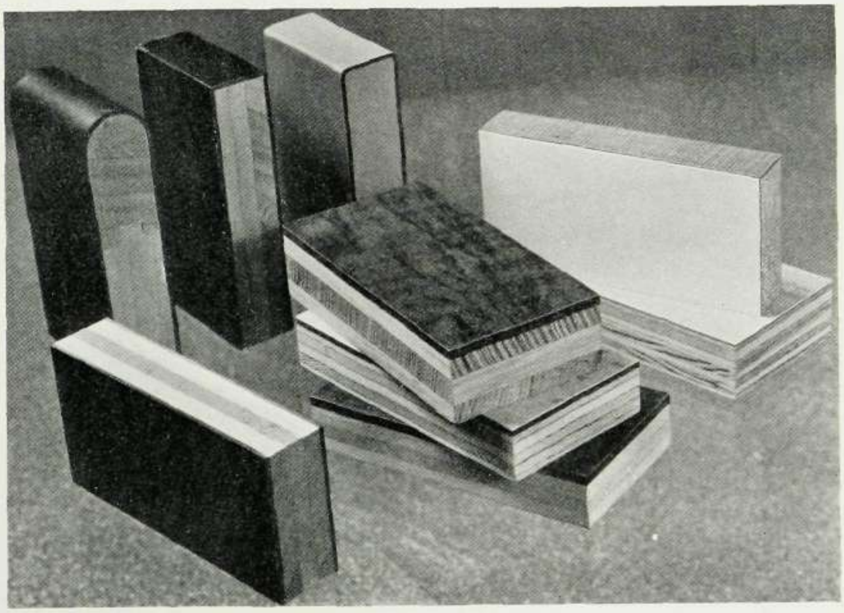


Fig. 1—Examples of Laminates.

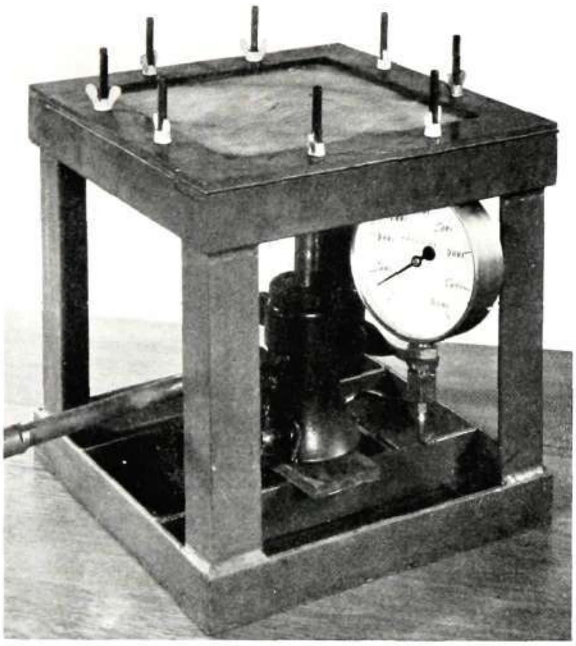


Fig. 2—Apparatus for Testing Bursting Strength.

liable to " move " during machining unless seasoning is carefully controlled.

IDIGBO (*Terminalia Ivorensis*).—This is a sound timber of general utility and is very suitable for the interior fittings of switchboards, etc. It is steady in kilning and machines well.

FREIJO (*Cordia Goeldiana*).—This South American timber has proved to be excellent for switchboard construction. When quarter cut, the boards exhibit a distinctive grain figuring which requires careful matching in the suite, but in other respects Freijo is a consistent wood and will be widely used when supplies are more readily available.

BLACK BEAN (*Castanospermum Australe*). This fine cabinet wood, native to Australia, possesses an attractive grain structure and is a good substitute for teak. It seasons rather slowly and care must be exercised during glueing operations, but it ranks as a first-class wood for switchboards and similar work. Its electrical insulating properties are better than those of most timbers.

MANSONIA (*Mansonia Altissima*).—Mansonia closely resembles American black walnut in appearance, but is reputed to be more resistant to attack by fungus and termite. Its kilning properties are excellent and it machines well, with little tendency to tear.

WOOD LAMINATES

The earlier types of wood laminates were referred to under the general term " plywood " and were built up from varying numbers of thin sheets of wood, each successive sheet being arranged so that the grain direction was opposed to that of the adjoining layers. The sheets were secured by bone glues or casein cements and, whilst they possessed considerable mechanical strength, the resistance to moisture was notoriously bad, so much so

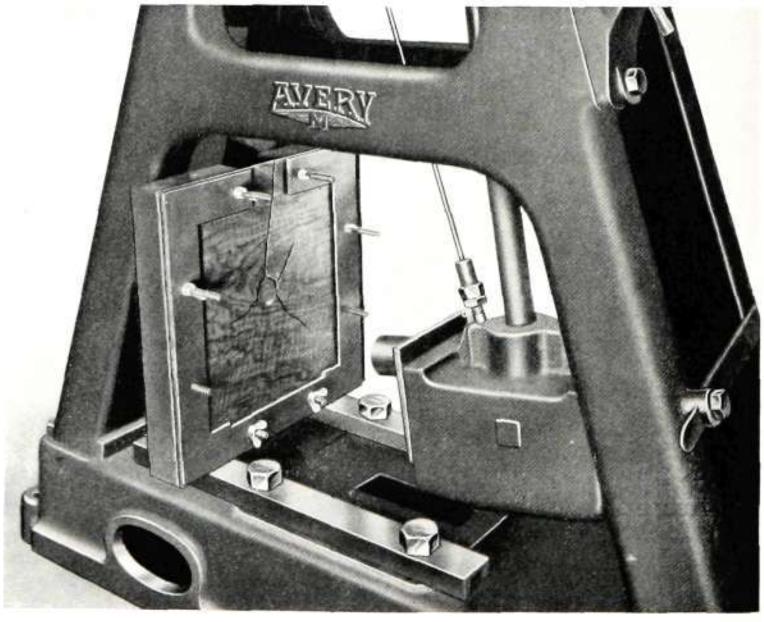


Fig. 3—Wood Laminate Undergoing Impact Test.

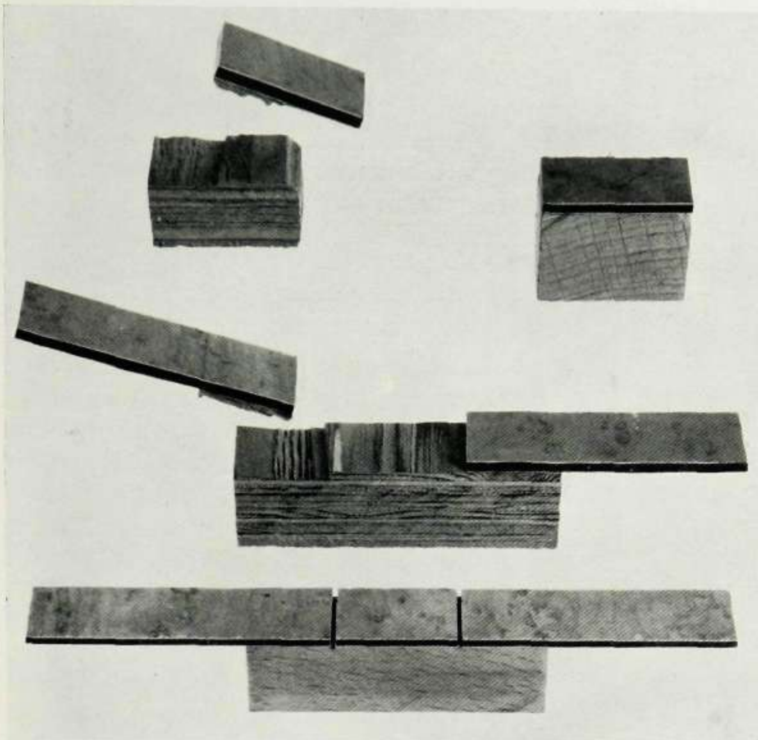


Fig. 4—Test Pieces for Assessing Strength of Cemented Joints.

that the product gained a poor reputation. In recent years however, superior types of plywood have been evolved and extensively used in the construction of certain types of aircraft. Tremendous improvement in strength and resistance to moisture resulted from the development and application of new types of synthetic adhesives. The new laminates, examples of which are shown in Fig. 1 are very little affected by immersion in hot water and can be exposed almost indefinitely to outside weather conditions, thus excellent dimensional stability is maintained even under excessively dry or moist heat.

The new adhesives which are facilitating the rapid development of composite soft and hard wood laminates are based on cold-setting urea-formaldehyde resins and phenol-resorcinol resins of various types. Extensive research by firms prominent in this section of the plastics industry has enabled an adequate range of these adhesives to be placed on the market, and a considerable amount of specialised technical information is issued to the user.

It is now possible to bond satisfactorily and permanently thin sheets of wood to most of the other materials commonly used in the engineering industry, and which include metals, plastics, fibre and rubber. Our process-research and development departments have closely studied the application of these new laminates to switchboard design, with the result that important customers overseas have now accepted boards with caseworks of synthetic resin-bonded wood laminates having extremely hard-wearing and attractive plastic facings. A stringent testing procedure has been developed so that these laminates can be assessed for strength, stability, resistance to wear and fastness to light.

The illustrations in Figs. 2, 3 and 4 are examples of some of the testing devices employed for the measurement of bursting strength, impact resistance and the strength of cemented joints. Test pieces are of course subjected for considerable periods to moist or dry heat, in addition to tests under normal conditions.

Reference should be made to other manufactured forms of sheet in which wood forms the main basis. In principle these are comprised of disintegrated wood fibres bonded together with modern adhesives under considerable pressure. These products are very stable and highly resistant to moisture, although generally lower in mechanical properties when compared with solid timber or sheet laminates.

Metallic Creep

THE telephone engineer's interest in metallurgy is principally confined to the simpler mechanical properties of the ferrous and non-ferrous materials employed in construction and manufacture. For most purposes, tensile strength, hardness, ductility and impact values are characteristics which determine the type of metal to be selected, or the features of design which must be developed. There are, however, instances where the more complex physical properties require consideration. For example, the fatigue resistance of spring steels used for vibrating mechanisms is an important matter which necessitates the special study of various alloys and heat treatments, sometimes over long periods.

Metallic creep phenomena are referred to somewhat infrequently in telephone engineering practice. For many years it has been known that certain plastic compositions, and metal wires, stretch very slowly and continuously when subjected to comparatively low stress over long periods, while the fact that there is a small downward movement of horizontal lead pipes which are unsupported, has been realized for many centuries.

During recent years, metallurgists have intensified the study of the creepage of metals. It has been established that over sufficiently long periods, many metals will extend to the point of fracture under stresses which are very much lower than those normally causing fracture after a short period. The behaviour of many metals in this respect has been determined accurately, under varying conditions of temperature and stress. Special alloys have been developed which are resistant to this slow process of deformation, and engineering projects have been facilitated as a direct result of this work. In some cases, the production of equipment has depended entirely on the use of these new creep-resistant metals. Intensive research has resulted in the development of a series of alloys consisting of nickel and chromium, together with small proportions of titanium, manganese, aluminium and silicon. These alloys possess considerable creep resistance at high temperatures and are of great importance in the construction of gas turbine engines.

The creepage properties of the softer metals are of considerable interest in telecommunications, lead and tin being used extensively for cable sheaths and solders, while low-melting-point (fusible) alloys are incorporated in heat coils for line protection units. In particular, the slow deformation of partially-supported lead-covered cables and the movement of cable joints under stress has been the subject of major research and investigation. A number of lead alloys have been developed in this country, especially for cable sheaths, and the British Non-Ferrous Metals Research Association has made important contributions in this connection. It has been found that the addition of small proportions of other metals to lead has a marked effect on creepage, as indicated in the following table which shows the relative figures at varying stresses.

Stress lb./sq. in.	Percentage creep per year		
	Pure Lead	Lead + 2% Tin	Lead + 0·5% Antimony
200	0·7	0·6	0·4
300	1·6	1·1	0·7
400	3·9	1·9	1·0
500	5·0	3·2	1·4

British standard specifications provide for a series of cable sheathing alloys which consist of lead with small amounts of antimony (B.S.810), antimony and cadmium (B.S.810B), or cadmium and tin (B.S.603 and B.S.810C). Lead alloys which contain calcium or magnesium have higher creep resistance, but unfortunately their use is limited owing to difficulties in manufacturing processes and the danger of decay due to atmospheric conditions.

The creepage of solders of various compositions has been widely studied. The general conclusion reached is that there is no limiting value of stress below which creep absolutely ceases. With ordinary lead-tin alloys, creepage is rapid at stresses of over 200 lb per square inch, and fracture may occur after about 200 hours. With a stress of about 1,000 lb per square inch, fracture may result in a few hours. Fortunately, the stress values for ordinary soldered connections in telephone work are of a very low order and there is little evidence of any failures or difficulties which may be attributed to creepage. The general practice of ensuring that connecting wires are securely looped around tags or other terminations avoids any direct strain on the solder but it is important that cables and cable forms should be well supported, so that stress at any particular soldered point is negligible.

Creepage is accelerated not only as stress or temperature increases but also as a result of vibration. Transmitted mechanical shock may, therefore, accelerate the rate of movement or deformation and this factor should be considered by designers.

Creepage of Fusible Alloys.

The creepage of low-melting-point alloys was first studied in the Company's laboratories in 1934, in conjunction with the British Post Office. This work was necessitated as a result of evidence that standard "push-in" type heat coils were actuating by slow mechanical movement which was clearly not due to electrical heating effects. It was established that, after one or two years under a spring pressure of 4 lb., the tube, which is secured to a pin by fusible solder, might move a distance of up to ·075″ as a result of creep, making the normal life of the heat coil undesirably low. If possible, these devices should remain rigid except when they function to give line protection if the current passing through the heater winding reaches the specified figure.

With a pin diameter of ·056″ and tube internal diameter ·073″, the soldered area about the pin is approximately ·044 square inches, therefore, with a spring pressure of 4 lb., the stress on the solder is a little over 90 lb per square inch. The magnitude of this stress is obviously one which may cause serious creepage with soft metals.

In order to comply with actuating current requirements, it is necessary for the solder to soften at 75°C. and to melt at 130°C. The fusible alloys generally employed are composed of lead, tin and bismuth although more recently cadmium has been included. There are several methods of testing the approximate creepage rate of metals by simple short-term comparisons, one of which is by the application of a load to a steel ball in contact with the material. Under a 10 kg. load with a 5 mm. diameter ball, creepage rates measured over one hour were as follows :—

Bismuth	0·0003″	per minute
Tin	0·00003″	,, ,,
Lead	0·000055″	,, ,,
Cadmium	0·000022″	,, ,,

Thus bismuth has the highest creepage rate while cadmium is the lowest, within this particular group.

Further creepage tests were carried out on the assembled and soldered tubes and pins, so that measurements were in a direct form. The test load selected was 10 kg. and under these conditions the original fusible alloys gave a rate of movement of 0·00006″ per minute.

A series of fusible alloys were produced as a result of experimental development, and the composition and the creepage rates of some of them are shown in the following table :—

Initial softening point	Composition (%) Pb.	Cd.	Bi.	Sn.	Hg.	Movement per min. 10 kg. load	
113°C	45	—	10	45	—	·0000055	Used on pull-out type heat coils.
74°C	28·6	7·1	50	14·3	—	·0000405	Experimental alloy.
67°C	27	10	50	13	—	·0000245	,, ,,
70°C	17·6	—	47·1	29·4	5·9	·0000216	,, ,,
180°C	60	—	40	—	—	·000032	Tinman's Solder.

Experiments were carried out with fusible solders containing higher proportions of cadmium, and eventually an alloy was developed having the following composition :—

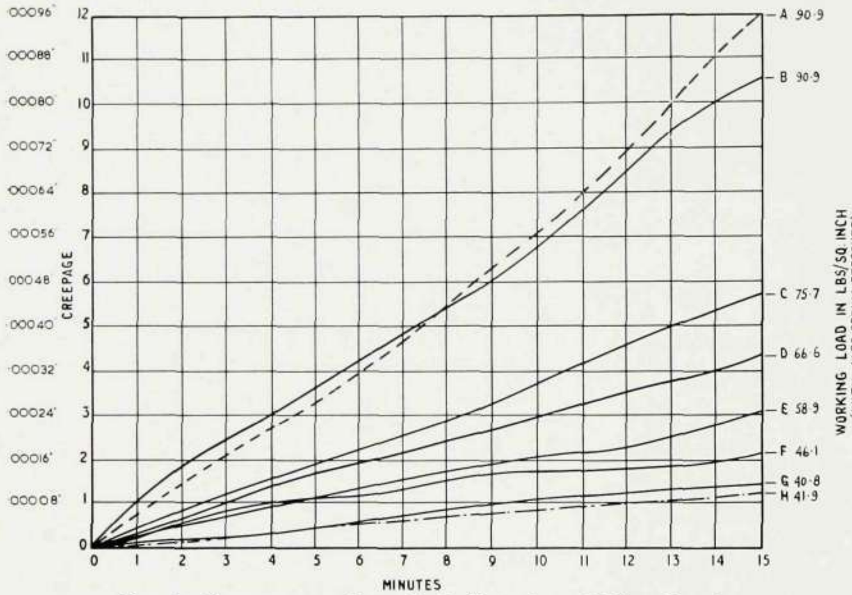


Fig. 1—Creepage on Heat Coils Tested on 45 Kgs. Load.

Lead 27·6%, Cadmium 34·5%,
Bismuth 27·6%, Tin 10·3%

This alloy has a wide melting range, becoming plastic at 75°C and fully liquid at 130°C., and heat coils assembled with this solder showed considerable improvement in rigidity, the creepage rate under a 10kg. load averaging ·0000011″ per minute. This new composition was finally approved by the British Post Office and was adopted for general use with standard heat coils. Under normal conditions the solder is dimensionally stable for upwards of 12 years. It is interesting to note that a load of over 120 lb is necessary to shear the soldered heat coil surfaces instantaneously, whereas under the low working pressure of 4 lb, minute creepage can still be detected, after long periods.

More recently, investigations have been carried out with the main object of still further reducing the creepage of the fusible solder in heat coils by reducing the stress loading. The surface area of solder was increased by using a straight-ended tube in place of the present standard, which has a belled end, and experiments were conducted with pins and tubes of various diameters at a load of 45 kgs.

The appreciable reduction in creepage achieved by decreasing stress in this way is indicated by the curves, Fig. 1, in which working loads at a constant spring pressure of 4 pounds are given. The final selection (curve "H") resulted from the use of a ·080″ diameter pin in conjunction with a thin-walled tube ·100″ internal diameter and slightly longer than the standard, giving a stress loading of about 42 lb per sq. in. With a 5-ohm winding this heat coil complies with electrical requirements, actuating with 0·5 amperes within the specified period and carrying 0·35 amperes for three hours. The coil, which has been re-designed by the Company in co-operation with the British Post Office, is in the form shown in Fig. 2 and will fit standard protector units, the pin end having been reduced to ·064″ diameter. It is anticipated that the creepage will be extremely low and therefore that the life of the coil will be considerably lengthened, apart from normal functioning due to excessive current.

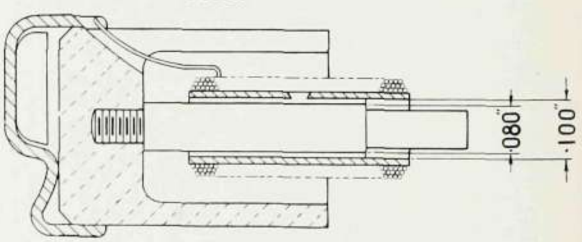


Fig. 2—Sectional Diagram of Heat Coil.

Fundamental research in connection with the creep of metals and alloys is being pursued by a number of firms and associations. The equipment and method for long period, high sensitivity, tensile creep testing are subjects covered by British Standard Specification A23 and also by the American Society for Testing Materials, Specification E22. 41. Other published information covers a wide field and deals with theoretical aspects of metallic creepage, in addition to specific measurements associated with many metals and alloys.