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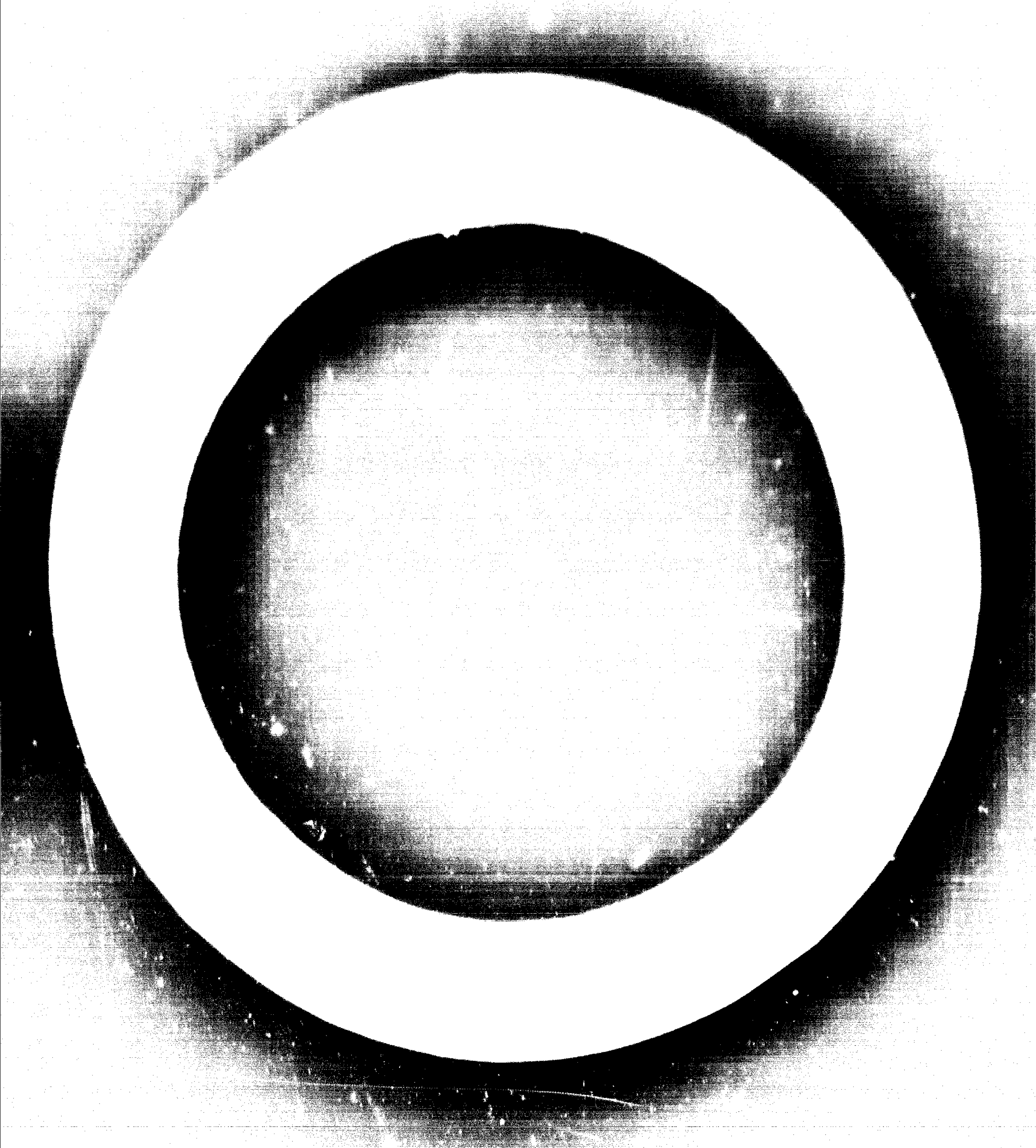

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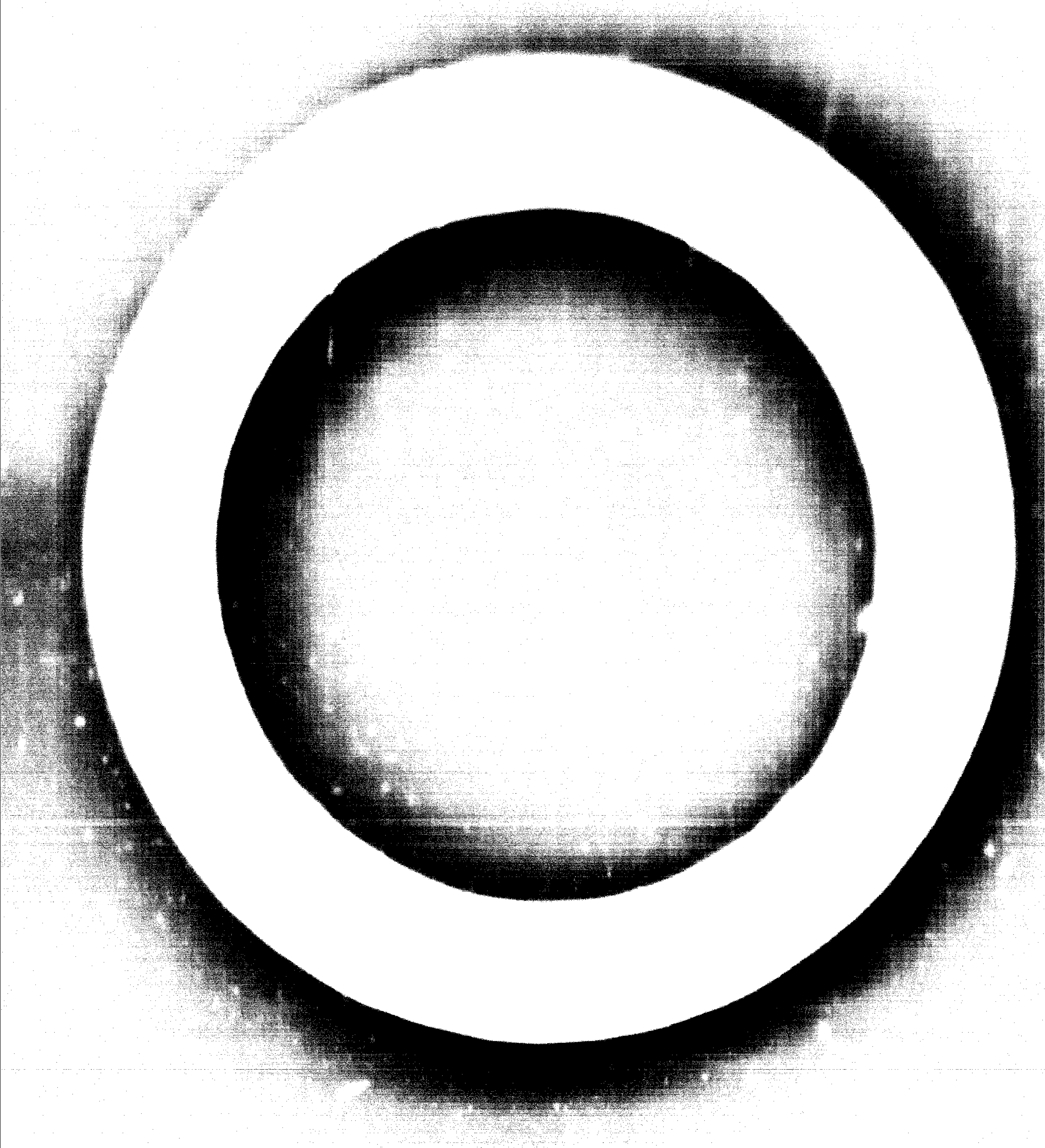

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In all countries of our globe a wealth of problems is being [illegible] by the competent authorities in furthering the development of telephone services. The object of these problem studies is to determine optimum solutions from the viewpoint of economy. It is the author's intention to illustrate some of these problems which [illegible] are of particular importance to developing countries.

1. State of the art and future aspects of switching

The above-mentioned study of GAS 1 was to deal with two questions:

(1) The influence of economic factors on the development of telecommunications in the various countries of the world

(2) Traffic forecasts for a long-distance network

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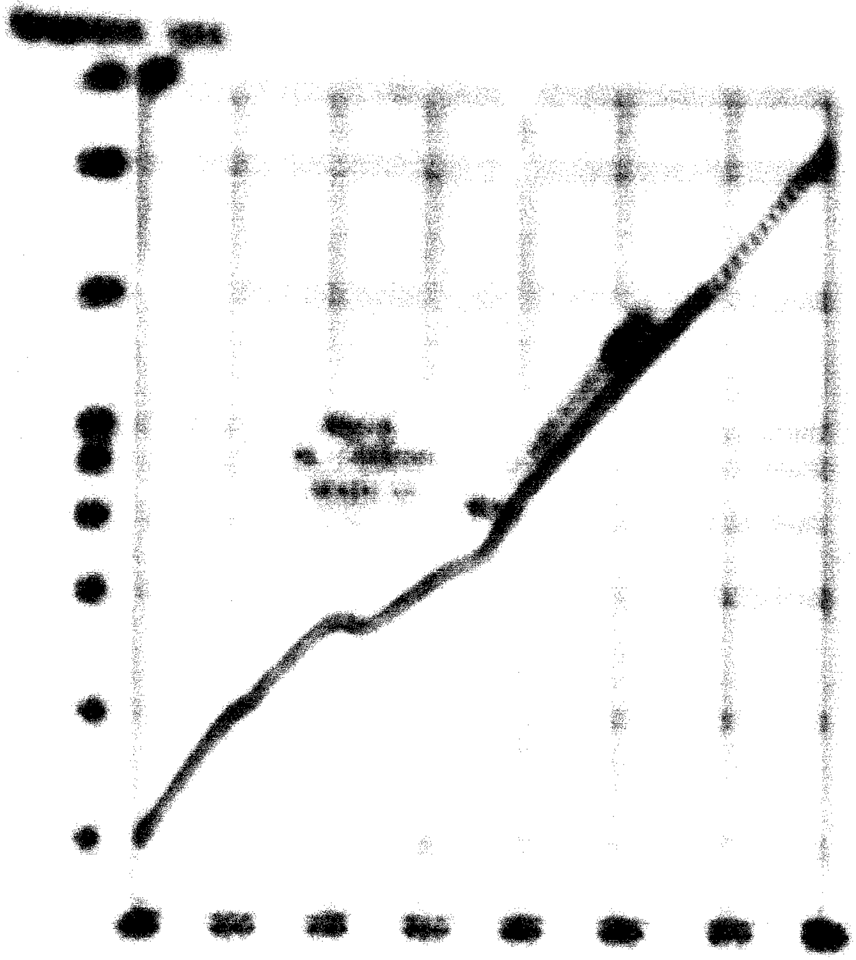


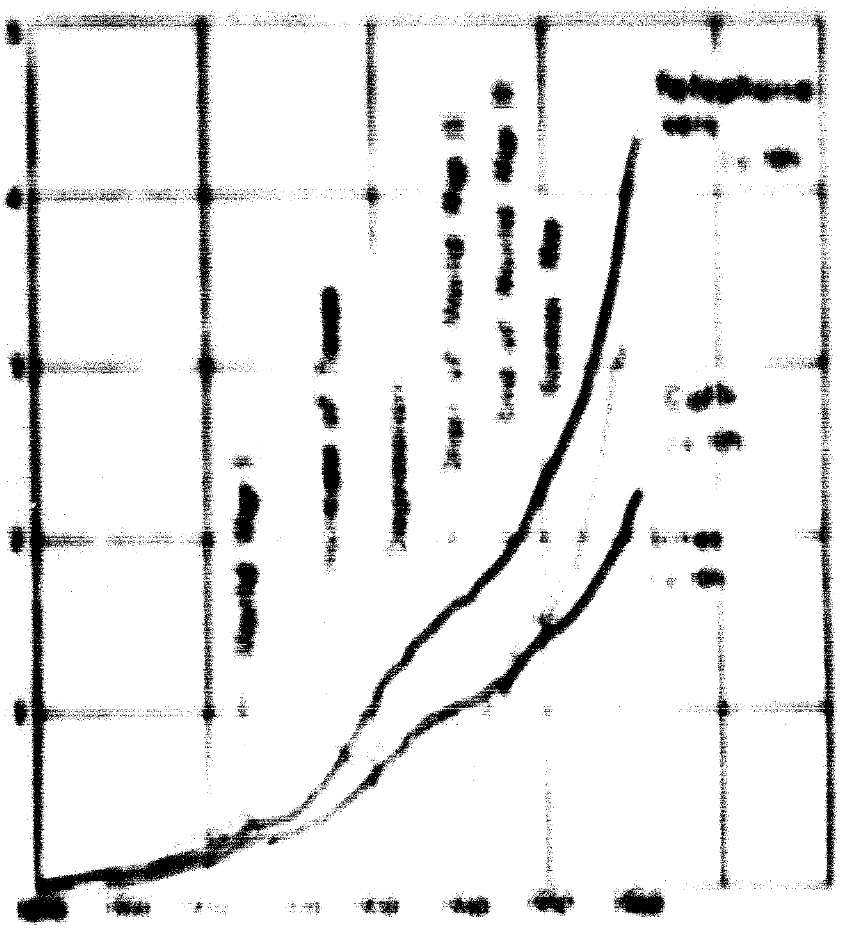


Fig. 2 Development of Telephone Penetration in France
(see ... Appendix ... [illegible])

The first somewhat surprising result, then, is the following: The curves in Figs. 1 and 2 show the development of telephone services has created something like a law of nature in that deviations caused by extra-ordinary factors return to the general trend as rapidly as possible once the unusual factor is removed.

It may be argued that to date no such "compliance with a law of nature" has been proved to exist in respect to developing countries, and, additionally, that it would be difficult to prove the existence of such a regularity because of the relatively small number of telephones involved, which would result in a high variance as telephones are added. On the other hand, nothing tends to indicate that this general law of the advancement of telephone systems should not apply to developing countries as well.

Similar considerations also hold for the dependence of the number of telephones in a given country on the prosperity of its population (i.e. on the national income). Virtually all studies on the future development of telephone services all refer in detail to this dependence, including the studies by H. Kramer (5) and H. Bornemann (2); the latter publication also contains the graph (Fig. 3).

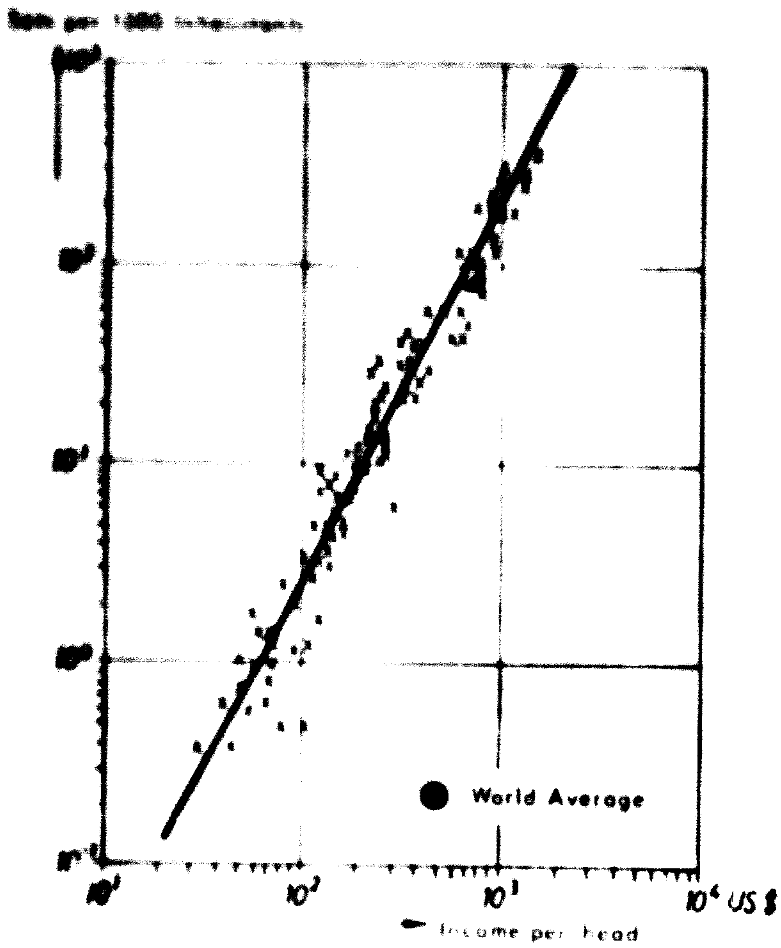


Fig. 3: Number of Telephones and National Income (acc. to Bornemann, 1963)

If logarithmic coordinates are used, a straight line can be drawn through this distribution, corresponding to the equation $d = C.E^k$, where d is the telephone density, C a constant and E the per-capita income. The exponent, k, which is relevant in this connection, is given by ATT as 1.7, while similar calculations in the German

Federal Republic //2// have resulted in a figure of 1.9 to 2.0. Other graphs have been designed //6//, //7// in which a curve is drawn through the values plotted in a system of log-log coordinates (Fig.4).

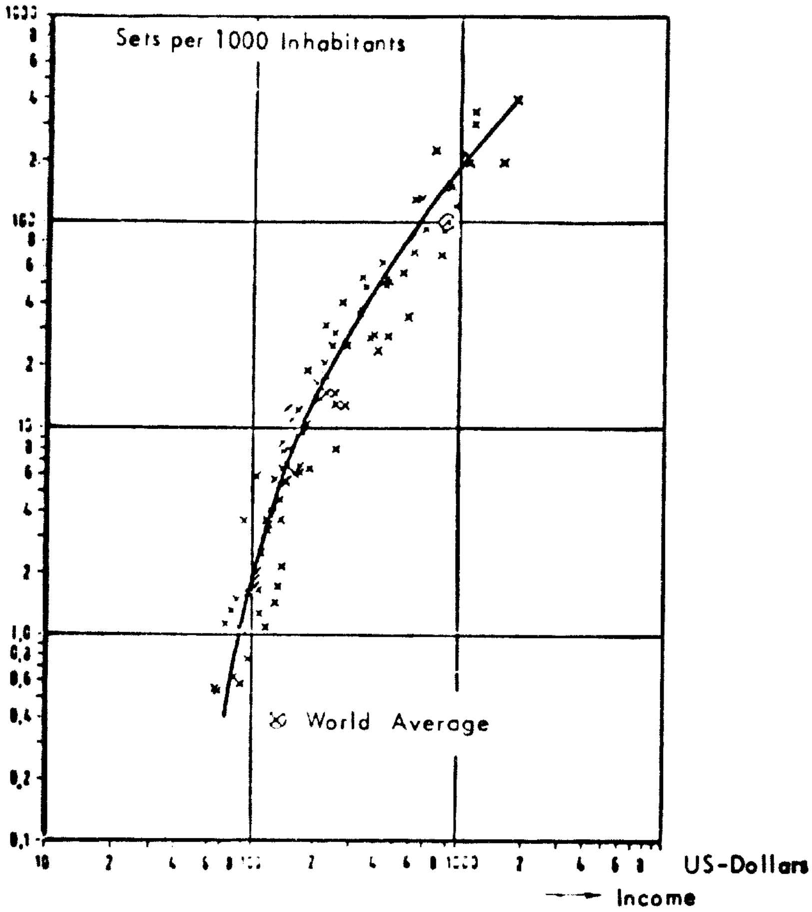
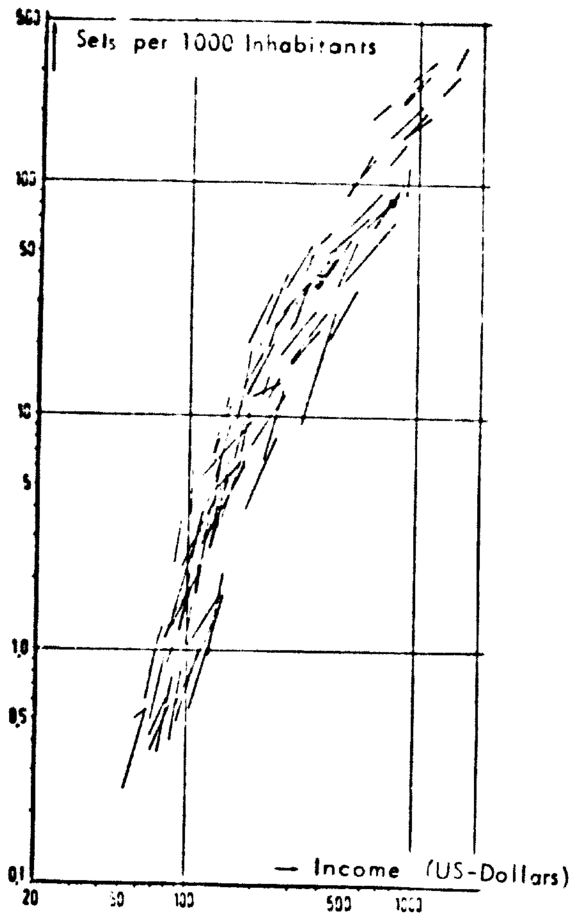


Fig.4: Number of Telephones and National Income
(acc. to A.Jipp, 1959)

A.Jipp has also studied the changes in the telephone density/(per capita) income ratio from 1953 to 1969 (Fig.5); the deviation of the curve from the straight line is, in fact, easily verified if we estimate, and add to one another, the averages of the slope of the individual curves.



·**Fig. 5**: Development of the Telephone Density / Income Ratio between 1953 and 1959 (acc. to A. Jipp, 1959)

This also seems to explain the different values that have been calculated for the exponent k, which depends on the points of the curve for which the tangent slopes have been calculated (certainly lower for the point representing the USA than for the point of the German Federal Republic).

The C.C.I.T.T. study //1// in Chapter III discusses at great length the relationship between telephone density and Gross Domestic Product (G.D.P.) per capita (Fig. 6).

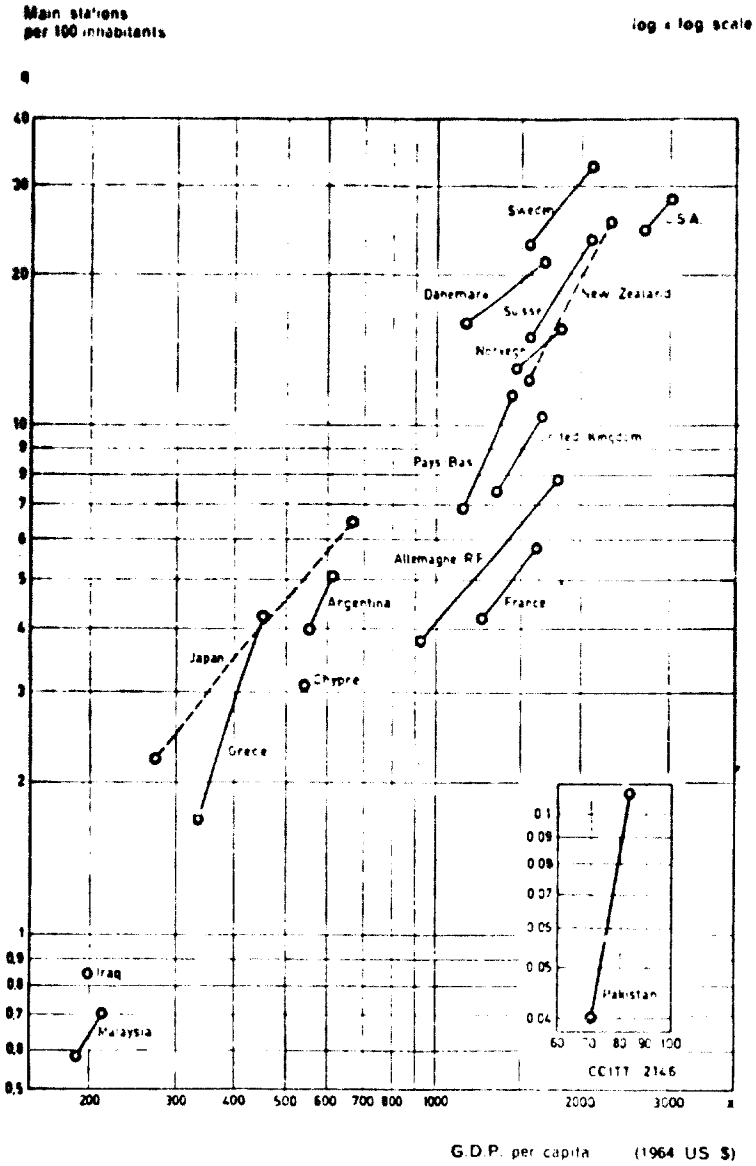


Fig. 6: Telephone Density and G.D.P. per capita, 1954 and 1964 (acc. to CCITT, 1968)

This graph shows the development - and the development trends - of a few (unfortunately of rather few) countries, and the study proceeds from there to the possibility of forecasting future telephone densities on the basis of projected G.D.P. figures, giving, inter alia, an example of the graphical calculation of future density.

The various findings mentioned above permit a multitude of useful and practically-applicable speculations as to the probable development of the telephone density and number of lines to be expected in a developing country. Since all of these forecasts are, however, based on projected or estimated G.D.P. figures, the task of forecasting reliable values for the development of telephone systems has simply been shifted to another plane, that is, the necessity of determining the future development of a country's G.D.P.

Since economic G.D.P.

trends are generally being studied much more intensively, it would nevertheless be advisable not to depend entirely upon this method as the only one for estimating future telephone densities.

In 1957, C. Lancoud and M. Ducommun /8/ made detailed studies on the above-mentioned

"law of development"

of telephone systems along with the other two basic factors

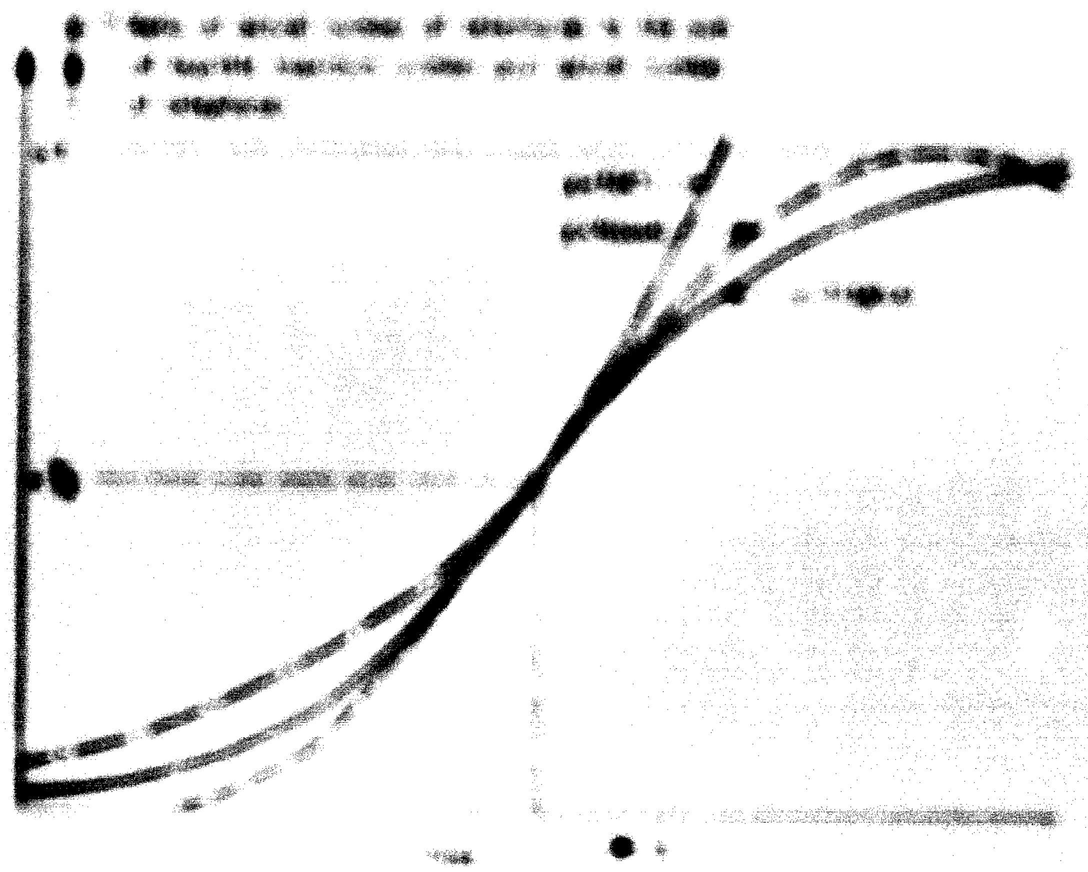
- "population trends "

and the

"economic situation of a country", -

as a basis for determining future development of telephone density. The paper proved that the "law of development" can be represented by way of a logistic growth function, i.e. a suitably transformed hyperbolic tangent (tgh) function (Fig. 7).

Of course, there are a few limiting conditions and premises that have to be borne in mind in describing this natural "law of development" by means of a hyperbolic tangent curve: The time axis (abscissa) cannot realistically be extended from $-\infty$ to $+\infty$; and the development of the economy of the country in question must be assumed to progress evenly and without disturbances (although it should be understood that, because of the above-mentioned tendency for irregularities to even themselves out in due course, this requirement is of less importantance than usually believed).



Another important study by Swiss scientists /9/ in 1963 resulted in a significant extension of this theory by the elaboration of formulae permitting the hyperbolic tangent function to be calculated from three distinct statistical values obtained at regular time intervals. In this way it also became possible – and this is of particular importance – to calculate the point of inflection, since beyond it, the rate of annual growth of telephone density will no longer increase but will decrease instead. The forecast projected by Lancoud and Ducommun in /25/ [illegible] 8 [illegible] years previously, proved to be highly accurate: the mean subscriber density, which had been predicted to reach 21 %, actually reached 21.1 % by the end of 1963.

The second result is well worth noting:
The future development of the telephone density of a country can be predicted by means of a logistic growth function whose determinant parameters can be calculated.

[illegible] in his above-mentioned study /4/ also published the findings of an international working party of ITT[x], which was formed under his chairmanship. These findings are based on the premise that general growth functions are applicable to every country and, therefore, the development of the number of telephone subscribers and the increase in telephone density will be the same in all countries. The great differences found between the actual values reported in the telephone statistics of the individual countries are, however, due to the sometimes considerable differences in the state of development of the individual countries at the point of departure of the statistics. This can be verified by placing the telephone density curves of Sweden and Switzerland on top of one another in such a way that Switzerland "lags" behind Sweden by 9 years; it will then be seen that the curves are in fact nearly congruent (Fig. 8).

(x) International Telephone and Telegraph Corporation

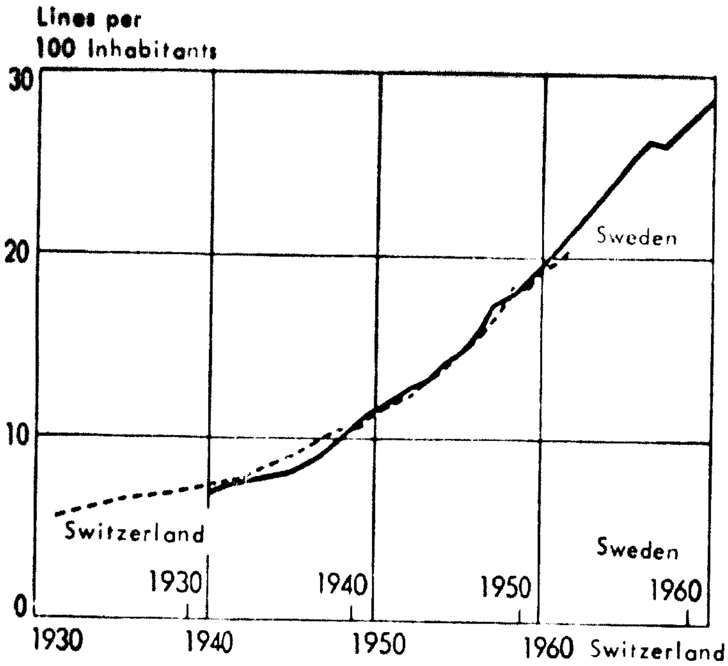


Fig.8: Congruence of Telephone Density Curves for Sweden and Switzerland (acc. to Bogaerts, 1963)

Similar findings have been obtained for a majority of the countries studied (Fig.9).

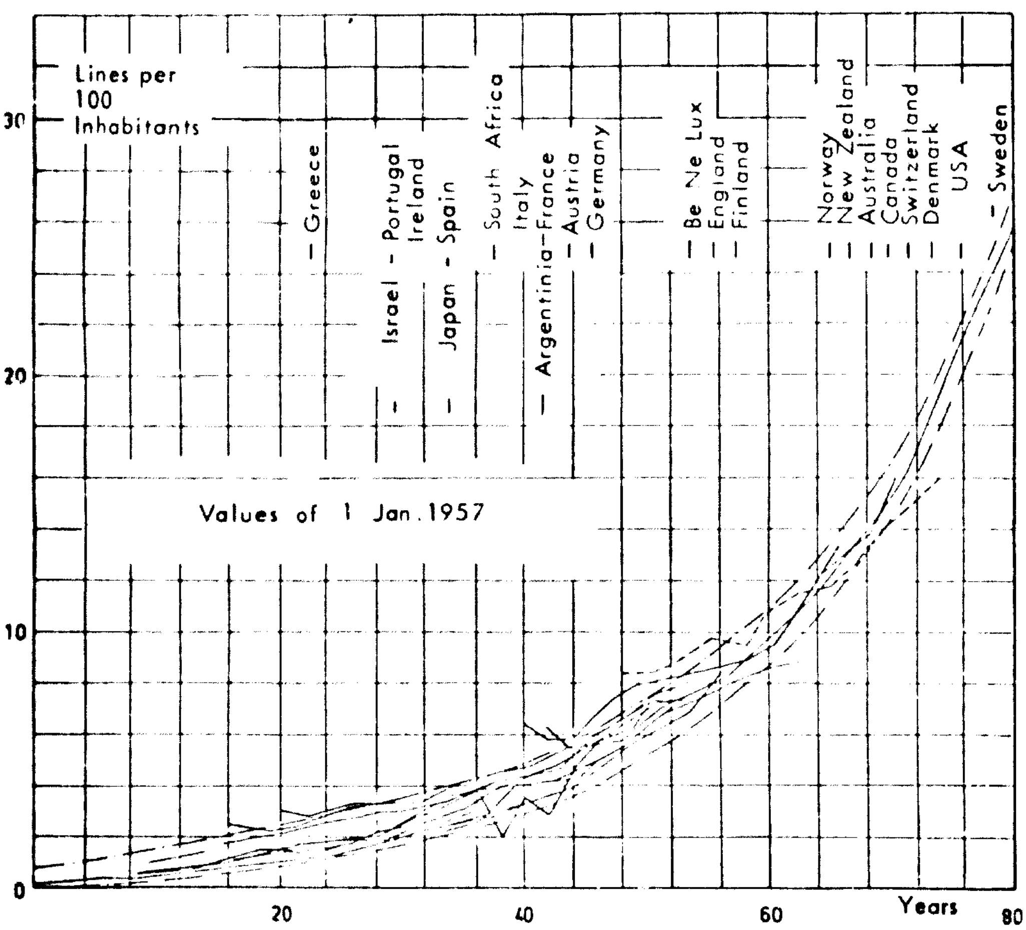


Fig.9: Superimposition of Line Density Curves to Show Maximum Coincidence (acc. to Bogaerts, 1963 for 1957)

The third result of studies aimed **at the determination of future** telephone requirements can be summarized as follows:
The general growth functions apply to all countries; that is to say, the development of the number of telephone subscribers and the resultant telephone density may be expected to be the same for every country, although there will be time differences.

In 1964, an attempt was made to calculate the development of telephone subscriber figures over the next few years and decades with the help of the Lancoud - Trachsel formulas //9// for a number of European countries with relatively low telephone densities //10//. It was first noticed that the selection of the three required values from the telephone density statistics is highly critical and may lead to results that may be considered impossible at first impression. This experience was confirmed two years later by E. Böhm, who replaced the rather cumbersome calculation by a graphic method using a logistic system of coordinates. This not only simplified the operation but also yielded a number of other advantages (e.g., the fact that the whole of the available density statistics is evaluated, not just the three values selected) //11//. In order to use Böhm's method, however, the saturation density has to be estimated, or obtained by means of other methods, and used as a known quantity in the calculation. This may be possible with a high degree of probability in countries where a wealth of comprehensive statistics concerning the most varied economic and sociologic fields have been prepared for a considerable number of years; for developing countries, however, it may prove very difficult to correctly estimate the point of saturation of the telephone system. It is hoped this publication will assist in determining this unknown factor.

A useful expedient may be found in comparing of the development curves of countries with similar economic structures but higher telephone densities according to Bogaerts, as has been shown in the above-mentioned attempt to determine future telephone line densities with those of low-density countries in Europe /10/, /12/ (Fig. 10).

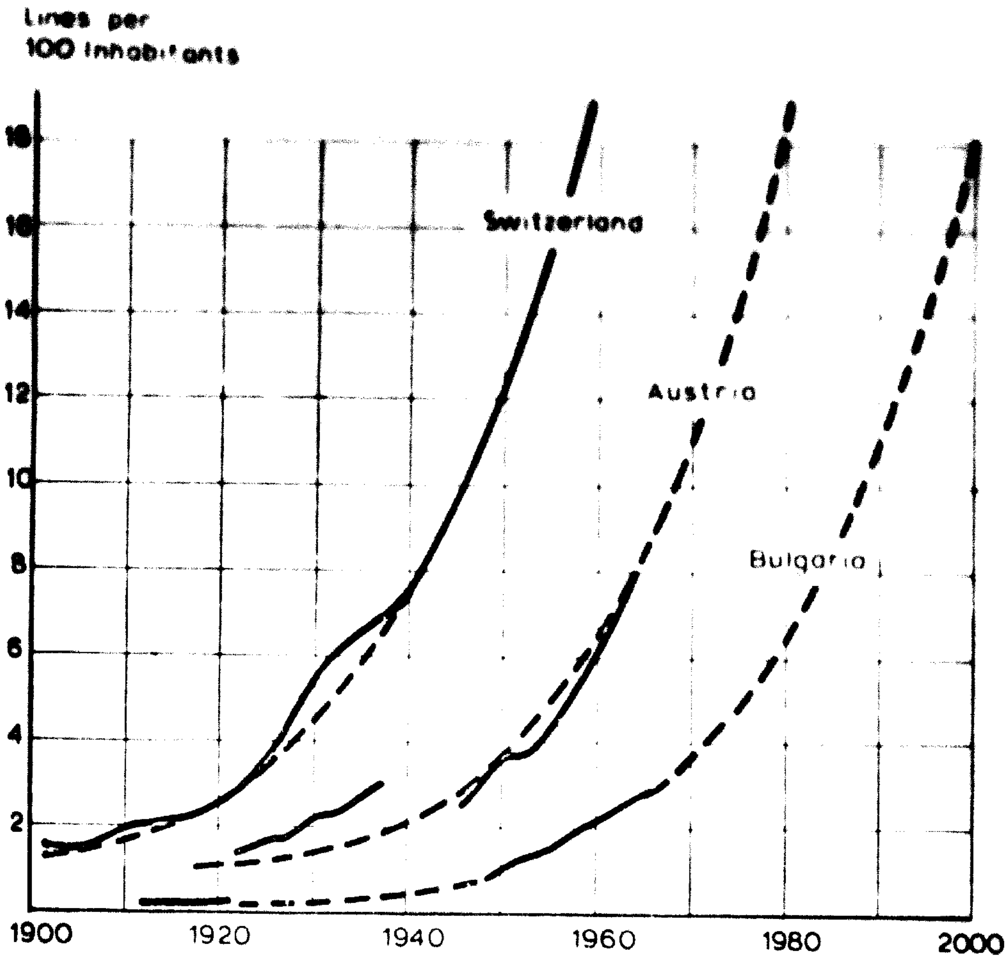


Fig. 10: Telephone Line Densities in Bulgaria, Austria and Switzerland - Probable Development (acc. to Ebenberger, 1964)

As far as known, this is the first instance in which the method developed by Bogaerts has been used in combination with the calculation method developed by Lancoud and Trachsel. As a result of combining these methods that it becomes possible, first of all, to determine the future development of telephone densities for countries with highly similar economic and sociologic patterns, and to project suitable telephone statistics to permit calculations to be made by the [illegible] and Bogaerts method. Once this is done, the logistic growth function curves obtained may be superimposed on the curve plotted on the same scale of the statistical data of the country under investigation and positioned for the greatest possible congruence by moving the curve along the time axis. In this way, the logistic growth function for the country concerned is found and the time lag between it and the reference countries is determined at the same time. Exhibit A shows one example of practical use relating to a country with a comparatively low telephone line density. Basically, one reference country would be enough, but the accuracy of the estimate is enhanced if more are used. It must be remembered there are a number of parameters that affect the future development of the telephone density of a country, which even this combined method leaves out of consideration. Among other contributing factors, the time lag between the logistic growth functions of two or more countries will not remain constant since some countries may make more rapid progress than others. Bohm's graphic method /11/ may also be combined in this way with Bogaerts's method /4/.

This combination offers a number of advantages if we can be sufficiently sure about the correctness of the saturation-point values used for the reference countries. This proved highly feasible in the case of the German Federal Republic using Sweden and Switzerland as the reference countries (Fig. 11).

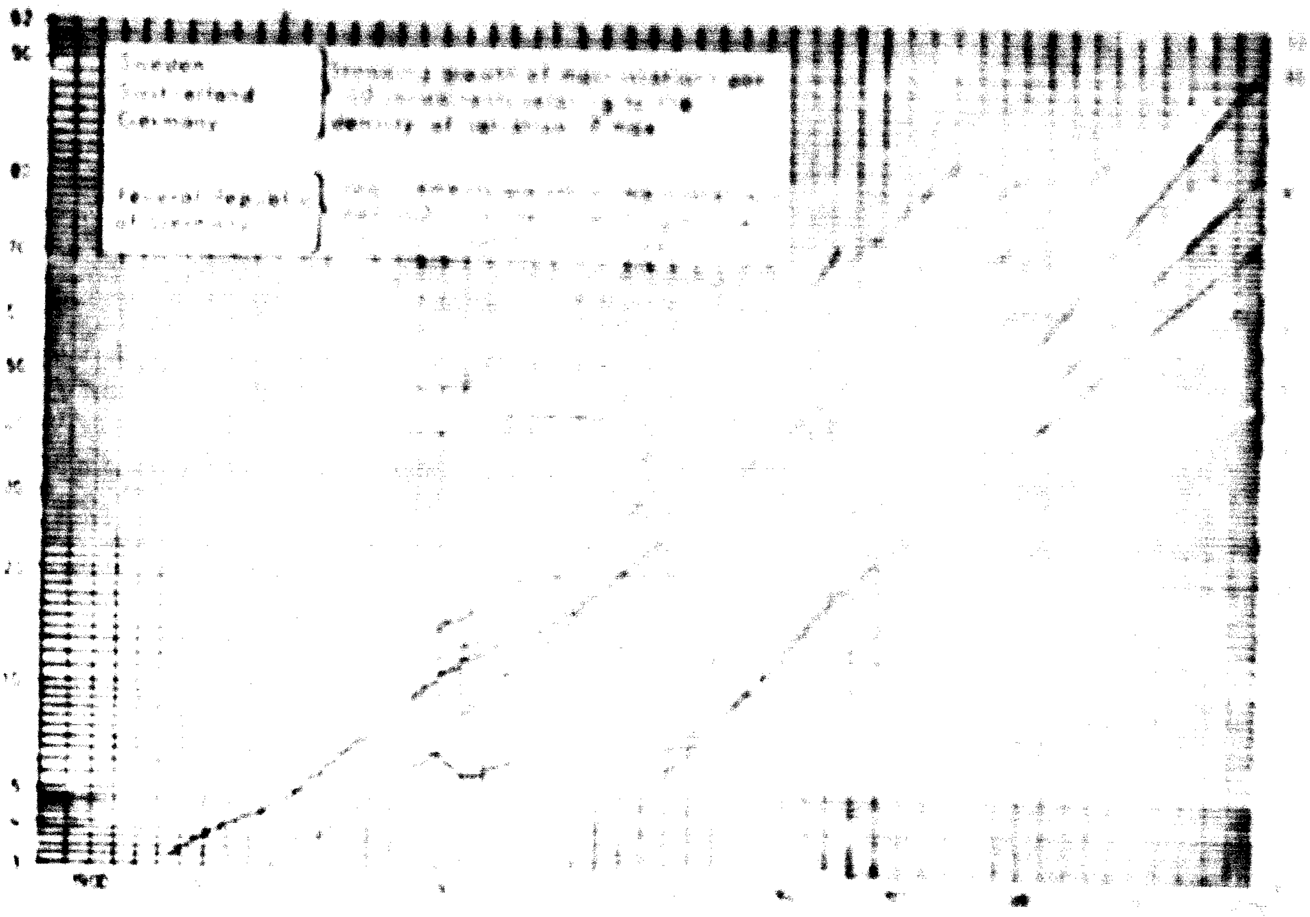


Fig. 11 Logistic Coordinates
(acc. to Bohm, 1966)

As to the question of the future development of the telephone services of developing countries, it may be said that reaso ably accurate forecasts can be made if all available statistical data is used - i.e. data not only relating to telephony, but also on general economy with social trends and patterns.

The recurring question of the future development of telephone communications - which may for convenience' sake be subdivided into local, long-distance, and international as well as intercontinental telephone communications - is covered in a separate chapter (Chapter IV) of the C.C.I.T.T. study //1//; further discussions in this publication will be related to results of forecasts regarding the development of the number of telephone subscribers.

Two further questions of considerable importance concern the investment required for telephone services and the part of the national economy that is devoted to telecommunications. Here again, planning for the future must be based on the forecasts of the development of the number of telephone subscribers as well as on the data of the growth of telex and telegraph services. The C.C.I.T.T. study [illegible] investigates, in Chapter [illegible], the influence of economic development on telex and telegraph traffic; the two questions mentioned above, i.e. "investment required ..." and "the part of the national economy ...", are covered in Chapters VI and VII, which contain much statistical material and give excellent insights into the problems concerned, particularly with regard to developing countries.

Another question of basic importance, and one that is raised frequently, relates to future developments in telephone technology, which are increasingly evaluated from the economic angle.

1.2 Present and anticipated technological solutions for switching systems

No other concept has attained the far-reaching and profound importance to telecommunications as that of 'electronics'. The conception of 'electronic switching techniques' has been developed only in the past twenty years. If we call to mind the situation of telecommunications at the end of World War II, it was characterized by the exclusive use of electromechanical components in a traditional switching art, as opposed to the manifold applications of electronics in all other fields, such as long-distance transmission systems, broadcasting, the many different types of commercial and - particularly at that time - military applications of radio engineering. The latter including air traffic control and radio ranging, more commonly known today as "radar". In addition, a rather large community of engineers in most of the countries of the world were familiar with microwaves, group and phase delays, and modulation techniques - to mention just a few examples - and considered them part of their daily lives. Various schools and universities deepened and disseminated this knowledge and the requisite skills; industries and associations in all industrial countries were instrumental in passing this knowledge on to a most interested and often enthusiastic youth. The "antiquated" and unexciting principles of the switching art, in comparison, were a subject deemed hardly worthwhile or interesting.

This discrepancy was the basis for the further development of the switching art, and the many efforts and attempts have been expended to introduce electronics on the basis of the most modern scientific knowledge. Much progress has been made in the past two decades in the technological and scientific advancement of electronic telephone systems. A quite normal reaction - that of resisting change and to the expenditures involved in adopting new concepts - has delayed world-wide acceptance of these new developments. Time has been too short, however, to do away completely with these restricting factors, which seem to be the key to an understanding of the many problems to face today. However, the trend toward fully electronic switching systems is advancing.

It is interesting to note that even today discussions of "the telephone" within the scope of physics classes in schools are confined to a large extent to the transmission problem of finding suitable transducers - a problem that the inventor of telephone, Philip Reis, solved in 1861, and Graham Bell 13 years later, when he succeeded in perfecting Reis's invention. The 100 years since, however, have seen the development of a switching art that is involved in tackling an entirely different problem, namely that of giving each one of the estimated 240 million telephone subscribers all around the world the opportunity to call any one of the other of this inconceivably large number of subscribers. Even though at present the feasibility of direct calls, i.e. of calls dialed directly by the subscriber without the assistance of a telephone operator, is confined to areas of predominant demand (for example, the territory of an individual country or a continent). The ultimate objective of intercontinental direct distance dialing can no longer be termed unrealistic.

Although the engineering and administrative task to provide 240 million subscribers with unlimited traffic facilities, while ensuring acceptable rate assessment, is gigantic, it is necessary also to consider the economics of the problem: If the investment value of a telephone line terminal is set at US-$ 1300,- according to V. Aschoff //13//, the replacement value of the switching equipment in the world's present telecommunication facilities is approximately US-$ 200 billion. Even in terms of the world economy, this amount is a highly significant factor and constitutes such an important part of the national wealth of all civilized nations, it obvious that the greatest possible care and effort must be exercised in considering and planning all aspects of the future development of this "global communications machine" (or, to use less dramatic language "world-wide communications machine"). Although only a a minute fraction of the capital expenditure required can be isolated as being reserved for a particular technique within the overall development scheme, several clear-cut demands may be formulated:

Each and every new installation or system must be conceived in such a way that it may be integrated - not only as an individual unit but also as a group, e.g. a group of a network, - with the existing telephone network, and at the same time, satisfy all pre-existing conditions. No responsible government in the world today can afford to replace major parts of its telephone system with new equipment before the old system has been properly depreciated. Additionally, the change-over must be gradual with interworking of existing and newly-added systems. This cannot miraculously take place over night.

These facts have been surprisingly rarely mentioned in the multitude of scientific writings, which is rapidly increasing in volume, particularly in the field of electronic switching //14//, //15//, //16//, //17//. The dependence of the switching art on these simple facts distinguishes this field from the other fields of communications engineering, which are characterized by virtually unlimited freedom in regard to equipment and installations. A ship's new radar unit may, for instance, contain completely new and different components, and may even be based on a fundamentally different concept using new engineering and design features. As long as its performance and operation satisfy the requirements or improve on the previous standard, such a new unit is most welcome if it can be obtained and operated at reasonable cost. A direct interaction of all existing naval radar stations of the world is usually never required.

This important difference between the switching art and the other fields of communications presents another major problem in deciding the future course of action and should be accorded much more attention.

The future development of the switching art will therefore be torn between efforts to eliminate the scientific and technological differences between switching and the rest of telecommunications while overcoming the natural caution and conservatism in allocating the required huge investments. It seems more reasonable to expect worldwide communications systems to continue to move in the direction of further integration and interdependence.

While only a few years ago the switching systems of more recent design were frequently classified as to the degree of their "electronization", it appears to be necessary today to make yet another distinction on a higher level: A switching system may be required to work with

wired program control

or with stored program control.

In the latter case, all switching operations are controlled by a stored program; this technique is often referred to as "processor controlled".

In addition, another distinction is of particular importance, although it is sometimes considered from a wrong angle: Sometimes the immediate object of a development effort, which may aim at an experimental exchange to obtain experience as to the behaviour of new components or the reliability and maintainability of the system's concept, or to study any operation problems arising from new concepts. Ultimate goals for such a project are aimed at the feasibility of mass-production of the system for large-scale use in a country. It is obvious that these two steps have to follow each other.

For example, the Stuttgart-Blumenstrasse exchange has been built as an experimental project on the principles of the system HE-60 L of ITT //18//,//19//,//20//. The establishment of a second, similar experimental exchange in Vienna //21//,//22// did not change anything in this respect. In both cases the tasks of an experimental exchange were fully performed: The Authorities were given an opportunity to operate, and to learn to operate under practical conditions, a new forward-looking system, while the manufacturers were in a position to obtain valuable information through a field trial which, in many respects, yielded results of fundamental importance in deciding on the further course of development work.

The stored-program controlled ITT telephone switching system 10 C [illegible] following the Blumenstrasse experience was inaugurated in [illegible] near Antwerp on September [illegible] 1967. This exchange had been specifically designed with a view to finding a competitive solution for medium and large exchanges of the public system by means of the most up to date technology. This means in other words that the system is ready for series production and use in existing telephone networks.

In any country intending to further expand its telephone network by means of a new switching system the question of whether a [illegible] experimental exchange should be [illegible] is the first and foremost question to be answered.

An experimental exchange in this connection may be defined as an installation of switching equipment for trial purposes only. Particularly in developing countries careful attention should be given to a number of considerations such as the following:

Is the existing switching system sufficiently modern to satisfy the extension requirements for at least several years to come and can expansion be accomplished simply by the addition of new facilities to the existing system without major changes? Or in other words, is there sufficient time for the establishment and thorough evaluation of an experimental exchange?

What is the situation with regard to national service and maintenance personnel? How will the training and further education of these men be coordinated with the gradual introduction of the new switching system?

What is the real demand in terms of economic needs for the development of the telephone system with relationship to the most economic return in the shortest possible time while fullfilling national telephone requirements ?

This very limited selection of problems, out of a long list of environmental conditions and premises, will readily show that no general answer can be given to the question whether an experimental installation is economically justifiable in a particular case. However, another aspect arises if one considers a demonstration exchange, i.e. an installation of a new and fully designed system to put at a customer's disposal to demonstrate its viability and performance. It is obvious that such an installation will be used by the customer as a study and training object.

After these basic questions have been answered, the second question - that of the basic technical approach - should be asked.

The first two decades of electronic switching systems, (roughly 1945 to 1965) have been characterized by the introduction of new, "modern" components which have replaced electromechanical parts. Up-to-date electronic components endow the system with additional performance features which may bring the administration, or the end user, or both, certain advantages. These components usually have two things in common : one, most of them are more expensive where they replace a simple electromechanical component with metal contacts needed in switching networks, and two, the quantity required for control and other circuits of an exchange is a greater number.

This has resulted in an intensive search for ways and means to use such parts sparingly, and to design them to perform multiple tasks. The high switching speed of these parts - in comparison with the speeds attainable with electromechanical components -, in turn, permits a higher degree of centralization.

This higher degree of centralization results in the need for a more sophisticated, intensive, and complex organization of the exchange. In recent years this trend has resulted in stored program controlled switching systems to come more and more into consideration, which is also reflected in the increasing share that such systems have in the literature /16//, //17//, //23// ... //33//, a list which by no means claims to be complete.

To go another step further, the concept of an integrated switching and transmission system is encountered, a solution which will certainly have excellent prospects //34//, //35//. To what an extent the organization of a future telephone network may exceed the bounds of a conventional system may be seen by subdividing the systems into "speech networks", "processor networks" and "remote control networks", as relevant studies and extensive experience with centrally controlled communications systems have shown //36//.

A great number of conditions and their consequences have to be borne in mind in answering the question of trained personnel.

As has already been mentioned, the availability of suitable labor from domestic sources to fill all positions at the various levels can have a decisive influence on the selection of a particular switching system. Maintainability and reliability are major problems to be solved, depending on the existing personnel and training capabilities as well as the general education possibilities.

Another decisive factor is that of the interface conditions regarding the existing switching systems. What requirements are imposed on the system to be selected by the existing national long-distance dialing network and by connecting international networks ?

Do any special climatic conditions have to be taken into consideration ?

H.Haslinger attempted in 1966 to critically survey, and to present in an organized form, the present state of development of international telephone switching engineering //37//. In this study, the author referred to 596 publications, to which more than 100 new ones have been added the subject covering the time period since 1966. This imposes an almost impossible task on any one person to survey the field, and it is only through the combined efforts of experts that a technological basis can be obtained which permits an optimum solution to be found for a new telephone switching system. In the beginning a developing country may frequently have difficulty recruiting a sufficient number of experts and specialized professionals. Ideally, the gradual establishment of a qualified group of specialists in a developing country should be accomplished by years of intensive training abroad. Foreign specialists, experienced in matters of creative scientific and technical work and in planning and development projects, might assist in the developing country's effort.

In summary, the question of what basic technological approach should be chosen for new telephone switching systems for developing countries can best be answered by saying that the requirement of a harmonious adaption of a new switching system to an existing technological environment, in particular the switching system used in that environment, and the necessity to take into account essential economic factors. These reasons are not only important during the initial phase of a study but continue to be in future considerations. The trend toward fully-electronic switching raises the question of future use of stored-program or wired-program controlled systems with dry reeds or open contacts. The choice a developing country has to make should be based also on maintainability, reliability, and experience from other administrations using modern telephone switching systems.

1.3 Computer Aids to Telecommunications System Planning

The Scope of the Planning Problem

The definition of a telecommunications planner refers to the communications engineer responsible for developing a network design, deciding where, and how many, switching centers must be included in the network, and finally what type of transmission facilities must be provided. Obviously, this requires a wide range of engineering capability, and therefore, in general the term "telecommunications planner" covers the responsibilities of an engineering group rather than a single engineer.

There are many points which the planning engineer must consider. Of these, the most important is the "fundamental plan", which contains the following:

(a) Numbering

(b) Routing

(c) Rates

(d) Switching

(e) Transmission

(f) Signaling

For each item in this plan, the criteria for operation of the telecommunications network are specified. When these objectives are not met, the plan must indicate the necessary steps to achieve the specified goals.

This plan is basic to the development of any communications network whether it is used for voice, data, or both types of service. It is assumed the plan in this exercise is fully developed, and it should be understood that without a fully-developed plan, computer assisted engineering studies have a low probability of being successful.

There is one fundamental reason why these plan details must be well defined for considering the use of computer assistance in such studies. The output of the computer, even though the computer program contains accurate processing rules (mathematical formulas, logic, etc.), can only be as accurate as the input data supplied for the analysis. Unfortunately, there is a tendency to estimate facts and over-simplify significant parameters which may be adequate for manual engineering studies. But these expedients can only lead to disappointing results when using a computer.

Other points the planning engineer must consider are:

(1) Capital - How much money is available?

(2) Existing Facilities - What is the condition of the present network? Which limitations are imposed on the introduction of new equipment and services?

(3) Manpower - Are there adequate and sufficient engineering skills available to develop both long and short range plans?

(4) Forecasts - How accurate are the forecasts of growth?

Here again, it is assuming that a telecommunications network already exists, and that the planning engineer is required to develop a scheme which may have to be implemented over several years, since the availability of construction funds is limited. In addition, he will be

required to integrate the new technology into his existing network design. Electronic switching will have to interwork with other types of switching systems e.g. crossbar, step-by-step, etc.

With these major points given, what is the planning task?

Studies must be undertaken with subsequent recommendations to management on "how much", "where", and "when" to spend their capital. The studies in a typical operating telephone company take several forms, but can be considered in two general types. They are usually separated into engineering studies which lead to the formulation of long range plans (5 years, or more), and short range studies, which obviously deal with decisions which must be made in the relatively near future. The studies must begin with an evaluation of existing methods, systems, and equipment. A thorough understanding must be acquired on what is to be accomplished during the time period being studied.

As has already been mentioned, the development of communications engineering continues to make rapid progress, and new approaches and technologies follow in increasingly rapid succession.

The significance of this trend is twofold. First, it places an increasing engineering burden on the administrations to produce more and more plans in less and less time. With the increasing costs of engineering skills, and the increasing shortage of engineering world-wide, the planning and implementation of these plans is falling behind. For all indications this trend will continu Second, because of this explosive growth, tremendous costs are being incurred. A administration's ability to generate this capital is dependent, to a large extent, on how well they are meeting the present demand for service.

It is increasingly evident in many developing countries, and also in some of the more sophisticated ones, that telecommunication services are simply not meeting the public need. Not only are the newer communication features such as data, push-button dialing, abbreviated dialing, automatic call transfer, camp-on busy, indialing into PABX's etc. being postponed, but even basic telephone service is difficult to provide. Waiting periods to obtain telephones range from a few months to several years in many developing areas.

Thus, to the short range problem of providing basic local area telephone service requires a large proportion of the planning problem in many areas of the world today.

The Short Range Planning Task

Important studies which an administration must conduct in this area are primarily associated with projects which can be completed within 2 to 5 years. Typical of such studies are:

(1) Placement of new switching exchanges.

(2) Network rearrangements to accommodate shifts in traffic patterns, or growth in the network.

(3) Cable placement to accommodate growth in subscribers, shifts in exchange areas, or growth in inter-office trunking.

(4) Traffic studies to determine requirements for additional transmission facilities, trunks, or switching equipment.

(5) Extension of subscriber dial service from local areas to adjacent areas previously handled via manual or operator dial toll service.

To further typify the planning task, the placement of a new exchange must be considered //39//, //40//.

The lead time for a new exchange is approximately three years. Not only is it necessary to consider manufacturing, delivery, and the installation time of the required switching equipment, but land may have to be purchased, right-of-way established, construction of a new building may be required, and exchange cable will have to be placed. So it is not uncommon to have a lead time of even more than three years in certain cases.

Thus, in order to meet a pre-determined date for cut-over of a new exchange, the planning work must be conducted in advance of this lead time. There may be some over-lap permitted during the manufacturing interval, but, in general, the planning work should be completed in order that a clear decision can be made without any restricting pre-scheduled activities placing pressure on the management to hasten this decision.

The planning time interval for the introduction of a new exchange is variable. It varies as an inverse function of the availability of fundamental plan, up-to-date commercial forecasts, and adequate engineering skills necessary to draft the plan.

This interval could be as long as 6 months. Frequently, extraneous factors place a constraint on this interval. There may be times when management may consider the plan inadvisable because of curtailments in budget, or there may be some technical objections to the initial plan.

In any event, the planning engineer is faced with several alternatives.

First, he can postpone the job while a second plan is prepared. However, as previously stated, the pressure to provide basic telephone service, improve the quality of the telecommunications network, and introduce technical innovations, is becoming greater every day. Furthermore, the postponement of certain extensions to the network may even cost money. Mechanizing switch-board traffic is a good example. Costs of operators, administration, and other items associated with manual switchboards can be expensive, whereas providing automatic switching can result in signifant savings in not too many years.

Thus, the postponement of any plan is simply not the answer, if a telephone administration considers itself modern and is attempting to meet the present needs for better service.

The planning engineer can attempt to shorten the planning interval. The answer lies in shortening the time interval devoted to development plans.

In the particular example just illustrated, let us examine the essentials of planning a new exchange to see what the possibilities are for improving the situation.

While many technical criteria have to be met, such as transmission, signaling routing, etc., the single most important factor in locating an exchange is cost. The concept of "wire centering", or locating the exchange nearest the center of subscriber density is the essential planning factor in order to minimize overall costs.

Performing an exchange placement study is a long and tedious process. There are a considerable number of calculations to be made. These are relatively simple calculations, but nevertheless there are many of them.

The costs of outside plant must be calculated, both for subscriber and inter-office circuits, and the costs of land, buildings, and switching equipment must be considered. In addition, two, three, or more configurations are required since it is not generally apparent where the optimal locations may be for exchanges, or what the network configuration should look like.

Since these calculations alone can take several months, it is also possible that the data being used in the studies could become obsolete before the study is completed, due to new forecasts of growth, either in subscribers, or in the traffic distribution, or both.

This, then, outlines the need for a planning tool which can:

(1) Accomplish a network design in a few hours, or minutes, as opposed to weeks and months.

(2) Accommodate more than one set (preferably many) of design criteria, e.g. transmission, signaling, routing, variable quantities of subscribers, variable traffic quantities, and distribution, costs, etc.

(3) Increase the accuracy of the results by eliminating many over-simplifications, and by increasing the efficiency of the calculations.

(4) Distinguish the most cost-sensitive elements of the system design.

(5) Be utilized by telephone planning engineers without a great amount of formal indoctrinal training.

These performance objectives can only be reasonably met by mechanizing the approach to the planning job. And this means only one thing ... computer aided design.

Computer Aided Designs

The task of planning was illustrated previously by a brief description of the short range engineering effort required for exchange placement. No attempt was made to describe the calculations required, the methods used, or the critical timing factors involved. The description was merely indicative of the type of task which is fundamental to the business of telecommunications planning administrations throughout the world.

Since the need is so fundamental, it is no wonder that investigators have first applied the development of computer aids to this problem. Companies where this work is currently being done are rare; one of them is ITT. The use of computer aid programs in this field spans all the way from designing the placement of components on miniaturized circuit boards to the computation of the quantity of inter-office trunk circuits in a large multi-exchange telecommunications network, and,to the simulation of the telephone exchange itself, to determine its traffic handling capacity //39//, //40//.

It is impossible to provide a comprehensive description of all these programs within the scope of this publication. However, an attempt will be made to outline a few of the fundamental requirements.

The type of computer program of most use in the planning field, such as the case of exchange placement, falls in the category of "simulation" programs. In other words, a model of the network, or exchange area system (comprising the subscriber cable plant, the exchange, and inter-exchange cable plant), is constructed, and a computer program is written which can simulate the operation of this system handling a simulated traffic load, or the program can simply perform calculations of the costs of the system.

Before describing one such simulation program which has been developed by ITT, it is appropriate to establish some facts about computer simulation.

A simulation study can, of course, be accomplished manually. In fact, in many engineering tasks this is precisely what is done. The study begins with the development of a working (mathematical or physical) model which contains properties and relationships similar to the real system being contemplated. Then, experiments are performed by operating the model in the same manner as the real system would be operated (see Fig. 12). There is really nothing new in this concept. What is novel, however, is the introduction of high speed, large memory capacity, high level logic, digital computers, to operate such models.

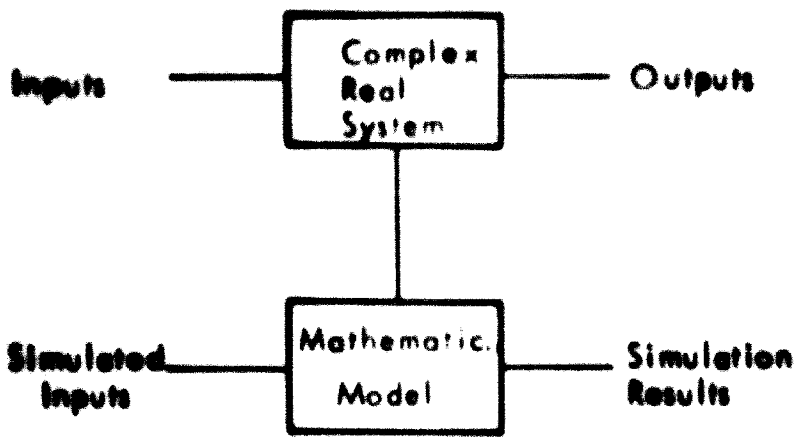


Fig. 12: Computer Aided Design, Simulation Example

In the type of simulation programs being discussed, the model is always of the mathematical type. This model must describe both the static and dynamic relationships between the significant variables in the system being simulated. Here it is essential to include all of the variables which have a major effect on the performance of the real system, and, at the same time, eliminate those details which have no material effect on the outcome of operating the model. How close to reality a model can be, is subject to the designer's knowledge of the real system, the time, costs, and method of operating the model, and the desired accuracy of the results.

If, for instance, we are interested in the costs for main and feeder cables in an exchange area over a range of lengths, we could employ a continuous curve in place of the step function usually associated with such curves. An illustration is given in Fig.13. The actual cost curve is discontinuous, but the simplified curve is continuous and much more easily expressed mathematically. However, its use would introduce errora in the calculation, especially near the points of discontinuity on the actual cost curve. Thus, it would be much more accurate to use a mathematical expression which describe the actual cost curve. In actual fact, this kind of accuracy is built into the models of all ITT's network planning computer simulation programs when it has a significant effect on results.

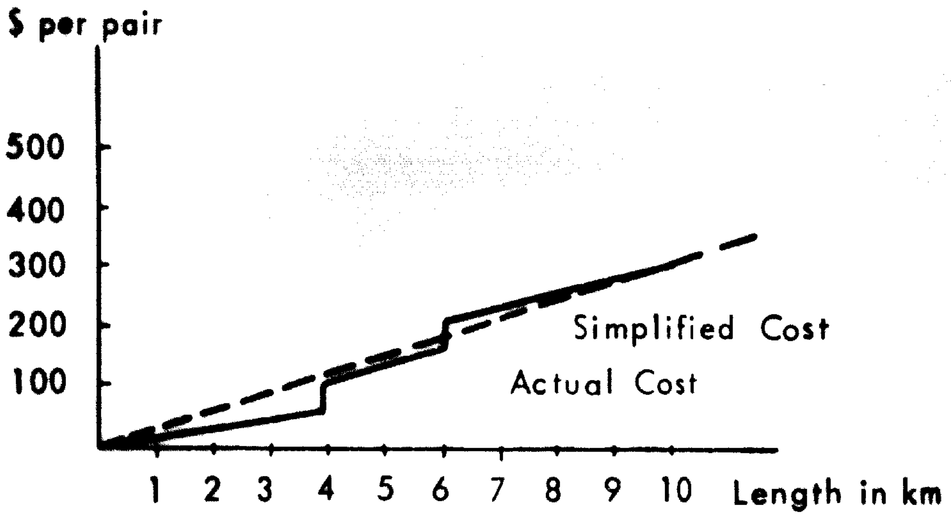


Fig.13: Typical Costs for Main and Feeder Cables in Subscribers Outside Plant

Fig.12 illustrates what can be physically accomplished in "simulation". It also points out one of the principal pitfalls in simulating. The model should represent, as accurately as possible, the real system being simulated. However, it is not sufficient to construct the model and then operate it. Some correlations and comparisons must be done between the simulation results, and the "expected" output of the real system to validate the accuracy of the model.

This implies, therefore, that some "a priori" knowledge of simulation results must exist. While this is difficult, and often impossible, in designing new systems where only a model exists, it presents no real problem when simulating existing present-day telecommunications systems. However, it does suggest that there must be extremely close liaison between the computer specialists, and the telecommunications planning engineers to test the reasonableness of the simulation results.

There is quite an accumulation of knowledge on simulation techniques, and this review has only high-lighted the barest essentials of the subject.

However, the above brief description will serve to introduce some of ITT's work in this field of computer applications.

ITT Computer Programs in Telecommunications Planning

ITT has been active in this area of computer technology for several years. Starting in several laboratory locations in 1965, a wide range of programs is now available in several ITT system houses to assist in preparing tenders, designing circuits, and reducing engineering and manufacturing costs. Planning programs were initially developed for assistance in preparing tenders.

Currently

ITT is working directly with several administrations in assisting their planning engineers by operating these planning programs on joint engineering projects.

Some idea of the ITT planning programs now available or under development, can be obtained from the following list:

(1) Placement of Exchanges in Urban Areas

This computer program will optimize the location of one, or more terminal exchanges in a local network where minimum total costs are the objective. Only first, or initial, costs are considered //40//, //41//.

(2) Establishment of Exchanges in Urban Areas

This program is under development, and is a modification of the preceding placement program. It is being designed to establish the best time to introduce one, or more, terminal exchanges to make optimum use of a telecommunications network already existing. Thus, annual charges are considered in this program in order to optimize the timing factors.

(3) Computation of Direct and Tandem Trunks in an Alternate Route Network

This program is used to perform trunk engineering in a telecommunications network where the terminal exchanges have a first and second choice outgoing route. Direct trunk-group sizes and tandem trunk-group sizes are computed to minimize total network costs. Alternate routing is restricted in this program to one tandem exchange. Under development at this time, however, is a modification of this program to include a wider choice of routing procedures such as the use of two tandems in series //41//.

(4) Equalizer Section Design

This program is of more direct interest to the field engineer responsible for cable design than the planning engineer. However, it is included here to indicate the variety of telecommunications problems being solved by ITT computer specialists. The program utilizes cable transmission-loss characteristics measured by the field engineer, and then computer equalizers component values and circuit configurations almost immediately. Graphic display terminals are employed to review response curves in an on-line mode //42//.

These programs (except (2)) have been in use for periods up to two years now, and have been under continuous refinement to make certain the models are as realistic as possible. Practical designs have been accomplished for many ITT houses and many important customer administrations have made use of them also, such as, the British Post Office, the Spanish Administration (CTNE), Peru Telephone Co., and other administrations in Latin America.

In addition the Norwegian Administration, the Dutch Administration, and TELMEX (Mexican Administration) are currently studying the programs for the possibility of using them later this year.

In order to present a slightly more definitive picture of these computer planning tools, the following description is offered of the Exchange Placement program.

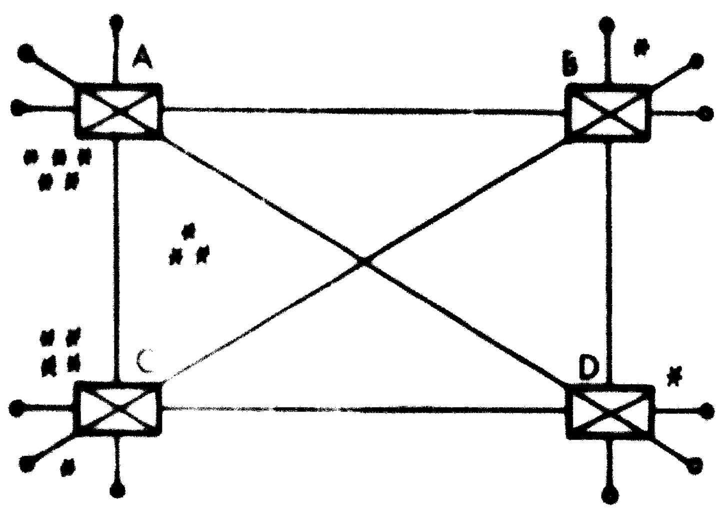
Exchange Placement Using the Computer

In the case of locating a new exchange, there are no dynamic variables since only the total cost of the system is to be calculated. Thus, the "model" here is only a static model, and is simply a statement of the total plant costs.

$$\sum_{i=1}^{v} C_i = C_{\text{Outside Plant}} + C_{\text{Switching}} + C_{\text{Buildings}}$$

The purists in the simulation business might argue from a generic standpoint that because there are no dynamic variables, this is not a "true" simulation. And from their view point, it may be a valid position. But the fact remains, that any mathematical statement can be considered as a "model", since it represents a "system" of some kind. The arguments on this subject are beyond the scope of this chapter. However, they are covered in detail in Mr. Chorafas's book "Systems and Simulation" //43//.

In Fig.14, a simple illustration of a typical exchange area is shown. The problem that the estimated future growth presents to the planning engineer is whether to add another exchange in the vicinity of exchanges A and C, or whether these exchanges can possibly handle this growth without making any network changes. The planning engineer must determine the capacity and present loading of all exchanges since these facts will be employed in the program. Cable distribution must be determined for each exchange area including the determination of the area boundaries.



Key

(1) ⊠ Existing switching centres

(2) • Existing subscribers

(3) —— Subscriber and trunk cable

(4) # Estimated future growth

Fig.14: Typical Exchange Area

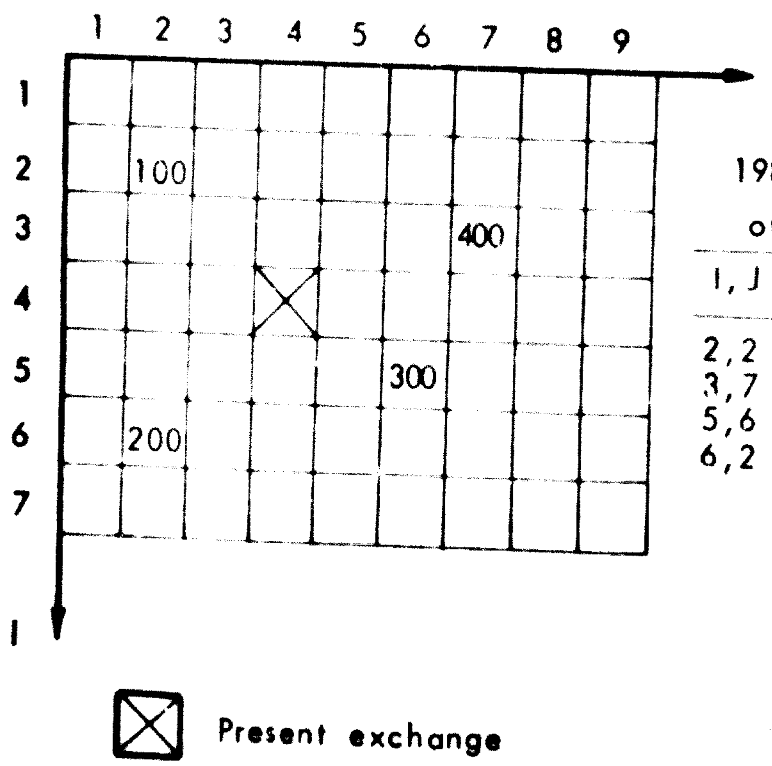
The planning engineer operating this program first estimates from his forecast of subscriber growth whether 1, 2, or more, new exchanges are required. The computer program then develops an optimum configuration based on this input, and the total configuration costs are used as a reference point. The program is designed to subsequently test alternate configurations by automatically varying the quantity of new exchanges to see if there is a superior design which will reduce the overall costs of the reference configuration //44//.

The program is also written to produce the results of all successive configurations tests. This permits the planning engineer to analyze all configurations, and possibly select one which is not the economical optimum, but which, because of some other planning reason, may be more suitable. (Even though there are penalty constraints placed on the computer in defining optimum exchange areas, existing exchange area boundaries may be sufficiently altered so that re-arrangement costs may offset the gain achieved in obtaining a minimum cost configuration.)

The types of information the planning engineer needs for operating this program are not different from those required for a manual calculation, and are shown below:

(1) Subscriber Matrix

This is the subscriber density forecast by geographical area. The program uses a coordinate system to define the topography of the exchange area. (See Fig.15)



1980 forecast of growth

I, J	Subscribers
2,2	100
3,7	400
5,6	300
6,2	200

Fig.15: Exchange Area Description

(2) Cost Parameters

Costs of all significant plant items must be included in tabular or graphical form if not linear. (See Fig.13) Linear costs can be simply stated on a per-unit basis. Included should be: subscriber cable, trunk cable, building, land, switching equipment, and power equipment.

(3) Traffic Matrix

This is the estimate of traffic volume and distribution for all future and existing subscribers in the exchange area under study. These parameters are specified in a manner similar to the subscriber information listed in (1).

(4) Grade of Service

The criteria for allowable traffic losses in the network must be established in order to compute switching equipment and trunks required. Other service criteria such as technical constraints imposed by transmission limitations, duct systems, cable sizes, etc., can also be included.

(5) Exchange Area Specification

As a starting point for the program the quantity of existing and estimated exchanges must be described, including location. Upper and lower limits may be set on the size of these exchanges as a constraint.

As mentioned earlier, the program operates on the model by successively changing configurations, and then computing the overall costs. It is interesting to note that the method of optimizing takes the form of moving the exchanges within the initially defined exchange areas. This has the effect of balancing the lengths of subscriber loops and inter-office trunk circuits to achieve the economic optimum. A special computer study was recently conducted at an ITT Laboratory where fundamental facts were uncovered about the sensitivity of these costs to changes in the basic parameters //45//.

Included also in the optimization is the calculation of required switching equipment and inter-office trunk circuits for each configuration in accordance with the grade of service criteria which has been specified.

Once several iteraticns of this program have been completed, results for each tested confi uration are then printed out for analysis. Each set of output data contain the following:

(1) Location of each exchange.

(2) Quantity of subscribers assigned to each exchange.

(3) Cost of building, land, power equipment and switching equipment per subscriber.

(4) Cost of inter-office trunk circuits and cable per subscriber.

(5) Quantity of inter-office trunk circuits and terminal locations.

(6) Volume and distribution of traffic.

(7) Boundaries of each exchange area.

(8) Total cost of subscriber cables.

(9) Total cost of inter-office circuits and cable.

(10) Total cost of exchanges.

(11) Total cost of network

Thus, the planning engineer has sufficient information to select the best among several different network configurations; and e performance objectives, stated earlier for a more efficient planning tool, have all been met.

The network design is accomplished in minutes, with several designs actually being prepared. Changes on forecasts or other input data can be accommodated immediately so that additional computer runs can be made right away.

Accuracy is improved since more precise computations can be performed.

The programs developed by ITT are designed in such a manner that telecommunications planning engineers require almost no training in utilizing them. Preparation of input data is exactly the same as for manual studies with the addition of preparing standard punched-card format sheets for the computer.

2. In-plant training problems

The subject of training local specialists for planning and management tasks has already been touched upon; this, however, is only part of the problem of how to train communications engineers for a multitude of fields and tasks. For illustrative purposes, it may be best to examine some of the training problems confronting a developing country.

The success of any manufacturing enterprise revolves among other things around its physical plant and facilities, the availability of raw materials, and the skill of its employees. The relatively high labor content required for telephone equipment manufacturing makes employee skill a most critical area toward which management must direct their attention if the enterprise is to be successful. Employee skill is developed primarily through training; consequently, the importance of this activity cannot be overemphasized.

There are many areas of concern for training in telecommunications. Two of the most important are the training of engineers and the training of operators in the plant. If strong programs of training are not developed in these two areas, the probability of success is limited.

Following are some of the details of engineering and operating training with a view toward providing information helpful to developing countries interested in this subject.

2.1 Engineering Training

Companies engaged in manufacturing of telephone equipment in developing countries are faced with two major problems with regard to their engineering talent. First, they must develop a level of competency sufficient to meet the engineering challenges of today. Second, they must make certain that engineers are constantly gaining the new knowledge that will be required to achieve engineering excellence in the future. The engineering force must not only have capability in design and manufacture of equipment, but must also be prepared to work in the design, installation, operation, and maintenance of the telephone network.

These problems are particularly difficult to overcome, since no institution of higher learning provides a curriculum specifically designed to meet the needs of the telephone industry.

Manufacturers in countries with highly developed telephone systems face similar problems as those described above, but they also have the advantage of an in-house experience built up over years of meeting the challenges in their field. These manufacturers can hire young graduate engineers, assign them to simple projects at first, and let them develop in competency over a period of time right on the job under the supervision of the more experienced engineers on the staff. These manufacturers can also make arrangements with local universities for periodic in-plant or on-campus courses to keep their engineers abreast of advances in the state of the art in specific areas such as solid state theory. The larger of these manufacturers can also maintain their own research laboratories to extend the frontiers of knowledge in areas related to telephony. The development of the transistor might serve as one outstanding example of this kind.

Big international companies of the telecommunications industry which manufacture telephone equipment in a multitude of countries throughout the world are enabled in developing countries to train their younger engineers on the job under the guidance of some experienced engineers. Also, they can take advantage of specialized courses at universities. On the other hand, such big companies must strive to overcome the problems faced in developing countries, where highly experienced engineers do not exist in sufficient numbers to train young engineers on the job, and where opportunities for advanced university training to prevent engineering obsolescence are markedly reduced. To discuss this solution in some detail, it appears appropriate to give a practical example, that of ITT.

ITT has both major manufacturing facilities and research laboratories. In one of them it was decided to use the resident technical capability to offer formal training to engineers from developing countries, so a training center was established where engineers could come for periods up to three months.

ITT had two major objectives for this training center. First, to rapidly increase the technical competence of engineers from manufacturing plants. Second, to offer technical training to customers upon request. The major consideration had to be the establishment of a schedule to meet these objectives. Broad outlines of a schedule to meet the needs of manufacturers could be established easily based on previous experience. Courses to meet customers needs had to remain more flexible due to the wide variety of customer requests. A summary of the courses currently offered will be found in Exhibit B. A course description of one of the courses will be found in Exhibit C.

The next step was to develop detailed lesson plans and lesson outlines for the individual segments of each course. For this, ITT drew heavily upon the combined resources of training personnel, manufacturing engineering people, and research specialists. Lesson outlines were developed in detail sufficient to guide a technical specialist toward successful attainment of the course's teaching objectives. All necessary handouts were prepared and included with the lesson outlines.

Next, ITT had to assemble a faculty. The approach here was to minimize the number of permanent staff and to draw heavily upon the close-at-hand availability of engineering specialists who could be brought into the training center to teach segments of courses within their special area of competence. Since the schedule had to be elastic, we chose to use special talent as needed, rather than strive to make the small permanent staff expert in all areas. These guest instructors bring with them the special feel for problems and up-to-the-minute solutions in quite the same way as a top university professor introduces the results of his most current reseach into the classroom situation.

The training facilities themselves have been kept simple, yet flexible and expandable to cope with the ever changing training demands placed on the center. Training aids are provided consistent with training needs. For example, a crossbar switching trainer was designed and built to simulate the entire spectrum of switching operations as a method of offering "hands on" training to trainees where necessary. Naturally, computers are necessary for portions of the training offered, but it was not necessary to provide computer capability within the training center itself, since one could make use of the computer facilities in the laboratories directly adjacent to the center.

Instructor training is also provided at the center for those companies from developing countries who wish to improve their capability of doing in-house training. Instructors are trained within ITT and are then sent back to their companies equipped with the instructor's guides and other training materials necessary for them to train others at home. This instruction is then offered to those who cannot come to the center.

The training center concept is meeting many of the needs for formal engineering training. ITT expects even more will be met in the future as the challenging goal of excellence is pursued. Formal classroom training can never be more than part of the total thrust. Other means must be devised to get the required training out to where it is needed. Correspondence courses are one way to solve this problem. These courses are prepared under the direction of the talent available and then offered to engineers in developing countries according to need. The completed papers are then returned to the training center for correction and grading by experts.

Programmed instruction is another technique which has merit in providing certain types of training. However, the investment in time required to develope high quality programmed instruction materials dictates that they be designed for large trainee populations. Thus, they customarily must deal with subject areas in wide demand, such as Basic Electronic Theory, or

Basic Transistors. This restricts the ability to tailor programmed materials to the specific needs of small populations.

Another technique, still in its infancy, but offering some potential for engineering training, is Computer Assisted Instruction. CAI will take some of the best features of programmed instruction and combine them to the diagnostic and rapid retrieval ability of a computer. High development costs, however, will place a restraint on the feasibility of tailoring to small populations.

One other method, which ITT has used to some degree, is to send out travelling teams of instructors to meet special needs of both manufacturing plants and customers. This method has obvious limitations, but it can be used when no satisfactory alternative is available.

In summary, telephone engineering training in developing countries can be met by :

(1) Drawing upon the technical skill available in more developed countries through training centers.

(2) Sending engineers out of the country for training with the objective of their coming back with the capability to train others.

(3) Using correspondence courses.

(4) Using programmed instruction.

(5) Drawing upon foreign instructors to conduct training in specific areas.

2.2 Operator Training

Training for production line operators is a particularly critical problem in developing countries, since it is unlikely that the newly-hired labor force will have had any significant factory experience. This lack of experience will mean that new employees will lack not only the skills necessary to do the job, but also the confidence and job attitudes prevalent among an urbanized, factory-conditioned workforce. Thus, the Training Department must direct itself to two major problems:

(1) Training as quickly as possible in the skills necessary to produce a high quality product at the least possible cost ;

(2) Breaking down the skills and sub-skills required for each job, and present the training so the trainee can quickly gain the confidence that he can master the job -- even if in the initial stages it is only one or two of the sub-skills.

Historically, much of the training of production line operators has been done right on the production line with a lead operator or senior operator assigned the responsibility of training the new people. While under some circumstances this method of training is the only feasible one, it leaves much to be desired in terms of training efficiency. Under this system, the new operator is usually shown the whole job, given a demonstration of how to perform the whole job, and then asked to do the whole job under the general guidance of the lead operator. The new operator starts slowly and gradually builds up speed as he or she becomes more familiar with the operation. ITT has developed a superior method of training called the "ITT Speed Vestibule" system. This system not only emphasizes speed from the very beginning of the training process, but it incorporated detailed job analysis and sound lesson planning into its over-all approach. Details of this comprehensive training system are discussed below.

The first step is to carefully analyze each job to determine just what knowledge and skills are necessary to perform the job. Care must be taken to include all necessary knowledge and skills. Equal care must be taken not to include any not absolutely required. On occasion, valuable training time is wasted by imparting knowledge and skills not required on the particular job. A partial list of those necessary for assembly of transmission equipment is as follows:

(1) Filling out time tickets

(2) Wire stripping

(3) Wire tinning

(4) Reading running lists

(5) Soldering

(6) Terminal crimping

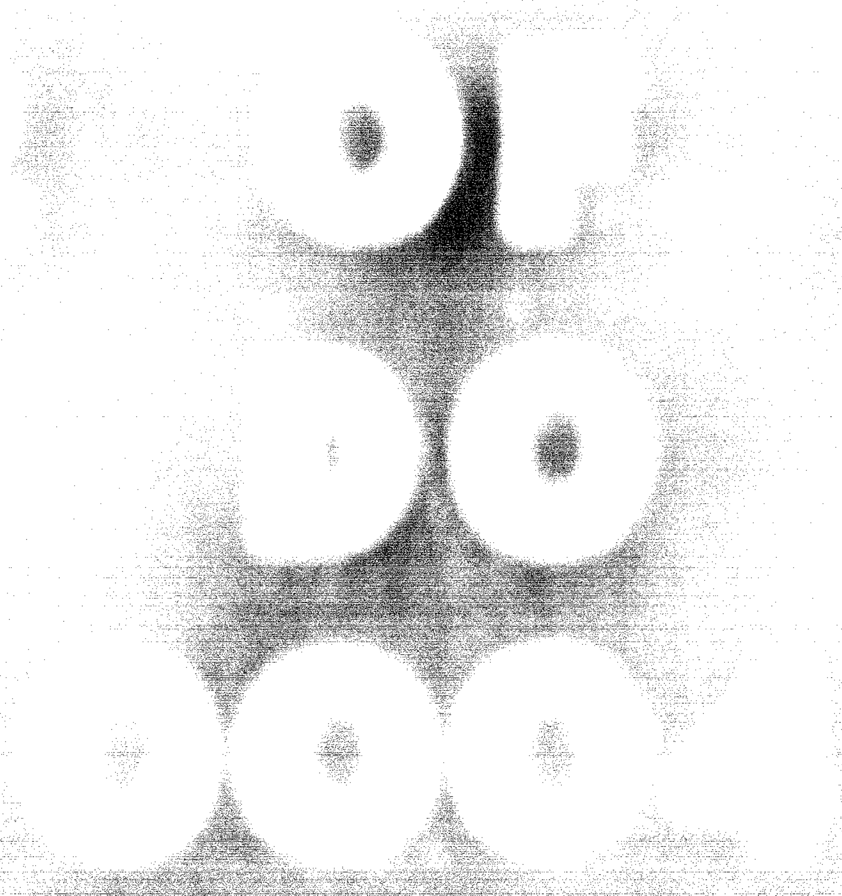
The next step is to examine each of the required skills to determine just what is required for the operator to perform at top efficiency. For example, if we examine "reading running lists", we find that an operator performing at top efficiency must not only be able to understand and interpret lists, but must also be able to read and remember several of the steps at one time to minimize the time and need for frequent referral to the lists.

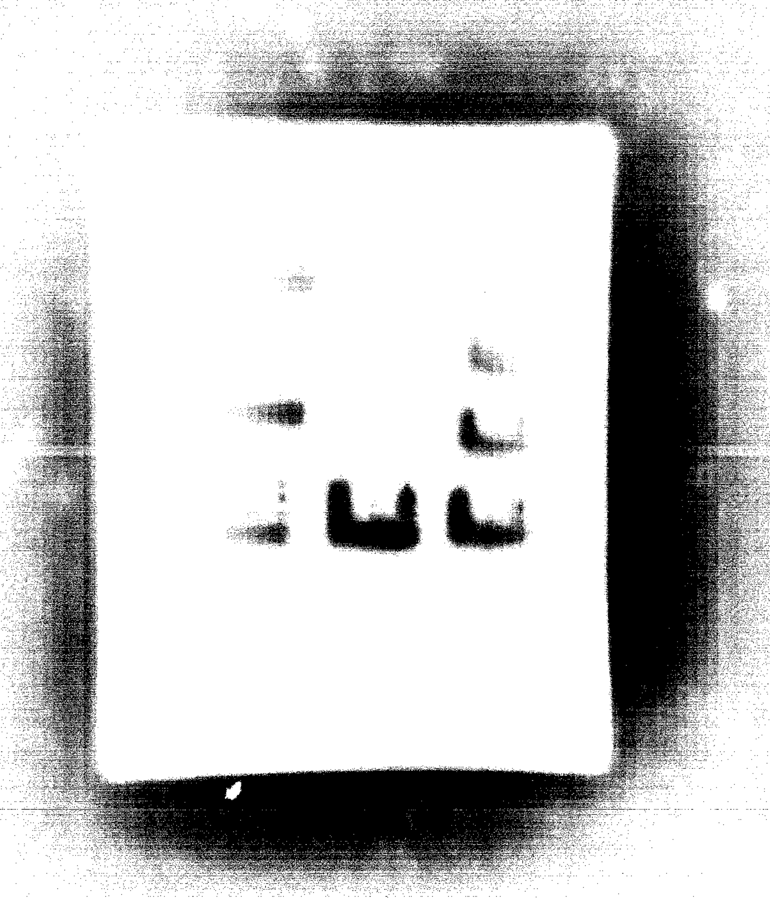
The next step is to determine the best teaching technique for each skill so that each trainee can be brought up to maximum efficiency rapidly. Using the previous example, we would want to teach interpretation of the running lists and then we would want to build up the ability to read and remember several of the connections at one time. The technique to accomplish this is to use flash cards or a tachistoscope.

The next step is to develop lesson outlines for each of the skills to be taught. These outlines should begin within carefully defined objectives, a list of the materials required to teach, a series of learning activities, and a method for evaluating the effectiveness of the instruction (see Exhibit D for an example). The sequence of the learning activities should be structured to provide learning in small steps, utilization of the most effective learning techniques, frequent repetition of the various elements of the skill to build up speed, and then integration of the elements and more practice on the total skill until 100 % efficiency is achieved.

The next step is to determine the number of people required for each of the jobs to establish the most logical grouping of people in the

24 2





training vestibule. These groupings will vary depending upon the number of people assigned to each job. For example, a shop concerned with the assembly of telephone switching equipment will usually have large groups of operators on each of the various skills required, such as cable forming, relay assembly, and plating wiring. Under these circumstances, the best approach is to set up a separate vestibule for each job since the skills required for each job are not [illegible] and since enough people will usually be required for each job to form a reasonable size group for each program.

Usually, the assembly of communication equipment requires a multitude of different jobs and consequently the number of people required to be trained on each job is low. Under these circumstances the recommended approach is to study the skills required for each of the jobs and look for families of similar skills that are common to all jobs. Larger training groups can then be assembled for the common skills portion of the training. These groups can then be split off later in the training cycle for training in those skills specific to particular jobs alone. An example of this network approach will be found in Exhibit I.

The next step is to establish the vestibule itself. The major guidelines to be followed are:

(1) The program must be carefully prepared in advance and all necessary materials and supplies must be on hand.

(2) A teaching schedule must be established. This schedule must start with intensive practice on sub-skills, and then follow with integrated practice on the total skill. (See Exhibit I for an example of a schedule for a cable forming vestibule.)

(3) Teach only what is required. All superfluous matter should be omitted.

(4) There must be sufficient production pieces available to allow for sustained practice runs.

(5) [illegible]

(6) [illegible]

(7) [illegible]

(8) Maximum interest and motivation should be maintained by having operators try constantly to improve their own performance and when feasible, to try to surpass the group average.

(9) Drills must be intense but for a short period of time only.

(10) About a [illegible] % overall labor turnover should be anticipated by operators who resist the speed concept or who are unable to work at acceptable speeds on specific operations.

(11) Operators consistently falling below the group average in the speed trials normally should not be retained on the specific operation.

(12) The vestibule class should be small enough or there should be sufficient assistant instructors so that each operator gets individual attention as soon as required.

(13) Quality should be emphasized to the extent required by the product. This standard must be met.

(14) Visual training should be stressed since inefficient eye movements can result in excessive lost time as far as production is concerned.

(15) The vestibule should be made realistic, that is, to be as similar to the eventual workplace as possible.

(16) The vestibule should be terminated when the desired standard on production is reached.

(17) Every program must be evaluated carefully, and comparisons should be made with the traditional methods of training and with previous programs conducted.

There is one more step once the operators have completed the cartridge. They must be followed up for a few weeks on the production line to make certain that they continue to do the job the way they were taught and to make sure that they do not lapse into bad habits. Supervisors [illegible] must understand the [illegible] used in the training cartridge and they must be instructed how to carry on with the follow-up process.

Is the grouped cartridge method of training operators efficient? [illegible] believes it is. [illegible] experience has indicated that learning times can be cut by 50% or more when compared to learning times required by more traditional courses and methods of on-the-job operator training. Maximum efficiency reached quickly must be a major objective in developing countries striving to raise the living standards of their people as fast as possible. Adoption of the training system described will help to attain this goal.

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The degree of technical assistance should never be minimized, because the most important condition for continuous results depends on the

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5.3 Quality Assurance Program

Another means to avoid manufacturing problems or poor reliability after the equipment is in operation, is the establishment of a sound and efficient quality assurance program.

This program should assure the final quality, starting with the incoming raw materials on through the entire manufacturing process. This should also hold true for various components purchased on domestic and foreign markets. The program should provide for early detection of discrepancies, together with the immediate initiation of corrective action to prevent recurrence.

A good example of organizing Quality Control is a manufacturing company of ITT whose main product lines have their own quality control departments consisting of the following three main groups:

(1) The reliability group

The main tasks of this group are:

- reliability determination, prediction and evaluation
- reliability evaluation in function of product targets
- setting up of programs, quality and performance tests
- supervision of the program execution, analysis of the results of failure tests and the longevity, influence of various environments
- establishment of corrective action plans and the selection of raw materials and components.

(2) The quality engineering group

The main activities of this group are:

- the establishment of quality specifications in cooperation with the reliability group and the "Research and Development" department
- the elaboration of instructions and procedures for visual and mechanical controls and electrical tests to be performed by the inspection department
- indication of testing and measuring instruments and equipment required for the execution of the prescribed controls
- determination of the frequency of calibration checks of this instrumentation

(3) The "quality assurance" group

The main activities of this group are:

- assure that adequate and up-to-date instructions are available at the inspection work positions, as well as determining periodic calibration checks have been performed
- assure by performing "random sampling" inspections that all controls are carried out in accordance with the imposed procedures and instructions
- assure that prescribed corrective actions are applied
- analyse the inspection reports and introduce any necessary corrective actions.

An inspection department performs the prescribed controls in accordance with the imposed procedures and instructions and is usually subdivided in:

(1) incoming inspection
(2) process control
(3) final test

The Quality Control Department may receive technical assistance from private or official laboratories, such as:

- the Electrical-Metrology Lab
- the Mechanical Metrology and Spectography Labs
- the Climatology Lab
- the Technology Lab
- the Chemical Lab

In the case of setting-up a local industry, the minimum for a quality assurance program would consist of providing the local manufacturing unit with

- a quality assurance department of one or more persons who make sure that the correct and comprehensive instructions are available at the inspector positions, and that inspection reports are being analyzed. When results are unsatisfactory, the local factory should have the means to determine the causes. Equipments should provide for inspection of incoming parts and components from outside suppliers and also for in-process and final test of the internally-produced items.

  If a continuing deviation from the imposed standards is observed, and the origin of the fault is determined, samples of the rejected parts should be sent for further analysis to laboratories.

When the rejected parts are caused by erroneous information, or when purchased parts do not conform to the test specification, the supplier should make the necessary analysis at his expense.

When a new factory is set up in a country at a considerable distance from the supplier, and when fast communication means between the two countries are lacking,

the above procedure will take time and may even lead to expensive material and time waste.

This may lead the local company to establish their own quality control facilities. Other reasons which contribute to this may be:

(1) Challenging and denying of the responsibility for certain characteristic deviations of the supplied materials.

(2) The desire to replace imported raw materials and components by locally available sources which necessitates local quality assurance measuring equipment to control the incoming materials on a continuing basis.

The establishment of a complete quality control test center utilizing the most modern and efficiently equipped metrology, climatology and technology labs will require an investment which surpasses the budget of a single manufacturing company.

The acquisition of the minimum "go / no go" equipment does not represent a major investment and is normally provided as a part of the proposed plant equipment.

In order to provide the necessary funds for more elaborate tests, the following possibilities may be possible:

(1) The establishment of a private test center with funds provided by several directly-interested local industries. The contribution could be equally divided or in proportion to the technical assistance supplied by the center.

(2) The establishment of a national test center, subsidized by the Government, to give assistance to local industries.

Instead of creating an independent test center, the national center could be installed as an additional section of an existing university. This solution has the additional advantage of promoting scientific research as well as the close cooperation between industry, education and government.

Several countries without sufficient resources to own their own national test center may combine their efforts to form an organization to raise the necessary funds for a common test center.

The UNIDO may find a new and grateful task in promoting the creation of national or supra-national test and research centers. This will contribute to the progress of local industry, to the greater development of local resources and to the expansion of the scientific research in developing countries.

This study would never have been realized without the intensive collaboration and assistance of numerous experts on the staff of Standard Telephon und Telegraphen AG as well as International Telephone and Telegraph Corporation.

Special thanks are due to

Mr. D.J.Marsh, Managing Director, ITT Laboratories of Spain,

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for his contribution on "In-plant training problems", and to

Mr. P.F. van Doorn, Assistant Manager Central Planning, Bell Telephone Manufacturing Co., Antwerp,

for the part on "Manufacturing problems",

all of whom have once again borne witness to the spirit of worldwide cooperation within ITT.

FORECAST ON TELEPHONE LINES' GROWTH IN BULGARIA

Bulgaria may serve as an example for the calculation of the probable development of the telephone density. Any such study must be based on detailed statistical data on the growth of population and telephones during the past. On the basis of the data available //47// the estimated development of both Bulgaria's population figure and the number of telephone lines in that country is shown in Fig.16.

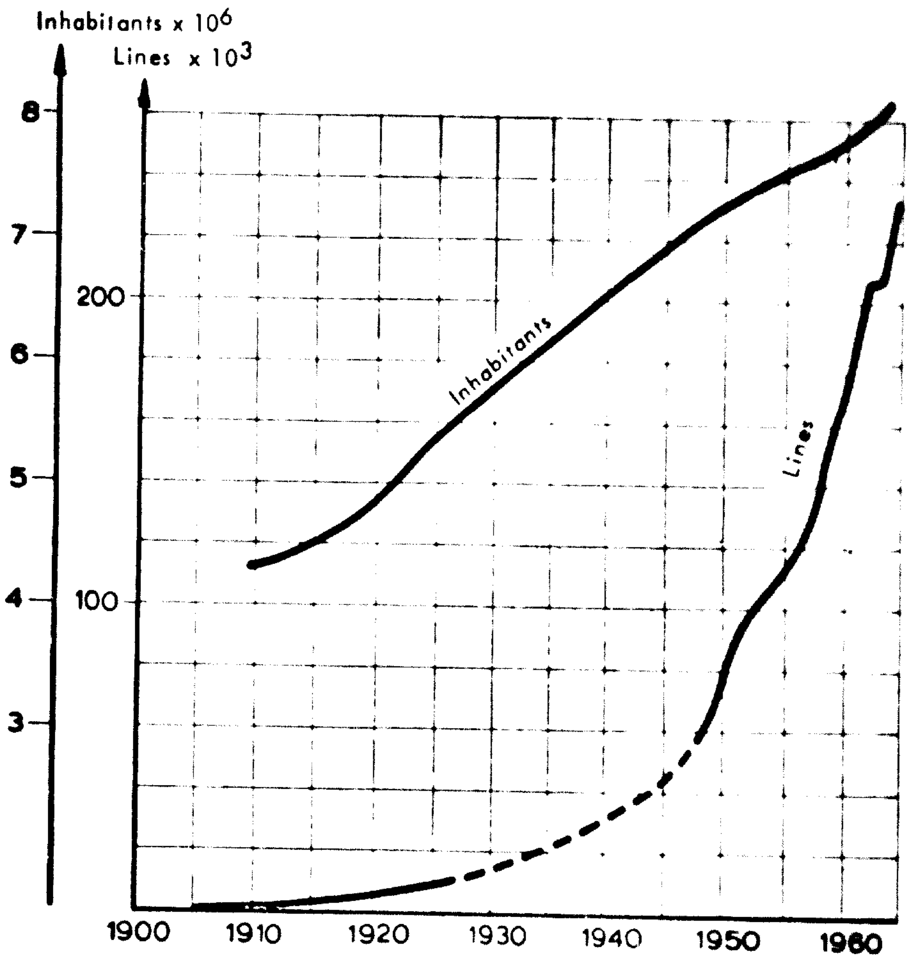
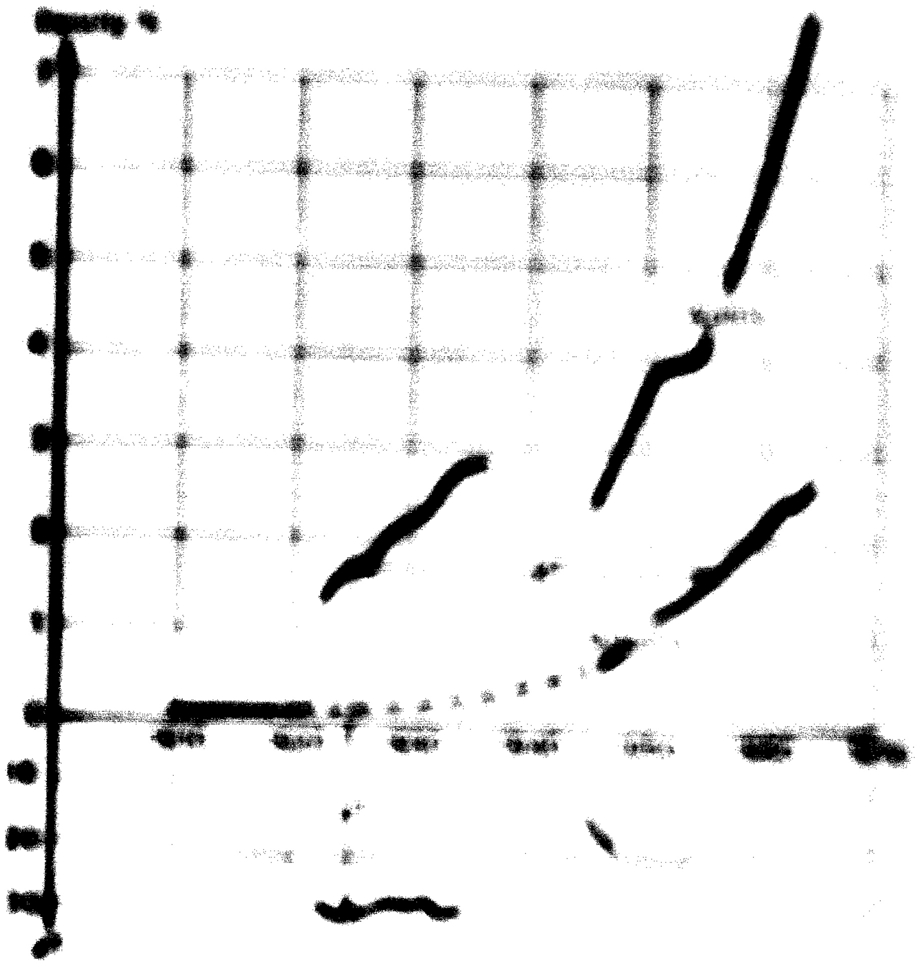
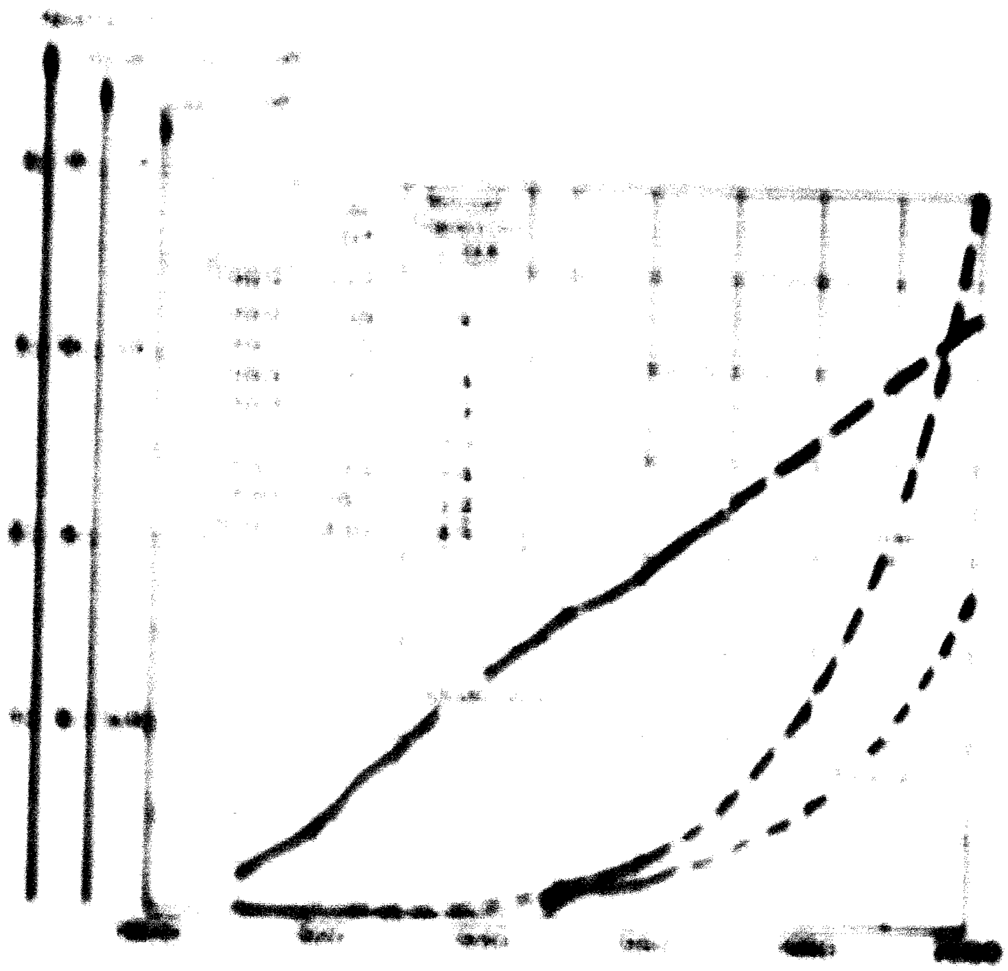


Fig.16: Growth of the Number of Telephone Lines in Bulgaria, 1905 - 1964 (acc. to Ebenberger, 1964)

By applying Bogaerts's theory, a time-lag can be calculated of roughly 22 years in comparison with Austria, as may be seen in Fig.17.





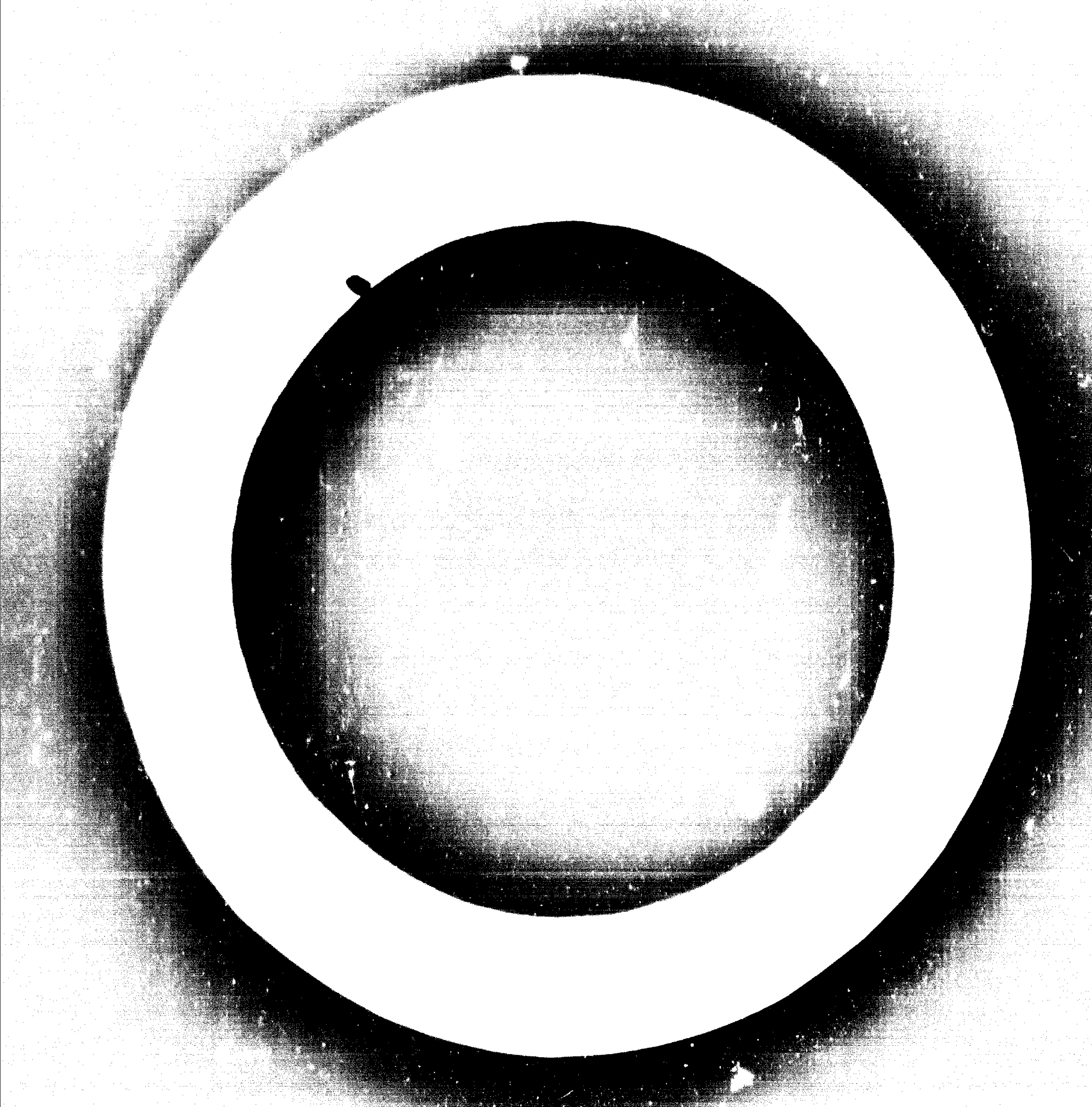
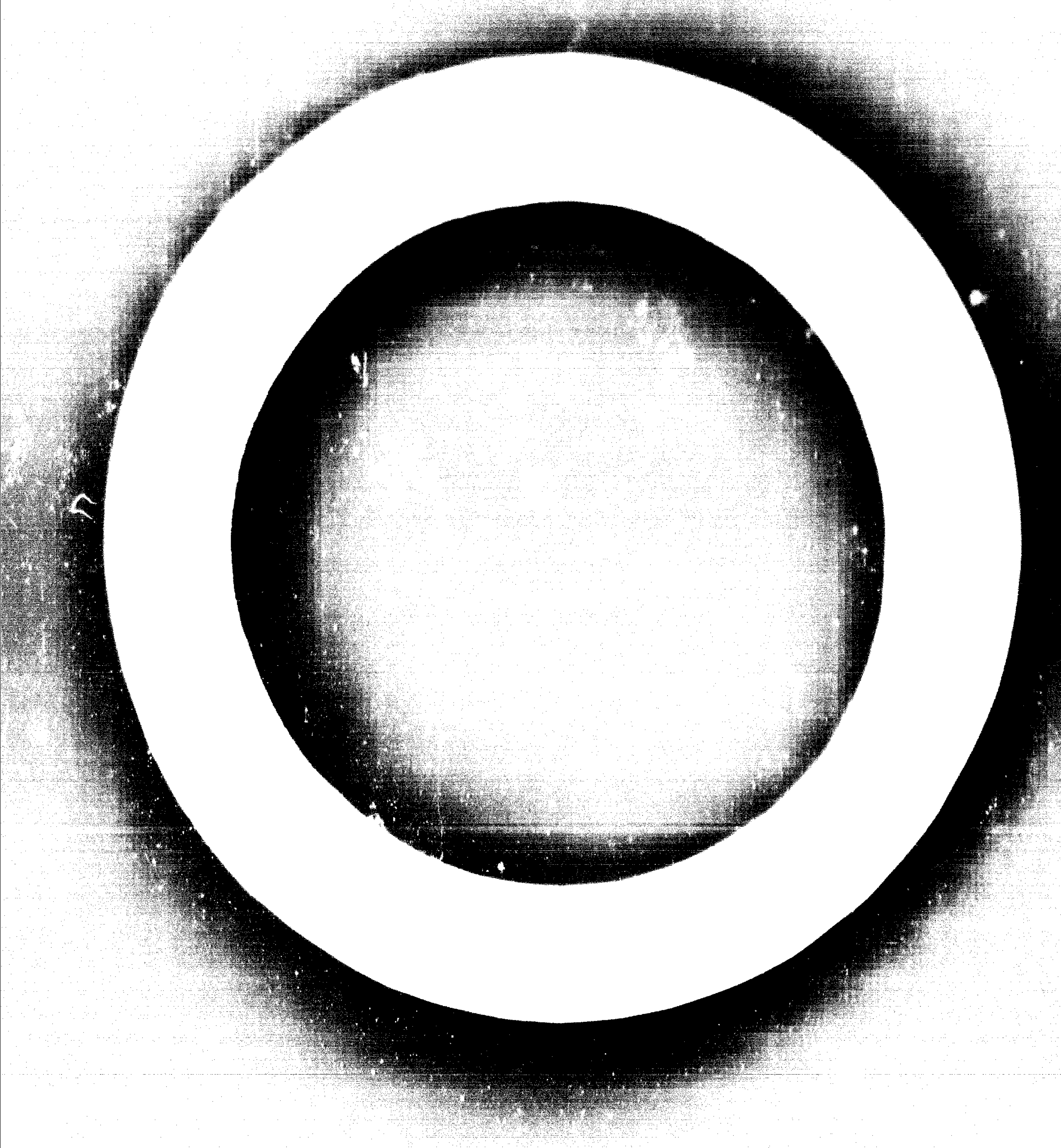


EXHIBIT 8

LIST OF COURSES

ITT Training Center

COURSE TITLE	COURSE LENGTH
1. Pentaconta Engineering	12 weeks
2. Maintenance	12 weeks
3. Installation	8 weeks
4. Computer Applications	1 week
5. Telecommunications Planning	4 weeks
6. General Telephony	8 weeks
7. Traffic Engineering	4 weeks
8. Probability, Statistics, and Traffic Theory	12 weeks
9. Engineering Management	1 week



PENTACONTA ENGINEERING COURSE

General Description

This course provides a detailed description of the Pentaconta 1000A and B1 Switching System. Some circuit tracing and descriptions are provided, but the course emphasizes the equipment engineering aspects of Pentaconta.

Objective

The objective of this course is to prepare an engineer to perform the basic job engineering of a Pentaconta exchange.

Intended For

The course is intended for university graduate engineers who have some familiarity with telephony and an elementary background in switching.

Subjects

Pentaconta - General Description
Pentaconta - Apparatus and Equipment
Signalling Principles
Circuit Descriptions
Wiring
Cabling
Installation
Maintenance Concepts
Probability and Statistics
Traffic Theory
Exchange Dimensioning

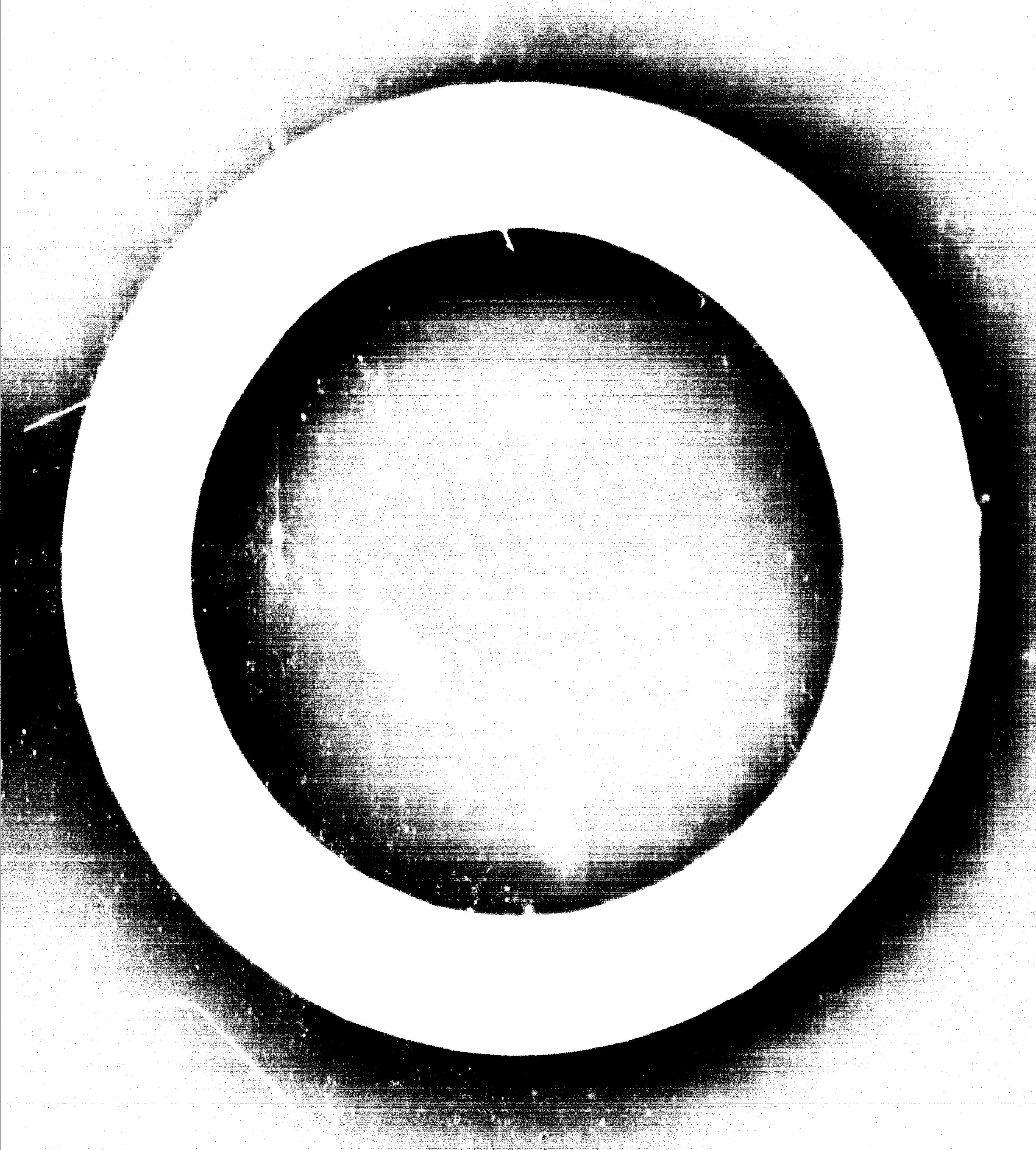


EXHIBIT D

STACKUP

Objectives

1. Develop an understanding of how the various relays are put together.
2. Develop the ability to stack B, T, BT, TR and X contacts at 100 % efficiency

Materials

All parts required to make B, T, BT, TR, and X contact springnests.
Copies of master stacking diagram.

Learning Activities

1. Begin by stating that up until now we have been talking about some of the operations preliminary to actually stacking the springnest, which is the heart of the relay
2. Explain that there are five basic kinds of contacts (B, T, TR, and X) and let the operators know that any relay is composed of one or more of these types
3. Show the operators how a contact is composed either of two or three springs in accordance with the five different types
4. Explain to the operators what a spring is and let them know there are different types in accordance with their structure
5. Explain to the operators that every spring is composed of two different parts the contact, which is the most important, and the terminal, which is at the opposite end
6. Show the operator how the contact parts could have contact points on just one or on both faces, and among these two types some of them will be different, depending upon the other end (terminal) Also, mention the very particular types such as the short springs used for TR contacts, and the very special ones for the X contacts.

7. Explain the difference when the springs have their contact points facing up or down in stacking, and point out how important it is to make the right combination.
8. Let the operators take a look and identify the various positions in accordance with the explanation.
9. Have them explain what a spring is and some of the important parts of the spring.
10. Explain to the operators how and why there is always an insulator between each spring.
11. Explain to them that the R contacts are composed of two springs. These two springs will always be L31 except in those cases in which a T procedes it.
12. Take the stacking diagram and explain how it is to be used in piling springnests.
13. Have the operator explain what makes up an R contact.
14. Show the operator how to stack up an R contact.
15. Have the operators stack R contacts using the skills they have acquired from practice on Location of Bins, Insulators and Work Preliminary to Stackup. After a while, time them.
16. Explain to the operators what a T contact is composed of mentioning both combinations L and J and the stacking diagram.
17. Show them how to stack up a T contact.
18. Have the operators stack T contacts. After a while, time them.
19. Make them stack R contacts again and then T contacts the same way.
20. Explain to the operators that the RT contacts are composed of three springs. Point out that here we start working with a spring that has contact points on both faces. Also, mention the two types of combinations and the use of the stacking diagram.
21. Show them how to stack up just one RT contact at a time.

22. Have them stack just one RT contact at a time, and then go back to stacking R and T contacts and RT contacts.
23. Have the operators stack up two RT contacts in accordance with the stacking diagram, then go on to three or more RT contacts.
24. Explain the composition of the TR contact, pointing out the three different springs to be used now, combinations L and J, and the stacking diagram.
25. Have the operators stack two TR contacts at the same time using the stacking diagram, then three and so on. Time them.
26. Explain and show to the operators how to stack up an X contact. Point out the unique combination: R32 - T31.
27. Explain to the operators how to mix all kinds of contacts in one pileup using the stacking diagram for the different combinations.
28. Have them make all kinds of combinations. Continue until 100 % efficiency is reached.

Evaluation

1. Operators are able to understand how the different combinations are put together in a pileup.
2. Operators have developed the ability to stack up any of these combinations with 100 % efficiency.

ad EXHIBIT D

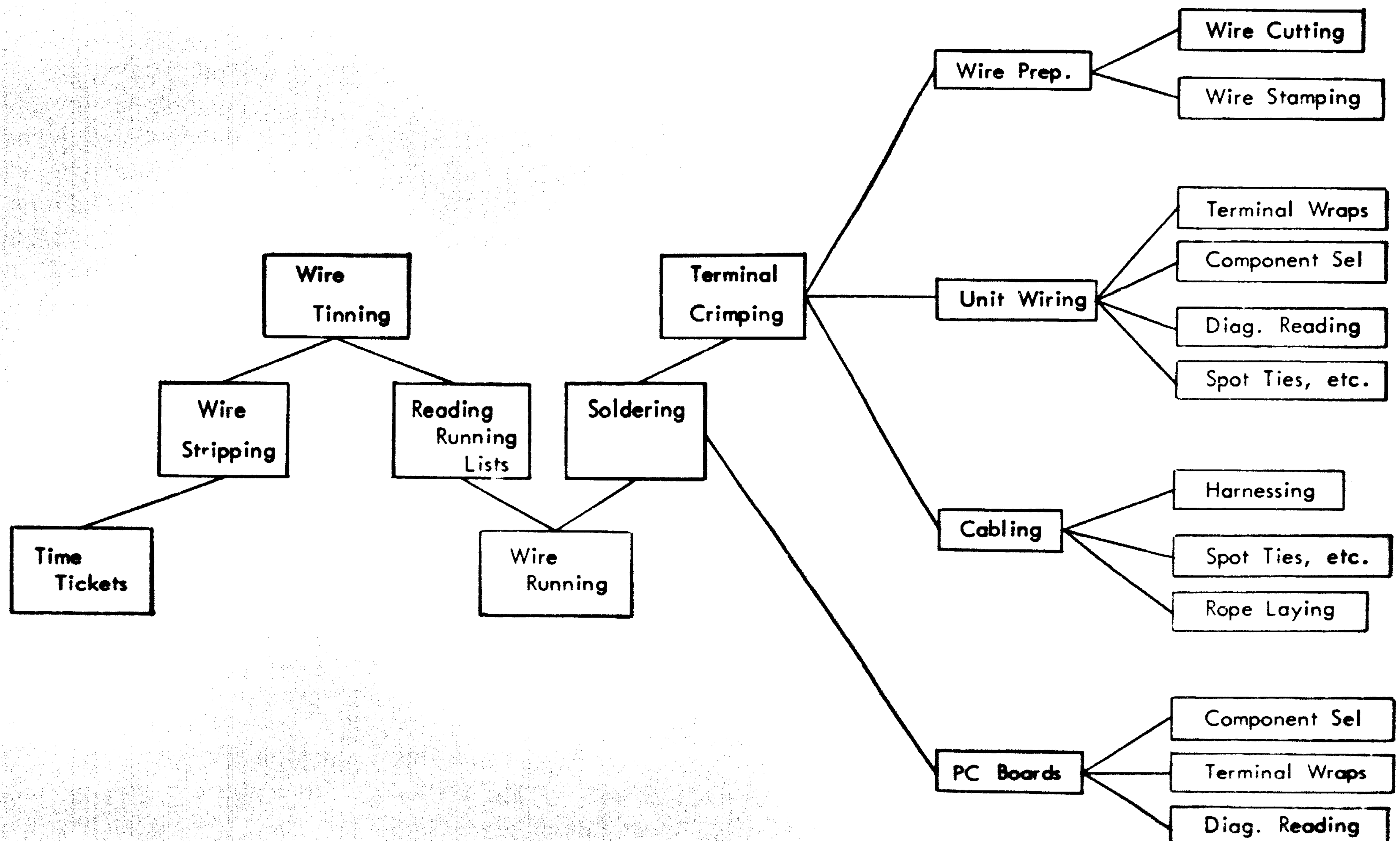
MASTER DIAGRAM FOR PENTACONTA RELAY STACKING

	L 31		J 31	
R				R
	L 31		J 31	
	L 32		J 32	
T				T
	L 32		J 32	
	L 32		J 32	
RT	L 30		J 30	RT
	L 31		J 31	
	J 16		L 16	
TR	P 31		M 31	TR
	L 34		J 34	
		T 31		
X				X
		R 32		

1. **START** STACKING IN LEFT HAND COLUMN
2. **WHEN** AN "R" FOLLOWS AND "R" OR A "T" **FOLLOWS STAY** IN THE SAME COLUMN OTHERWISE CHANGE **COLUMNS**

EXHIBIT E

MAJOR ELEMENTS - TRANSMISSION EQUIPMENT



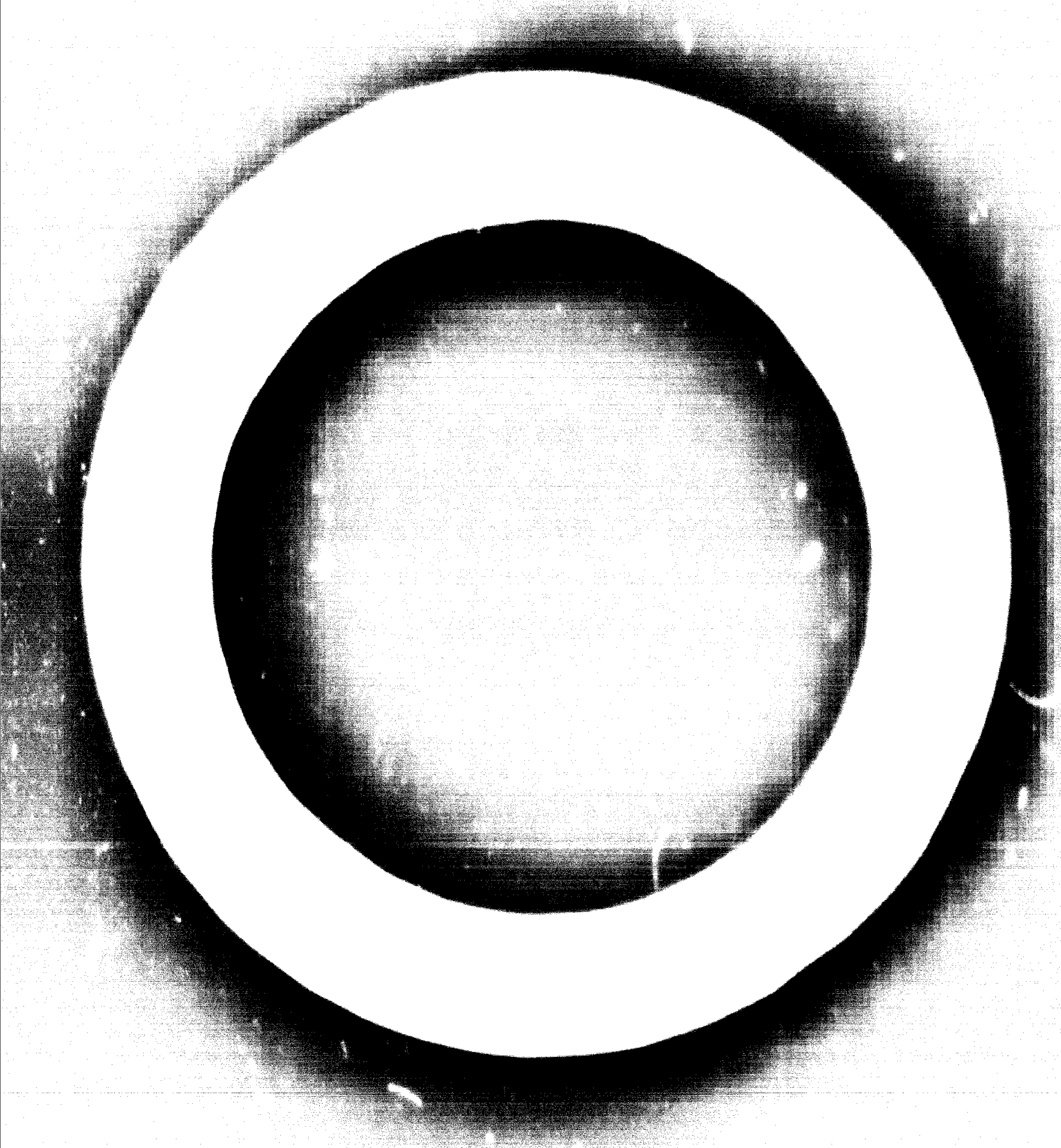


EXHIBIT F

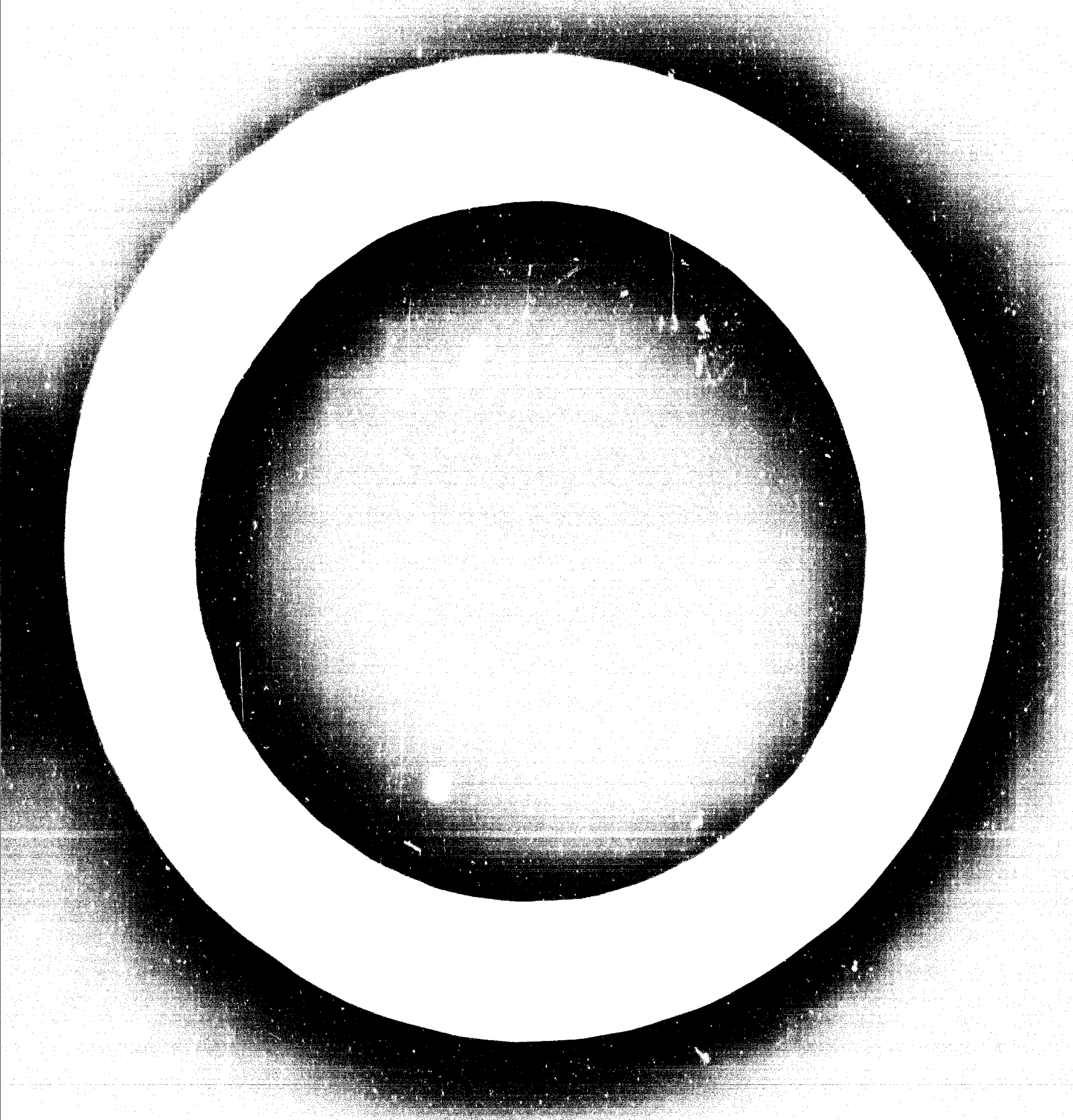
CABLE FORMING

First Week

Time	Monday	Tuesday	Wednesday	Thursday	Friday
7:30 to 9:30	Orientation	Color Code	Color Code Practice Runs	Lacing Practice	Cable Form Run
9:30 to 11:15	Orientation	Running Sheets	Running Sheet Practice	Running Sheet Practice	Cable Form Run
11:45 to 1:30	Color Code	Color Code	Running Sheet Drills	Lacing Practice	Lacing
1:30 to 3:30	Running Sheets	Running Sheets	Lacing	Lay-out Cable Form Boards	Cable Form Runs

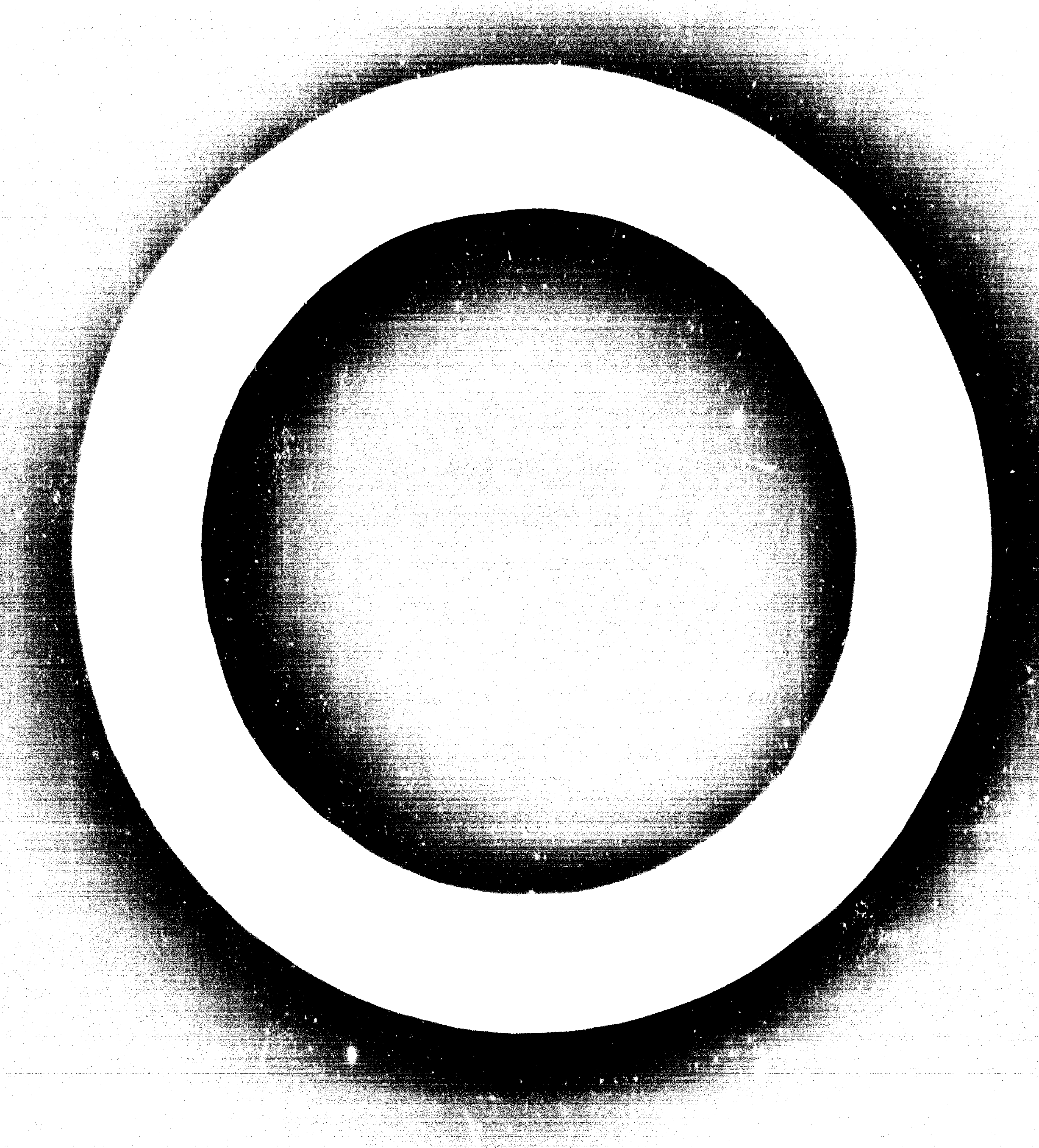
Second Week

Time	Monday	Tuesday	Wednesday	Thursday	Friday
7:30 to 9:30	Cable Form & Lacing Practice	•	•	•	•
9:30 to 11:15	•	•	•	•	•
11:45 to 1:30	•	•	•	•	•
1:30 to 3:30	•	•	•	•	•



EXAMPLE OF BASIC INFORMATION REQUIRED FROM THE CUSTOMER

- Type and specification of the equipment to be manufactured
- Volume and final capacity of the factory
- Start up period in years
- Base of capacity calculations:
  - Existing exchange or
  - theoretical exchange with traffic and interworking data and special facilities required
- Degree of local manufacturing integration
- Working time in hours per year
- Availibility of existing local facilities and services
- Program of change-over to new system
- Availibility of local components
- Government factory or supplier participation
- Long term financing or local financing
- Availibility of local tool manufacture
- Availibility of skilled labor
- Local efficiency and local wages
- Type and schedule of first exchanges to be manufactured
- Services to be provided in factory
- Climatic conditions
- Information on local currency
- Plant location and transport facilities
- Tax holiday and other concessions granted by the Government



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