The L. M. Ericsson Review

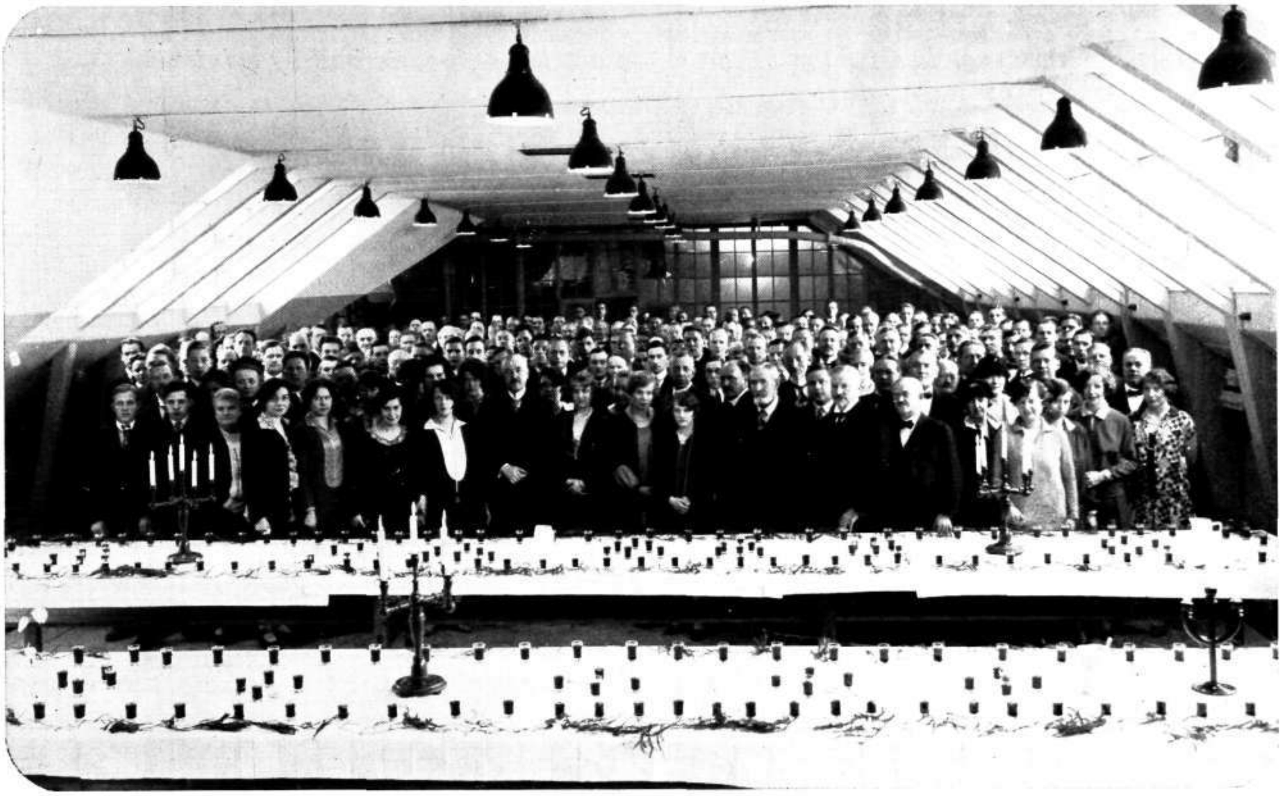
VOLUME 5

1928

KURT LINDBERG
BOKTRYCKERIAKTIEBOLAG
STOCKHOLM 1928

The L. M. Ericsson Review

VOL. V | JANUARY—MARCH 1928 | Nos. 1 to 3



STAFF, DEPARTMENT HEADS AND OFFICE FORCE OF TELEFONAKTIEBOLAGET L. M. ERICSSON IN STOCKHOLM AT AN INFORMAL GATHERING ON NEW YEAR'S EVE IN ONE OF THE FACTORY DEPARTMENTS.

ENGLISH EDITION

L. M. Ericsson

THE L. M. ERICSSON REVIEW
ENGLISH EDITION.
JOURNAL OF
TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM.
Responsible publisher: HEMMING JOHANSSON
Editor: WOLDEMAR BRUMMER.
Issued quarterly. Yearly subscription rate: 7/ –
All communications and subscriptions to be forwarded to the Editor.

Look forward!

The past year has for the Ericsson concern been characterized by substantial gains within all fields of operation. Orders received and deliveries executed by the manufacturing and sales organizations as well as the number of subscribers of the operating companies have shown a powerful increase. The greatly increased amount of work has required the straining of every nerve. I can state with the utmost satisfaction that every member of our organization has to the best of his ability been instrumental in the achievement of this excellent result. There is reason to believe that our gains during the coming year will be still greater.

I want to express my appreciation of the work that has been accomplished and at the same time extend my best wishes for

A HAPPY NEW YEAR

to every member of this organization.

Stockholm, January 1st 1928.

R 660

ANDERS LIGNELL,
Superintendent of Telephones,
Stockholm

Member of the International Consultative Committee for Long Distance Telephone Communications

Suburban Telephone Traffic in a Large City.

By A. Lignell, Superintendent of Telephones, Stockholm.

In foreign countries, a certain fee is almost always charged for telephone calls between the larger cities and their immediate suroundings, i. e. such calls are subject to a special tariff rate and are consequently not included in the regular subscription rate for local telephone service.

Another method is to extend the zone for the purely local traffic to include the outlying districts as well, calls within this zone being handled in exactly the same manner as city calls and being metered together with these latter. With regard to the traffic, this is possible only if a sufficient number of lines for suburban traffic are available, these lines necessarily being of sufficient number to prevent an excessive busy percentage during the busy hour. Otherwise, the advantages of a direct traffic are lost and the local service will be weighted down with ineffectual work.

It is now quite a number of years since Stockholm established direct service within a so-called 'free service zone' without any extra charge for rural or suburban calls — the suburban exchange was opened for traffic in 1923 —, consequently a more detailed description of how this traffic is handled and of the importance of this type of service to the telephone administration as well as to the subscribers may be of interest.

Stockholm's free service zone comprises at present 158 exchanges outside of the city limits with a total of 27,626 subscribers, plus 115,176 subscribers within the city.

The map on page 6 shows the extent of the area included in this zone.

The number of subscribers at the various exchanges varies from 2500 down to about 50, most of these exchanges being provided with direct city lines.

For some thirty of the smaller and most distant exchanges the traffic is transited over some other exchange with a direct city line. In such cases the transit exchange is provided with a sufficient number of direct lines to permit the effectuation of city calls without delay.

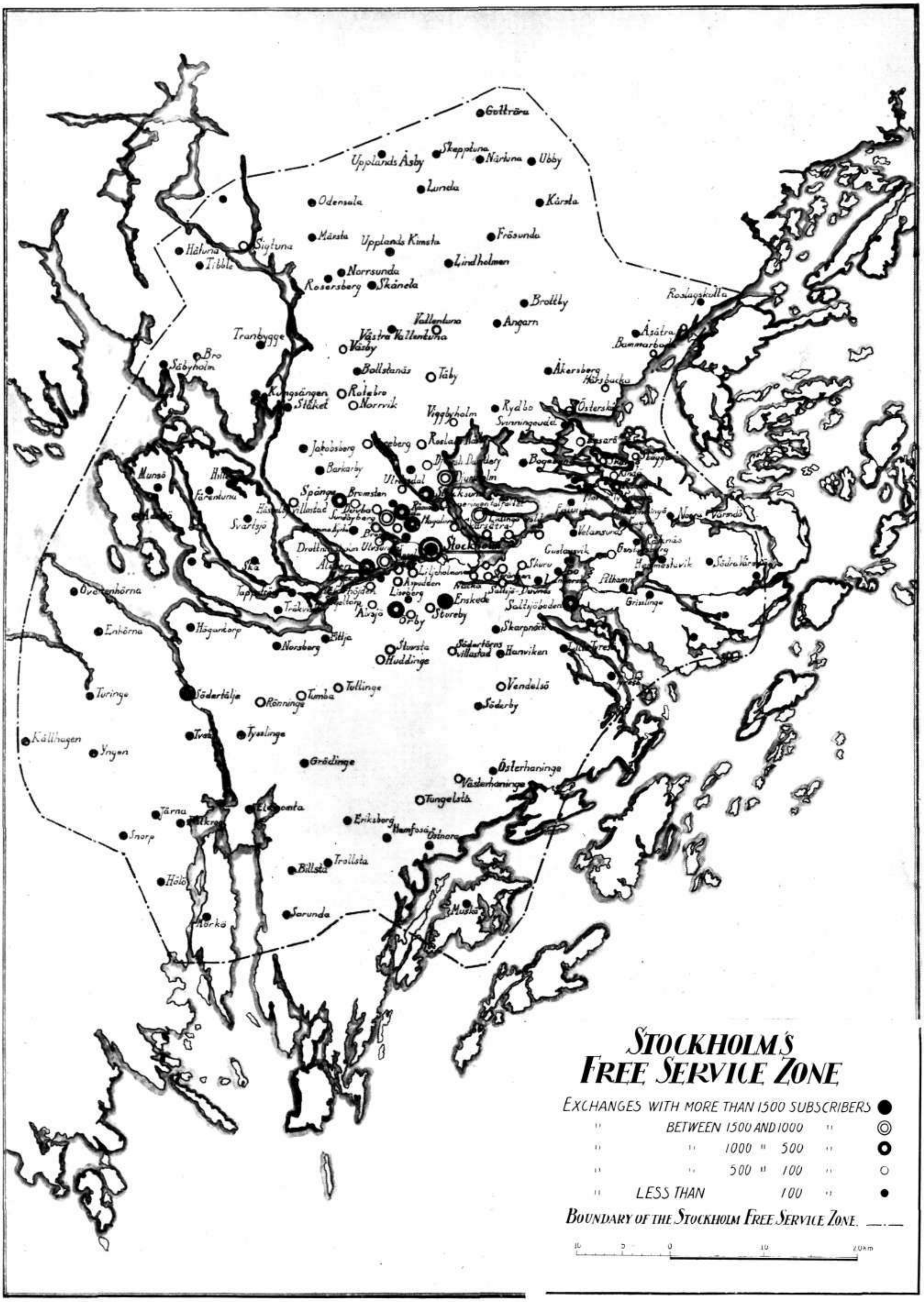
The total number of direct city lines is now 2172, 1139 of these being reserved for outgoing traffic from Stockholm and 1033 for traffic to Stockholm.

The suburban traffic is handled in Stockholm by a specially arranged *suburban traffic exchange* which comprises two main divisions — one for incoming and one for outgoing calls — as well as reference boards for toll traffic with the suburban net, junction boards for junction traffic between exchanges within the free service zone whose calls in some cases must pass over Stockholm, arrangements for carrying the outgoing traffic over the call order service division during temporary reductions in the number of lines on account of trouble, and a supervision room.

Wherever the requirements of the traffic call for direct lines of communication between the suburban exchanges such lines have been provided, thereby avoiding as much as possible the routing of the traffic over Stockholm.

Outgoing traffic.

The outgoing traffic from Stockholm is handled over a 7-panelled B-board at the suburban traffic exchange. The multiple is built up of 20-line lamp and jack strips, the lamp strip lying above and being se-


STOCKHOLM'S FREE SERVICE ZONE
EXCHANGES WITH MORE THAN 1500 SUBSCRIBERS
" BETWEEN 1500 AND 1000 "
" " 1000 " 500 "
" " 500 " 100 "
" LESS THAN 100 "
BOUNDARY OF THE STOCKHOLM FREE SERVICE ZONE
Stockholm
Södertälje
Sigtuna
Upplands Väsby
Lidingö
Saltsjöbaden
Huddinge
Enskede
Österhaninge
Västerhaninge
Vallentuna
Täby
Gottröra
Kärsta
Ubby
Lunda
Odensala
Märsta
Norrsunda
Rosersberg
Skånela
Brottby
Angarn
Roslagskulla
Åkersberga
Vaxholm
Tungelsta
Tumba
Tullinge
Rönninge
Grödinge
Järna
Hölö
Mörkö
Sorunda
Trollsta
Enhörna
Turinge
Källhagen
Ytterjärna
Munsö
Färentuna
Svartsjö
Kungsängen
Jakobsberg
Barkarby
Spånga
Bromsten
Hägersten
Liljeholmen
Årsta
Örby
Storeby
Skarpnäck
Hanviken
Vendelsö
Söderby
Stuvsta
Norsberg
Högantorp
Tyresö
Gustavsberg
Grisslinge
Säbyholm
Bro
Tranbygge
Viggbyholm
Rydbo
Östersund
Djursholm
Danderyd
Vällingby
Västerkänerna
Eriksberg
Ösmo
Billsta

parated from the jack strip by means of a designation strip. The lamps in the multiple serve both as calling and clearing lamps. On a line with the designation strips are located the test buttons, the buttons used for testing an adjoining group of five lines always belonging to the same exchange. In order to test the lines, the operator depresses the test button, a disengaged line being indicated by the glowing of the lamp above the jack of this line. If a line is engaged, the corresponding lamp remains dark.

On making a call, a city subscriber gives the name of the desired suburban exchange after which the A-operator gets a disengaged operator at the suburban traffic exchange by means of an order wire provided with a selector, this last operator establishing the connection over an idle suburban line by means of the trunk multiple, after previously having tested the lines. On receiving an answer from the suburban exchange, the calling subscriber himself requests the desired number.

A clearing signal is obtained on the test lamp over the line jack in the multiple as well as on the lamp of the trunk cord. The glowing of the lamp in the multiple contributes towards a speedy disconnection at the end of the conversation, a very important factor for the effective utilization of the suburban lines. Besides, loss of time through slow disconnections would result in an increased busy percentage and this, in turn, would unfavourably influence the service at the local exchanges.

The extent of the outgoing traffic from Stockholm is given in the following table:

1927	Number of calls during whole day (including toll calls)	Average number of suburban calls during week day: 8 to 21 o'clock	Average number of suburban calls during week day: and per operator-hour, 8 to 21 o'clock	Number outgoing suburban lines	Average calls per suburban line including toll calls, 8 to 21 o'clock	
January	2,116,603	69,852	332	1109	66	
February ...	1,963,358	68,483	330	1112	65	
March	2,215,428	70,237	343	1117	67	
April	2,266,889	75,981	347	1122	71	
May	2,465,304	79,691	341	1126	74	
June	2,546,489	87,077	333	1121	82	Summer season
July	2,546,657	82,158	318	1129	77	
August	2,691,663	84,931	330	1135	79	
September...	2,533,586	83,001	330	1134	77	
October......	2,367,254	72,540	327	1134	70	
November...	2,235,906	70,403	333	1134	68	
December...	2,350,202	72,417	338	1139	69	
Total	28,289,339					
Average		76,398	333	1126	72	

As will be seen, the number of calls from Stockholm to the 158 exchanges within the free service zone amount to over 2 million per month with an average of 76,398 calls per week day between 8 and 21 o'clock. During the same hours, the average number of calls per operator hour is 333. Seventy-two calls per line — including toll calls — took place between 8 and 21 o'clock over the mean number of suburban lines (1126) available during the year. This figure must be judged with due consideration for the fact that a large number of the suburban exchanges have so-called season traffic. Over line groups to exchanges with a constant yearly traffic load, the average number of week day calls during the same hours is considerably greater, amounting to between 130 and 140. The busy percentage of the suburban lines has varied between 1 and 1.9 % during different parts of the year. The salary cost per outgoing suburban call has amounted to .004 Swed. crowns, or about the same as for local calls handled over B-positions. Thus, one may say that the service cost in Stockholm for an outgoing suburban call (during the entire day) is the same as for a purely local junction call to any other city exchange. The increase in cost over a local call is for the work which takes place at the suburban exchange for completing the connection.

The distribution of the outgoing traffic over the hours between 8 and 21 o'clock and the adjustment of the number of operators to the traffic curve is indicated in the graph on page 8, in which the required number of operators is based on 330 connections per operator hour, this figure being easily exceeded during the busy hours between 10 and 13 o'clock, however, without inconveniencing the service. The average value for the curve is 334 connections per operator hour, the total number of operators required for handling the traffic between 8 and 21 o'clock amounting to thirty-three, with a maximum of nineteen occupied positions. That the personel curve lies over the traffic curve during lighter traffic is due to the fact that one must have good selecting possibilities from the different local exchanges.

The service is supervised by keeping continuous records of the answering and disconnecting times at the suburban traffic exchange as well as at the suburban exchanges. The answering times on the order lines from the local exchanges to the suburban traffic exchange have an approximate length of one second, 1.5 % of the waiting times exceeding five seconds. The disconnecting times at the suburban traffic exchange amount to about 1.5 seconds, none of them overrun-

OUTGOING SUBURBAN TRAFFIC

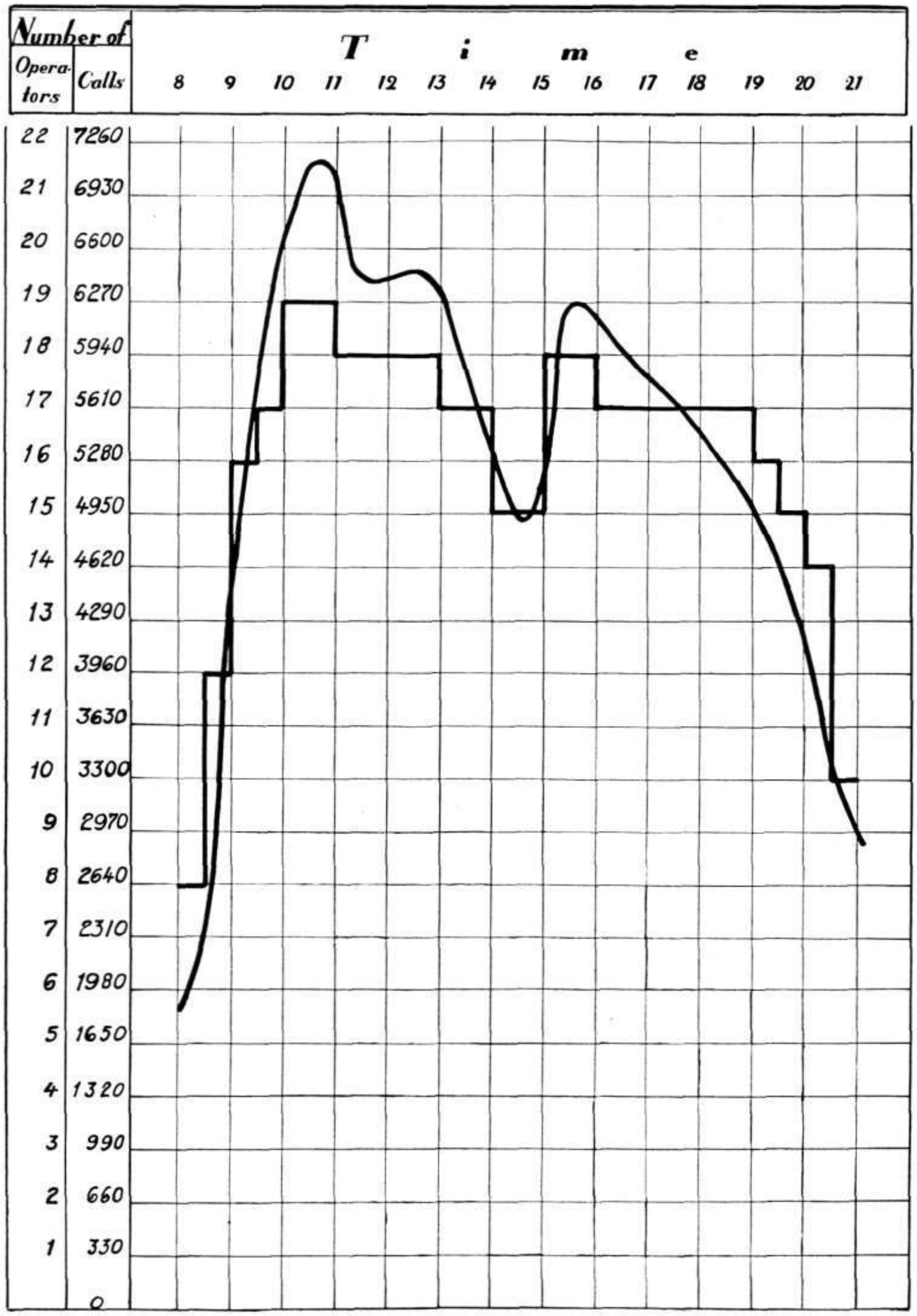
STOCKHOLM

8 TO 21 O'CLOCK (AVERAGE 6 WEEK DAYS)

TRAFFIC CURVE

SERVICE CURVE (number of operators)

based on 330 connections per operator hour.



ning ten seconds. The answering times at the suburban exchanges during 1927 were as follows:

Number of answering times under supervision	18,303	
Average disconnecting time	8.3	seconds
» answering time	4.3	»
Percentage of answering times exceeding ten seconds	8.9	

Incoming Traffic.

The traffic coming in to Stockholm from the exchanges within the free service zone is handled over sections, each section comprising nine operators' positions. Each section accomodates 160 incoming lines, the answering jacks (with the calling lamps over each jack) for each line being multiplied so as to be within the reach of all nine operators in the same section. The calling lamps are of different colours, red, green or white, these colours being distributed over the multiple in such a manner that the lamps within the reach of each operator are to an equal number red, green or white. The answering lamp of a line which is red in the three first positions, is green in the next three positions and white in the last three. When answering a call, the operator takes a red lamp as first choice, a green lamp as second and a white lamp as third. Before plugging in to answer a call with a green or white lamp (auxiliary lamps), the operator should glance up to ascertain that no other operator is just about to answer the same call.

This arrangement has resulted in exceptionally good answering times, and there have been no difficulties in getting this type of auxiliary service to function properly. During 1927 the average answering time was 4 seconds, with 7.2 % of the answering times exceeding 10 seconds; the average disconnecting time was 5.5 seconds with 15.6 % exceeding 10 seconds.

A suburban call to Stockholm is handled in the following manner.

The suburban subscriber asks for Stockholm, the number of lines usually being so large that no waiting is required. The operator connects the subscriber to a disengaged Stockholm line (at the larger suburban exchanges these lines are provided with visual testing) and gives a calling signal. Any of the nine operators at the section in which this line terminates in Stockholm can answer the call. The answering operator gives the number of her position, for instance 32. The subscriber requests the desired Stockholm number and the operator at the suburban traffic exchange gets in touch with the B-operator at the corresponding local exchange over an order wire with selector. The connection is then effectuated over the trunk multiple.

A double clearing signal is received at the suburban traffic exchange on the lamps of both the answering and calling cords, the operator breaking the connection after both lamps have registered the clearing signal. When only a single clearing signal is received, the operator cuts in on the connection before breaking the same.

The pulling down of the calling cord results in the giving of a clearing signal in the B-position at the desired exchange.

The figures in the following table give an idea of the extent of this traffic.

Incoming Suburban Traffic 1927.

1927	Number of calls during entire day	Average calls per week day 8 to 21 o'clock	Average calls per week day and operator-hour 8 to 21 o'clock	Number of incoming lines	Average calls per incoming line, 8 to 21 o'clock	
January	2,163,498	74,695	124	995	75	
February	2,032,544	74,614	119	997	75	
March	2,248,371	75,305	126	1000	75	
April	2,245,071	78,818	127	1008	78	
May	2,421,308	80,987	124	1012	80	
June	2,583,417	91,894	125	1018	90	Summer season
July	2,593,963	87,535	121	1021	85	Summer season
August	2,733,638	90,580	125	1022	88	Summer season
September	2,500,323	84,861	121	1028	83	Summer season
October	2,303,432	76,776	123	1028	75	
November	2,189,286	74,938	123	1028	73	
December	2,295,892	77,048	126	1033	75	
Total	28,310,743					
Average		80,671	124	1016	79	

As indicated above, there was an average of 80,671 calls per week day between 8 and 21 o'clock, the average number of effectuated connections per operator-hour during the year amounting to 124. In judging these figures one must not forget that all of these calls are trunked.

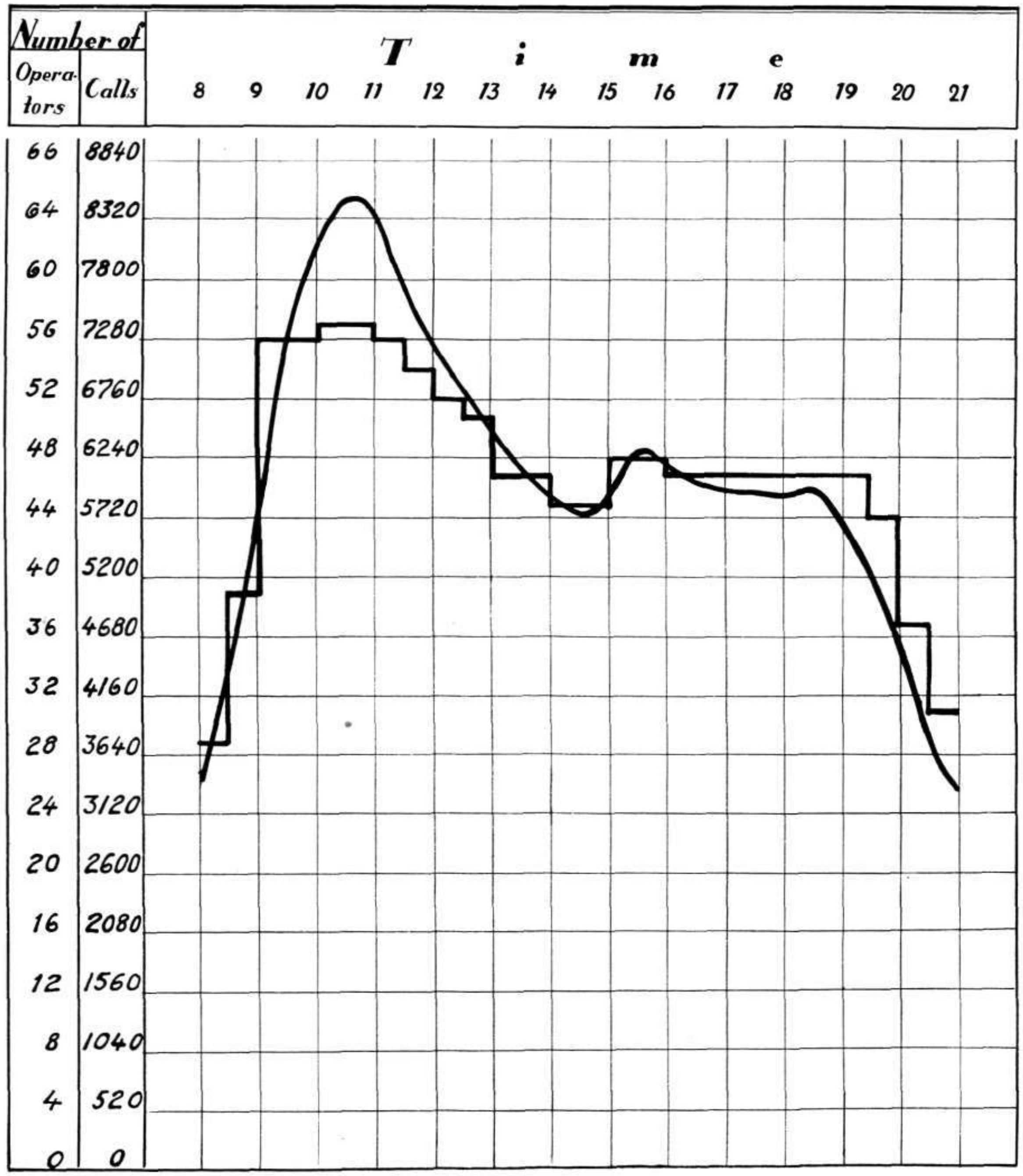
The average number of calls per incoming line between 8 and 21 o'clock amounted to 79, which can be regarded as an exceptionally good utilization of the lines, especially as a considerable number of the suburban exchanges have season traffic, as previously mentioned. The distribution of the traffic over the different hours of the day as well as the adjustment of the number of operators to the traffic curve is shown in the graph on page 10.

INCOMING SUBURBAN TRAFFIC

STOCKHOLM

8 TO 21 O'CLOCK (AVERAGE 6 WEEK DAYS)

TRAFFIC CURVE
SERVICE CURVE (number of operators)
based on 130 connections per operator hour.



Comparison between call order service and direct service.

Let us now regard this traffic as subject to a special tariff rate, the calls being effectuated in turn after the placing of an order and the service being placed under supervision the same as for toll service. In the first place, a much larger number of positions and operators would be required, as well as increased exchange space. Besides, the subscribers would lose the advantages provided by the direct service since the calls would be subject to waiting times, not to mention the added nuisance of the ordering process.

It may be of interest to make a rough estimate of the requirements for a traffic amounting to 76,400 outgoing calls — the average week day traffic between 8 and 21 o'clock — with call order service as compared with direct service.

First, we must determine the number of operators required to handle the traffic, not forgetting to take into consideration that we must do without the possibility — afforded by the use of B-positions — of easily adapting the number of operators to the varying traffic loads, this being due to the necessity of distributing the lines over a large number of positions between which there is a minimum of coöperation, since the suburban lines are restricted to certain positions.

With call order service — in which the order for the call must first be received and noted down (either at an order service section or by the respective operators), then dispatched in turn, the subscriber connected over a B-position when his turn has arrived, the length of the conversation registered and noted down — an operator who also receives the call orders can dispatch from thirty to thirty-five calls per single hour.

The variation in the traffic loads during the various hours of the day and over different traffic routes does not permit the distribution of the lines in such a manner as to make it possible to maintain this number of calls as a daily average, however. There is no doubt but that an average of twenty-five calls per hour and operator is a liberal figure.

For the 76,400 calls this would require 3056 operator hours or — with 6.5 effective working hours per operator and day — a total of 470 operators. With 7150 calls during the busy hour (see on graph page 8) and figuring on 30 calls per operator during this hour, this would mean that not less than 238 operators would have to be on duty at the same time, requiring a minimum of 238 positions.

From the table on page 7 we find that with direct service the average number of calls per line is 72. With advance order service, the lines might *possibly* — the waiting times on these short distances during periods of intense traffic must not be too long — accomodate 80 calls, which would mean that with call order service the number of lines could be reduced to 1012, a reduction of 127 lines.

Consequently, a comparison gives the following figures for 76,400 calls:

	Direct Service	Advance order Service	Difference	
			to the detriment of call order service	in favour of call order service
Calls per operator hour	330	25	305	
Number of operators ...	33	470	437	
Maximum occupied positions	19	238	219	
Number of connections over B-positions at local exchanges	—	76.400	76.400	
Number of lines	1.139	1.012	—	127
Exchange space required			Abt. 15 times more space	

And just what do these differences signify in yearly expenses? The 437 operators required for handling the call order traffic — naturally on condition that the orders are received and registered by the regular operators on duty, and not by a special order service section — in excess of those required for direct traffic must be better qualified than the B-operators for the simple direct service and consequently receive better salaries. However, if we disregard this difference in salaries and assume the yearly cost per operator (salary, vacation and other remunerations) to be 2200 Swedish crowns — a low figure according to Swedish standards — the increased cost for the call order service would amount to .... 961,400 crowns

The difference in the number of operators' positions — 219 — gives an increased first cost of abt. 800,000 crowns. 10 % for interest and amortization, plus maintenance, gives a yearly cost of abt. .... 135,700 »

The connections over B-positions at the local exchanges at .004 cr. for a yearly traffic of 22,900,000 calls .... 91,600 »

Fifteen times more space than for direct service (rentals, heat, cleaning, light, etc.) abt.	50,000 crowns
Total	1,238,700 crowns

Thus we arrive at an increased cost of approximately 1.24 million crowns for call order service as compared with direct service. In addition to this, however, we have the cost of sorting and filing the call order tickets, making out of bills, collection of fees, etc., all of which amounts to considerable sums. We do not think it necessary, however, to go any further into these details in this connection.

Against this enormous increase for call order service stands only the cost of the 127 lines with which the suburban net for call order service might *possibly* be reduced. At the present prices for telephone cable and maintenance, the corresponding reduction in the yearly cost will be comparatively insignificant and can be estimated at 40,000 crowns at the most.

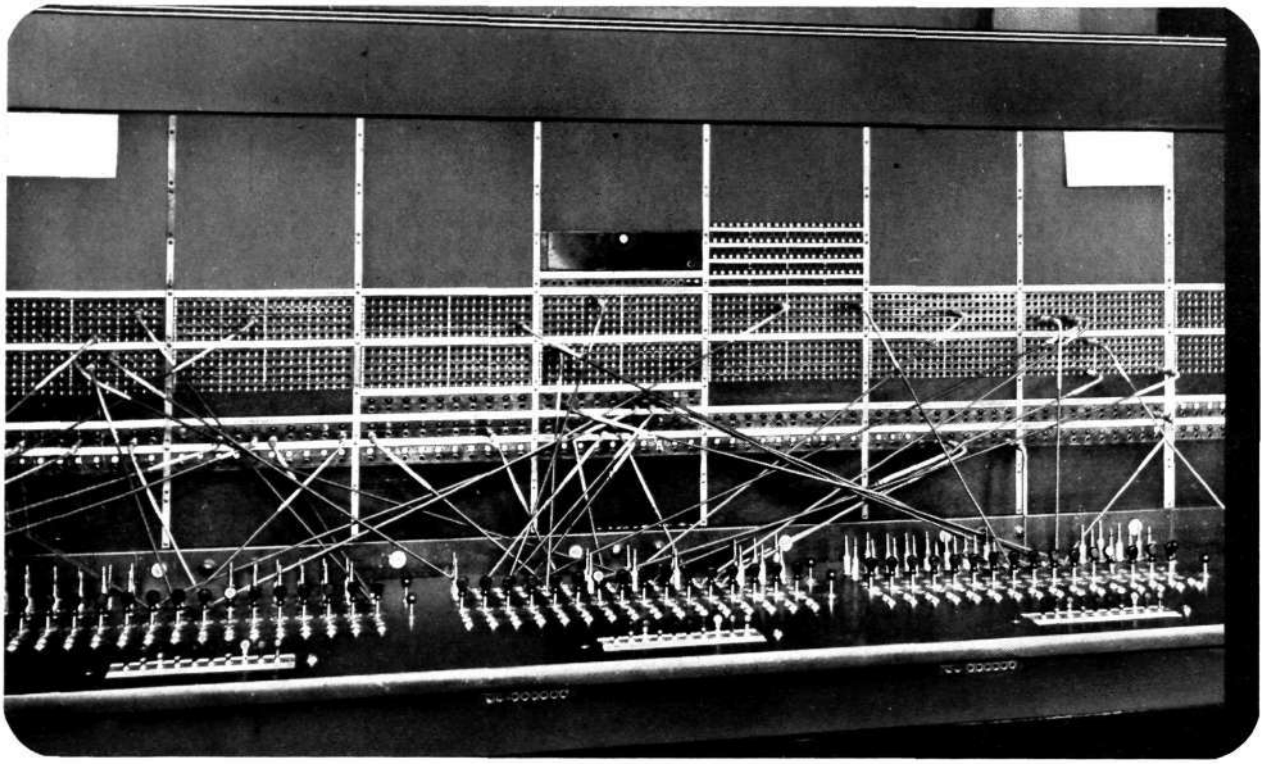
Compensation for direct service.

In what manner shall a reasonable compensation for the service be levied? In order to make this question more clear we will investigate its aspects with regard to call order service.

According to our experience, the cost for such short distance calls with call order service is so great that the tariff rate which could reasonably be imposed would not compensate it, the sole reason for this high cost being the large sums required for salaries. These conclusions are confirmed in a most interesting article in the May 1927 number of *Archiv für Post und Telegraphie*, entitled *Die neue Fernsprechordnung*, in which are given the costs for toll calls over various distances in Germany. The article shows that for distances under 5 kms., between 5 and 15 kms. and between 15 and 25 kms., the toll service occasions the administration a direct loss.

For distances under 5 kms., the cost of a call — not including a reasonable profit and other charges — is given as 32 pfennig, 25 of which went to salaries. The tariff rate was only 15 pfennig.

For distances between 5 and 15 kms. the corresponding costs were 37 pf. and the rate 30 pf. For distances between 15 and 25 kms. the cost is 42 pf. and the rate 45 pf., thus giving a surplus of 3 pf., which becomes a deficit of 6 pf., however, if the



R 857 Seven-Panelled Switchboard for Incoming Suburban Traffic. (The upper part of the multiple contains junction lines to the various local exchanges.)

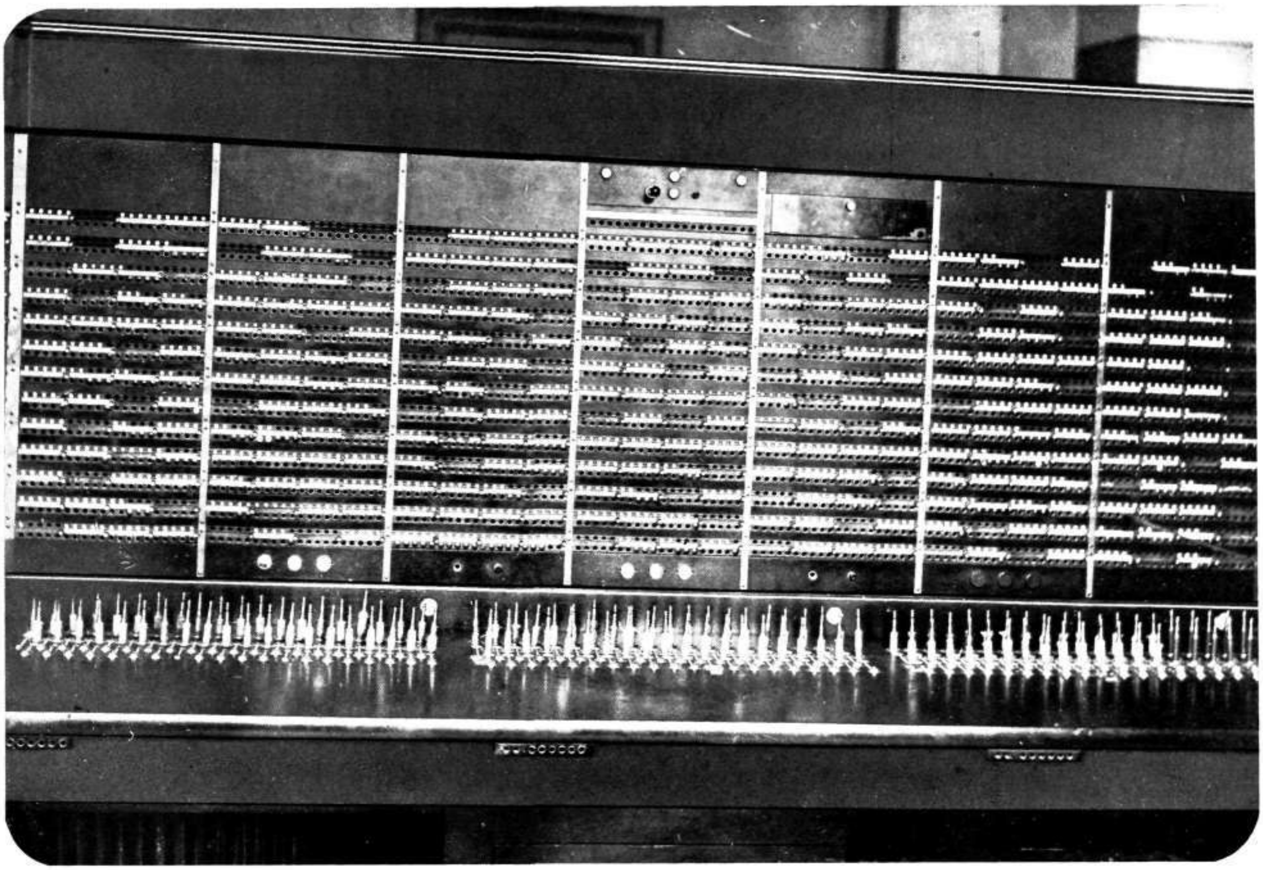
reasonable profit and other charges are taken into consideration. Since the rate is figured per 3-minute period while the costs are figured per call, the actual loss decreases in the same proportion as a call is extended beyond the 3-minute period, but the total loss on this category of calls within Germany is stated to be about 22 million reichsmarks.

With the above described direct service, the net cost for an outgoing suburban call has been reduced to the cost for a junction call to another city exchange, plus the cost of completing the connection at the suburban exchange, this latter being extremely low. The cost of the service which lies within the city net should be included in the local subscription rate. The problem, therefore, is to cover the expenses for service at the suburban exchange and the cost of the lines themselves in a simple and effective manner.

For an incoming suburban call from the free service zone, the cost of service within the city is the same as for a local junction call, to which must be added the cost of service at the suburban exchange plus the cost of the suburban lines.

Since the total costs for suburban calls, including the cost of the lines, would be amply covered if these calls were metered twice instead of once on the local subscribers' meters, this would be a simple method of solving the tariff question provided the technical arrangements required for such a change in the metering of the calls would not prove too expensive. In Sweden, this problem has been solved by raising the yearly subscription rate for service within the larger free service zones, not only for the local city subscribers but also for the suburban subscribers.

The object of this article has been to show in a general way how unsuitable call order service is for traffic over short distances, with low cost of lines and high overhead. The call order service is accompanied by a much greater amount of work, the only result of which is a greatly increased cost for which no special advantages are obtained. The service is handled in a roundabout way, which not only is an expensive proposition in itself but also burdens the traffic with waiting times and the subscribers with increased inconvenience, besides which the rates for such short



R 858 Multiple of Seven-Panelled B-board for Outgoing Suburban Traffic.

distance calls — requiring special registration — cannot be set high enough to give a reasonable profit. Furthermore, the entire system puts a restraint on the development of the traffic. With the introduction of automatic switching, further measures for reducing the personel required for handling the outgoing as well as the incoming traffic can be devised.

The suitable size of the free service zone must in each special case be determined with due consideration for existing local conditions. The large size of the Stockholm zone is due solely to the intense competition which existed here during the first development of telephone communications in Sweden.

R 735

Call Order Service at the Stockholm Toll Exchange.

By Chief Inspector M. Agrell.

Unlike a number of other large toll exchanges, the Stockholm exchange is not provided with a central order section to which the various call orders placed by the subscribers are directed for subsequent distribution to the different toll positions. Instead the toll call orders are received direct from the subscriber by the toll operator who will effectuate the connection.

This method of handling the service has been in use ever since the time when Stockholm did not have more than two telephone exchanges — one local exchange with a rural service section and one toll exchange. The necessary equipment, however, has undergone successive changes and modernizations along with the growth of the net and the building of new exchanges.

Originally, the ordering lines entering the various toll positions were admitted directly to the multiple of the local exchange and identified with designations consisting of the abbreviated names of the exchanges whose toll calls were handled over the corresponding toll positions; also, these lines were arranged alphabetically according to the names of the exchanges.

At the toll exchange each ordering line was provided with a drop indicator — which was actuated as soon as the connection was completed to the corresponding line at the local exchange — and a key by means of which the operator could get in on the line in order to receive the subscriber's order.

In 1909, the Telegraph Administration opened a number of smaller local exchanges in Stockholm, originally intended for subscribers with residence 'phones. These exchanges were not provided with direct ordering lines to the toll exchange, a connection for a toll call order from a subscriber at one of these exchanges being carried over the ordering multiple of the central exchange. This traffic was handled in exactly the same way as the junction traffic between a subexchange subscriber and a central exchange subscriber.

In 1916 the toll exchange was removed to a new location. The switchboards which now came into use were built on the same principle as the former ones, it is true, but at the same time they displayed a number of rather important dissimilarities, of which only those that have a direct bearing on the ordering lines will be here described.

Each operator's position in the new toll exchange was provided with two ordering lines with calling lamps, placed on the vertical part of the board, and keys, placed on the keyboard. In order to make it possible for the operators to help each other with the receiving of orders, the ordering lines were multiplied in the nearest adjoining positions on each side. For this purpose, each position was provided with six order keys, the two to the left for making a connection over the ordering lines of the adjoining left position, the two middle keys for connections over the own lines, and the two to the right for connections over the ordering lines of the adjoining position to the right. The ordering line lamps, on the other hand, were not multiplied, but were provided with extra large linses so as to be readily observed from the adjoining positions.

Thus — by means this arrangement, which is still being used — if a signal is given over an ordering line and the corresponding operator is busy with a toll connection or the like, either the operator to the left or the one to the right of her can receive the order.

In addition to this relief service, intended to exert an equalizing influence on the answering times, the manner in which the ordering wires at the local exchange were connected up underwent a change for the very same purpose.

In the multiple of the central exchange these lines were mutually arranged in the same manner as at the toll exchange, i. e. the two jacks corresponding to the ordering lines for a certain toll position were flanked by jacks for the ordering lines belonging to the toll positions adjoining the one first mentioned. In this manner the local operator was able — in case both ordering lines to a certain toll position were busy — to establish a connection over one of the nearest two lines on either side of the busy lines.

In this manner a sort of distribution of the order receiving service among five toll operators was obtained, i. e. if a local operator desired to make a connection over either of the ordering lines belonging to toll position number 3 and these were busy, she could make the connection over the lines leading to positions 2 or 4. An order signal to position 2 could also be answered by either of the operators at positions 1, 2 or 3 and — if a line leading to position 4 had been chosen — by an operator at position 3, 4 or 5.

Since the arrangement of the toll lines at the toll exchange quite naturally could not be in alphabetical order according to the names of the exchanges, it follows that neither could the multiple jacks of the ordering lines be designated as formerly with the names of the respective exchanges alphabetically arranged.

Consequently — as well as for other reasons — the name designations in the local multiple were removed and instead the jacks were provided in pairs with the number of the corresponding position at the toll exchange. At the same time, a special *Information Section* was organized, its duty being to give the local operators information as to the number of the ordering line for a given exchange, since it stands to reason that the many local operators could not be expected to memorize the numbers of the various ordering lines, neither was there space on the multiple boards for the setting up of the necessary instructions.

The information operators, however, — which did not number more than five to each relay and whose only duty it was to give information as to the numbers of the ordering lines — could easily be trained to memorize these numbers. As an aid to the information operators, however, lists over all the central exchanges and larger distributing exchanges with the numbers of the corresponding ordering lines were set up on the switchboards.

The numbers were inscribed on removable number pegs, thus facilitating a change if called for through the moving of lines at the toll exchange. Besides, the information operators were provided with lists of all the telephone exchanges in the country with the names of the governing central exchanges.

Thus, when a subscriber desired to place an order for a toll call, the local operator depressed a button for an order wire to the information section, causing a disengaged information operator to be selected. The local operator then repeated the name of the desired exchange, receiving in reply from the information operator the number of the corresponding ordering line, after which the local operator connected the calling subscriber to either of the two lines with this number or to one of the two adjacent lines on either side of the same.

As concerns the call order traffic from the other local exchanges, the procedure differed from the above insofar that it was no longer directed over B-positions at the central exchange but over special B-positions arranged especially for this purpose and at the same time functioning as information positions. For this purpose, these boards were furnished with the same lists etc. as the information boards, besides being equipped with a necessary number of cords and plugs and with the same reference multiple as the central exchange.

The increase in the number of subscribers at the sub-exchanges and the building of new sub-exchanges, however, were responsible for a considerable increase in the call order traffic over the above-mentioned reference boards during the following year, at the same time as the call order traffic from the central exchange decreased on account of the removal of subscribers' lines from this exchange to the sub-exchanges.

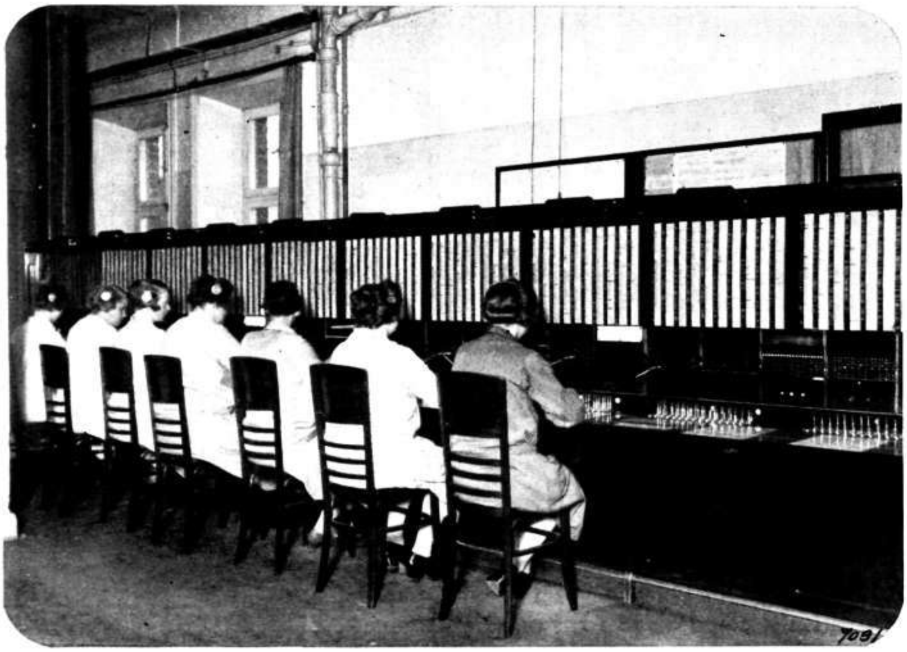
This necessitated an extension of the reference boards, at which time it was deemed wise to adopt a uniform type of call order service for this traffic from all the local exchanges. As a result, the information section was in 1919 replaced by reference boards and the reference multiple of the central exchange was changed to a common multiple for junction lines to this reference board.

This type of service for the call order traffic from the local exchanges has been retained unchanged since 1919.

The existing call order reference board with its fourteen positions is shown in fig. 1, only ten of these positions being fully equipped at the present time, however, and not more than seven of them being occupied by operators during the busy hour. As may be seen, the keyboards are arranged as for regular B-positions. The multiple contains the jacks of the ordering lines, numbered in pairs similar to the operators' positions at the toll exchange. Above the multiple are the lists containing the names of all the central exchanges in the country and those of the larger distributing exchanges, with — to the left of each name — the number denoting the position which handles the toll call to the exchange in question. These numbers are inscribed on removable number pegs, making them easily exchangeable in case a toll line should be moved over from one position to another. The reference boards are also provided with an easily accessible list of all the existing telephone exchanges in the country together with the names — in certain cases — of the central exchanges over which the calls are handled.

As has already been mentioned, however, the trained reference operators can in most cases effectuate the connections with the respective ordering lines without having to refer to either the lists of names over the multiple or the complete list of exchanges. Consequently, it is possible for a well trained reference operator to effectuate as many as 600 reference connections per hour.

The following method has been adopted for handling call orders from automatic subscribers. The subscriber dials the digit 9 and is connected to a first group selector which hunts for a disengaged junction line to the call order reference board. When such a line has been found, the corresponding lamp in the reference board glows at the same time as the reference operator is connected to the cord. When this operator answers "9", the subscriber requests "Gothenburg", for instance, and after having answered "Just a moment, please", the operator connects the subscriber to the desired ordering line.

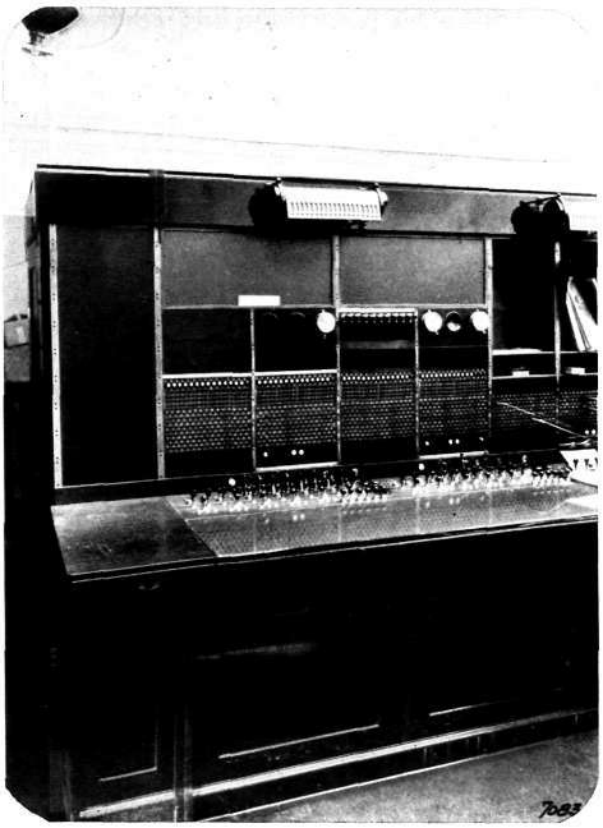


R 829 Fig. 1.

The toll operators themselves have recourse to the call order reference service in those cases when — with transfer calls — they wish to communicate with one another. The service is then fully analogous to what has previously been described.

In fig. 2 we see the keyboard of a toll switchboard at the toll exchange. In front of the toll switching devices and to the front may be seen the six keys for an equal number of ordering lines. The calling lamp for the own ordering lines of the position — corresponding to the two middle keys — are located on the vertical panel.

The arrangement of the ordering lines from a technical point of view is so simple as to require no special detailed description. It is sufficient to state that the pressing down of an order key connects the operator to the line in question and at the same time disconnects her from the rest of the equipment in her position. Thus, if the speaking and ringing key of a toll line is in speaking position, the operator will be disconnected from the toll line on the depression of an order key. Although the decentralization of the call order service



R 828 Fig. 2.

in Stockholm is believed to have been accompanied by more advantages than disadvantages, this does not mean that this system in all cases is preferable to a centralized service.

A choice between the two systems must be made with due consideration for the special conditions ruling at different toll exchanges, such as to what degree it is possible to utilize the lines, the efficiency of the personel, whether several kinds of calls shall be permitted, the existance of cancellations, number of requests for information concerning ordered calls, linguistic conditions, etc.

The existance or nonexistance of these and other conditions will influence the value of those qualities that are characteristic for the two systems and which sometimes make the one preferable, sometimes the other.

The decentralized call order service has the following advantages.

The subscribers come in direct contact with the operator who will later on effectuate the desired connection and are therefore able to obtain from her any desired information, such as concerning waiting times, traffic conditions, etc.

Since subscribers often have their toll traffic concentrated to certain localities and certain persons there, it is of advantage to the subscribers to be able to give their call orders to operators who not only are well acquainted with traffic conditions over the line of communication in question but who also possess a wide knowledge as to which subscribers can be regarded as daily users of the various traffic routes. This is of special advantage for the international traffic where the language problem must be considered.

Information as to previously ordered toll calls may be obtained and calls cancelled much more conveniently with decentralized call order service than with the other type.

During the time a line stands idle, incoming orders can be more quickly effectuated than with centralized service with all its intricacies.

Finally, the toll boards are not encumbered with all the expensive pneumatic dispatch paraphernalia which accompany centralized service arrangements, designations required to enable the operators to give the subscribers desired information as to waiting times, etc., as well as arrangements for communications between the centralized service operators and the toll operators or for giving the subscriber a through connection to the toll boards when it may be necessary to obtain information direct from the toll operator.

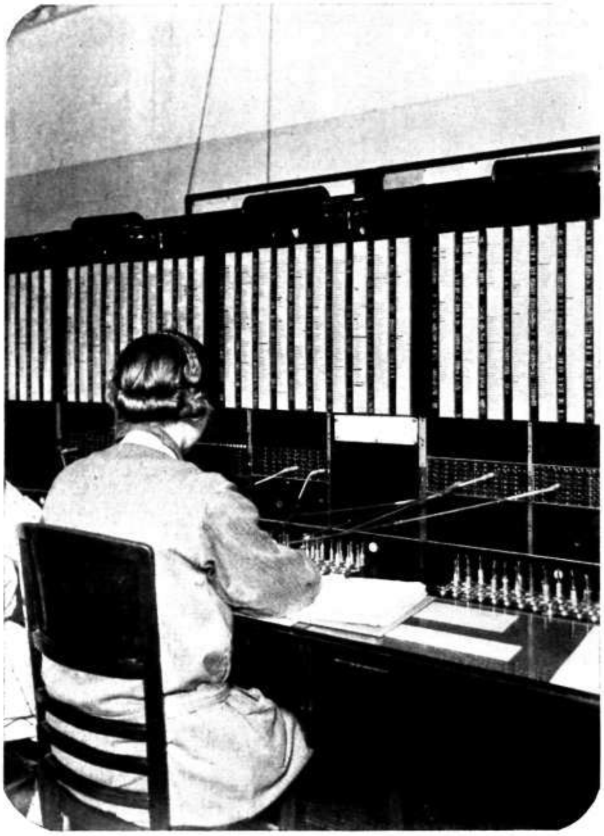
The greatest advantage which centralized service possesses over the decentralized call order service lies undoubtedly in the possibilities it offers for a better distribution of the work and for the adjustment of the personel to the intensity of the traffic resulting in shorter and more uniform answering times. With the arrangements at the Stockholm exchange, however, enabling three or even five toll operators to coöperate in the receiving of order calls it has been possible to so restrict the length of the answering times as to make them entirely free from criticism on the part of the public.

Whether or not the better utilization of the personel obtainable with centralized call order service means a direct saving in the total expenses for the toll service naturally depends on to what degree the total amount of work is increased by the sorting and distribution operations etc. which accompany centralized service, and also to what degree the decrease in work for the toll operators — resulting from their not having to receive the call orders — can be compensated by other work.

In most cases it is more than probable that a centralized call order service will not result in any financial saving.

Stockholm, December 1927.

Mauritz Agrell.



Making Register Connections by Means of Cord Circuit Finders.

By Prof. R. Trechcinsky, of the Warsaw Institute of Technology.

Since a register belonging to an automatic system is engaged only during the dialling of the number and the setting of the switches, and not during the conversation, the number of registers provided for a certain number of cord circuits is smaller than this latter and is determined by the existing traffic conditions. A disengaged register is connected to a certain cord circuit by means of a line finder. Either the cord circuits or the registers can be provided with line finders, these latter then being termed register finders or cord circuit finders respectively.

There are two alternatives for the connecting of a register to a cord circuit by means of a cord circuit finder. According to the first alternative, all the cord circuit finders belonging to disengaged registers are set in motion as soon as a call enters a given group, and do not stop until the right cord circuit has been found. In the second alternative, the cord circuit finders of all the disengaged registers — or of only a certain number belonging to the group in question — are actuated and successively come in contact with all the cord circuits within the group until under certain conditions a permanent contact with one of the cord circuits is established. This last alternative is dealt with in the following.

An example illustrating this principle is given in fig. 1, which shows this method as applied to the Ericsson automatic system — called 'Salme' on the diagram — and to junction lines between the same and the Strowger system of Siemens & Halske — called 'S & H' on the diagram.

A. With the Ericsson system, the registers are connected up by means of cord circuit finders according to the method in question and in the following manners, depending on the varying traffic conditions.

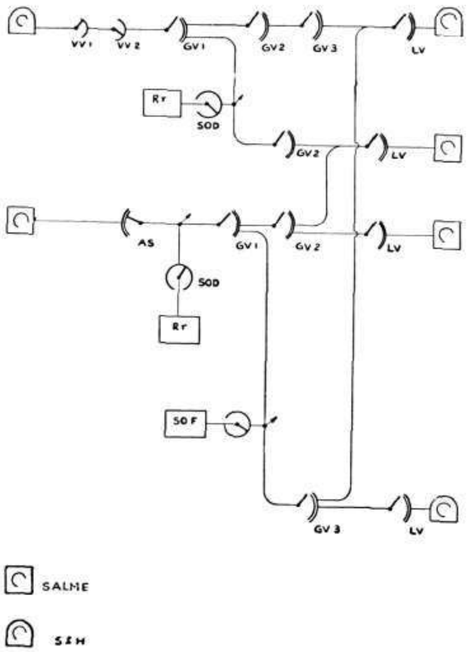
I. The number of cord circuits required for a certain group of subscribers' lines can be calculated with sufficient precision by means of the following formula:

$$x = 0.17 \times SM \times \sqrt[3]{C^2}$$

where S equals the number of calls per subscriber during the busy hour, M is the average gross length of calls in minutes and C is the number of subscribers' lines in the group.

Assuming that $S = 1.5$, $M = 2$ and $C = 500$ we obtain the following:

$$x = 0.17 \times 3 \times \sqrt[3]{500^2} = 32.$$

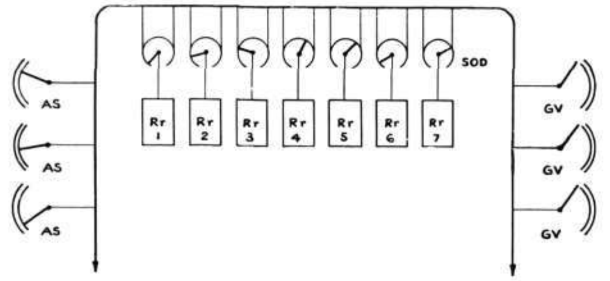


R 766 Fig. 1.

These cord circuits require a certain number of registers which is obtained by means of the formula:

$$R_n = 0.07\, S \sqrt[3]{C^2} = 0.07 \times 1.5 \times \sqrt[3]{500^2} = 7.$$

Each register is provided with a sequence switch *SOD* adapted as a cord circuit finder and with thirty-six contact positions. During the rotary movement of this cord circuit finder, the register is successively connected up to the thirty-two cord circuits. The cord circuit finder stops as soon as it has found a disengaged cord circuit, the register being then connected to this cord circuit and to its line finder *AS*. When a call enters the five-hundreds group, only such idle line finders as are connected to idle registers are actuated in order to find the calling subscriber's line. If all seven registers are simultaneously connected up to idle cord circuits, an incoming call entering this



R 767 Fig. 2.

group will consequently actuate seven line finders. After the register has completed its various functions, its cord circuit finder *SOD* continues to funtion until a new idle cord circuit which is not already connected to a register has been found, and so forth.

registers, i. e. to lessen their number, the subscribers' lines are suitably brought together in larger groups with common registers.

In such a case the connection is made as indicated in the diagram shown in fig. 4.

Under identical conditions, the above formula gives a smaller number of registers for *one* group of 1000 lines:

$$R_n = 0.07 \times 1.5 \times \sqrt[3]{1000^2} = 10.$$

Assuming that the peak loads in a group of 1000 lines are of no practical importance, this result indicates that five registers is sufficient to handle the normal traffic within each five-hundred group. The two registers required — according to the previous calculation — for an additional five-hundred group can therefore be considered necessary to handle the above-mentioned peak traffic loads. If several five-hundred groups are assembled so as to form one large group, the number of registers Rn required to handle the peak traffic load can be calculated by the aid of the formula:

$$R_n' = 2\sqrt{G_{500}}$$

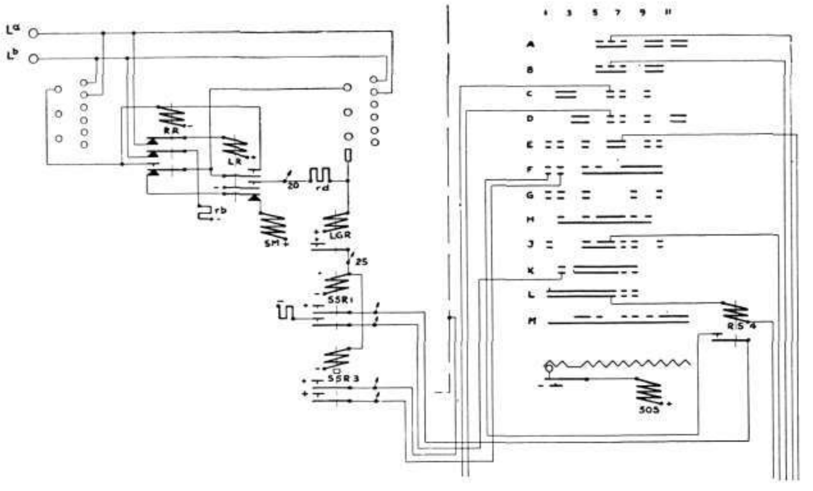
in which G_{500} = the number of five-hundred groups.

Thus, for four groups of five hundred lines each, i. e. for 2000 subscribers' lines, we will require

$$R_n' = 2\sqrt{4} = 4 \text{ extra registers,}$$

and consequently, the total number of registers required for 2000 lines

$$R_n'' = 5 \times G_{500} + 4 = 5 \times 4 + 4 = 24.$$



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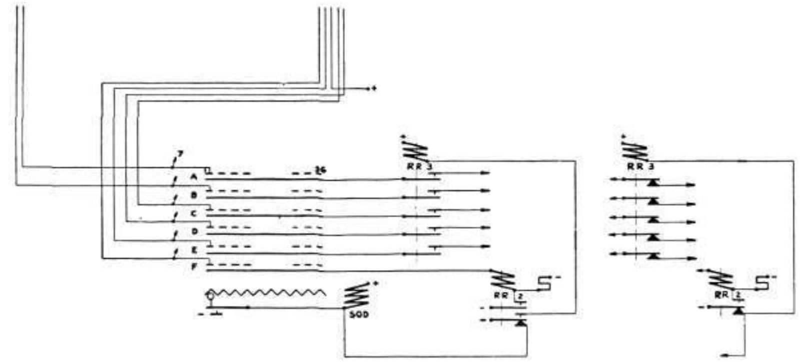


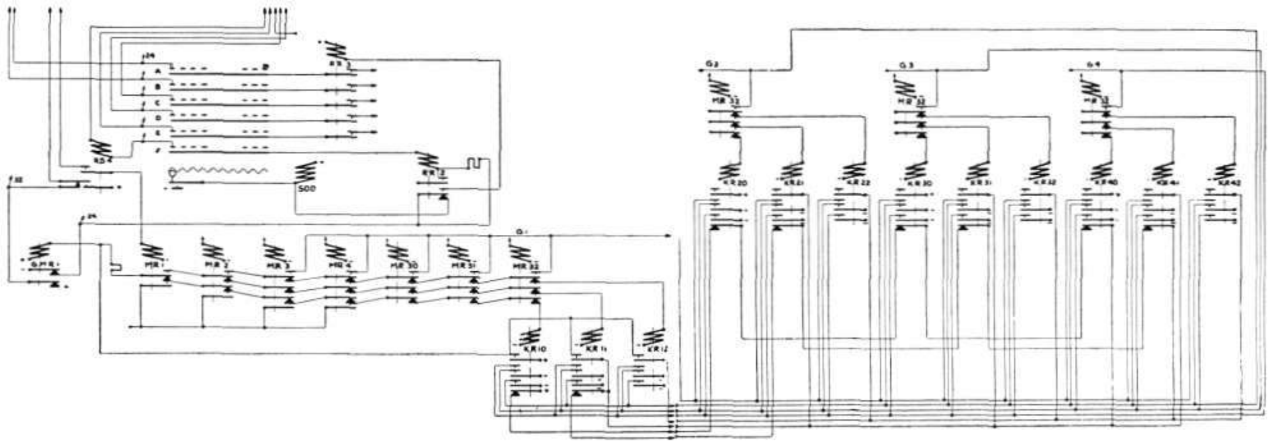
R 768 Fig. 3.

This arrangement is shown in principle in the diagrams, figures 2 and 3. Each group of 500 subscribers' lines is alotted a certain number of registers with their cord circuit finders. In this case, a plant with 10,000 subscribers' lines will require 140 registers and an equal number of cord circuit finders *SOD*.

II. In a small group of subscribers' lines, the peak traffic loads are more noticeable than in a large group on account of the varying demands of the subscribers on the service, due consideration having been taken to this fact in the above-mentioned formula. In order to lessen the influence of these peak loads on the required number of

Since the cord circuit finders — as has already been stated — have thirty-six contact positions, it is possible — in the present case — for a register to make a connection to only $\frac{36}{4} = 9$ of the thirty-two lines in each of the four sets of cord circuits for the four groups.

In order to prevent all the registers from being connected up to the same set of thirty-two cord circuits, thus depriving the other three sets of the necessary register connections, the number of registers which can be connected to the same set of cord circuits is limited. An arrangement of this kind is shown in fig. 5, in which the number of registers which can be connected to one set of cord circuits is limited to four. Each cord circuit is provided with an indicator relay *MR* and each set of thirty-two cord circuits with a similar relay *GMR* and three control relays *KR*. When relay *GMR* energizes, this indicates that the entire set of cord circuits is busy. This occurs when any four of the relays *MR* are energized, i. e. as soon as four registers have been connected to the same. Thus, out of twenty-four registers, only sixteen are

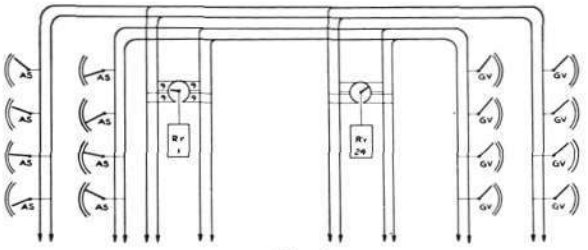


R 772

Fig. 5.

connected up, the other eight remaining in their rest positions. As soon as one of the four connected registers begins to function — resulting in the setting of the sequence switch of the cord circuit in question from position 1 to position 2 — the indicator relay *MR* is de-energized. This causes relay *GMR* also to de-energize, upon which the cord circuit finders *SOD* of all the disengaged registers are set in motion for the purpose of finding a disengaged cord circuit in this set.

Even though the traffic may be heavy, it is possible that none of the cord circuit sets are indicated as busy, for instance if three sets occupy three registers each and the fourth set only one register. It might now be possible for the first disengaged register to connect itself to a line in a set that already has three registers at its disposal, the fourth set still having but one register at its disposal. For this reason, it is necessary to provide some arrangement whereby a disengaged register will obtain a connection with the set which for the moment has the least number of registers. This



R 770

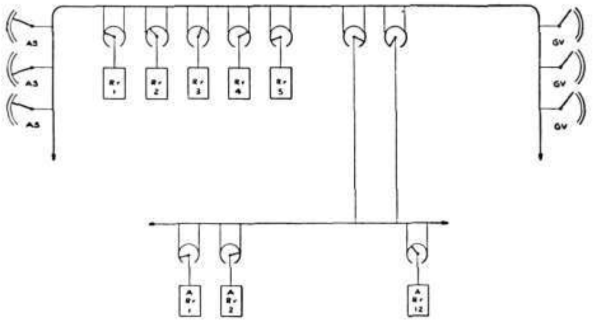
Fig. 4.

function is filled by the control relays *KR*. A set with no registers is indicated by the relay KR_{10}, one connected register by KR_{11} and two connected registers by KR_{12}. In the above example, therefore, sets 1, 2 and 3 are indicated as not fully occupied by means of the relay *GMR* only, all the control relays for this set of cord circuits remaining de-energized. In the fourth set, on the other hand, KR_{41} is energized, causing negative to be connected to the indicator lines *G1*, *G2* and *G3* of the first, second and third sets respectively. These three sets of cord circuits with three registers each are now indicated as occupied, causing the next disengaged register to be connected to the fourth set instead of to one of the other three.

Still another example is given by way of illustration. If the cord circuit set no. 2 had only two connected registers at its disposal, KR_{22} would also energize, and the line *G4* be connected to negative. However, this connecting takes place only when this set of cord circuits has three connected registers at its disposal, and consequently it does not influence the fourth. Since relay KR_{41} is energized, the circuit from positive to all the relays KR_{12}, KR_{22}, KR_{32} and KR_{42} is broken at contact *a*. As a result, relay

GMR_2 is not short-circuited, but remains energized, causing set no. 2 to be indicated as occupied.

If each of the sets nos. 1, 2 and 3 have only two



R 773 Fig. 6.

connected registers at their disposal, the relays GMR_1, GMR_2 and GMR_3 are energized over KR_{12}, KR_{22} and KR_{32} respectively, since positive has been disconnected at contact a in KR_{41}. This condition will arise even if the fourth set of cord circuits has no

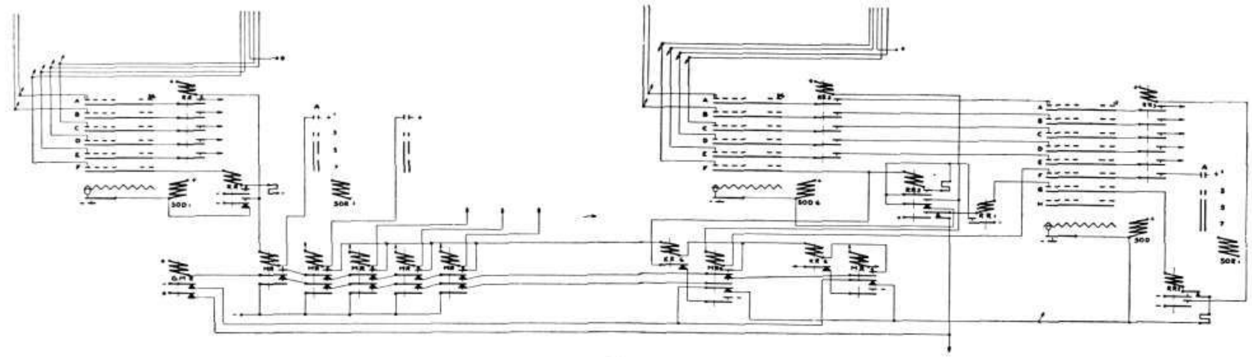
cord circuit finder. After inserting the values for this special case we get

$$x' = \frac{32 \times 4}{24} \times \left(\sqrt[3]{\frac{32 \times 4}{36}} - 1\right) = 3.$$

The number (x_s) of cord circuits is therefore

$$X_s = x + x^1 = 32 + 3 = 35.$$

With systems where an insufficient number of switching devices is responsible for lost calls or for the giving of a premature busy signal, the necessary increase in the number of cord circuits is much greater and cannot be figured with the aid of the foregoing formula, as it sometimes can amount to three times as much. In the present case, the saving achieved through the reduced number of registers is ample to cover the increase in the number of cord circuits. At the same time, it illustrates the importance of using good judgement in the choice of ways and means to reduce the first cost. They can often lead to the very opposite.



R 771 Fig. 7.

connected register at all at its disposal. In such a case the first three sets are indicated as occupied and the next disengaged register will be connected to set no. 4.

Since each register, as already mentioned, can only be connected to a certain limited number (9) of cord circuits, it might even happen — with intense traffic — that these cord circuits are all busy when the register becomes disengaged. Such a condition would unnecessarily delay or even paralize the functioning of the cord circuit finders. In order to increase the chances of the register finding a disengaged cord circuit among the nine of the set, it is necessary to increase their number according to the formula

$$x' = \frac{x \times G_{500}}{R''_n} \times \left(\sqrt[3]{\frac{x \times G_{500}}{Rk_n}} - 1\right)$$

where Rk_n is the number of contact positions of the

Another solution intended to eliminate the abovementioned drawbacks is shown in the diagram in fig. 6.

In accordance with the previously given method of calculation, each group of five hundred lines is provided with five registers which can be connected to any one of the cord circuits in the same set. The excess traffic is taken care of by registers which are common for several sets of cord circuits and which can be connected to every line in all the sets by means of double cord circuit finders. As already mentioned, two registers per group are required for this purpose. Thus, an exchange with 3000 subscribers' lines, i. e. six five-hundred groups and six sets of cord circuits, would require twelve additional registers. In order to reduce this number as much as possible, two register lines per group or $2 \times 6 = 12$ lines and twelve cord circuit finders are reserved for this purpose.

These lines connect the respective finders with a group of common registers *ARr*, whose number (R_n''') is calculated by the aid of the formula

$$R_n''' = 0.44 \times S \times \sqrt[3]{x^2} = 0.44 \times 1.5 \times \sqrt[3]{x^2}$$

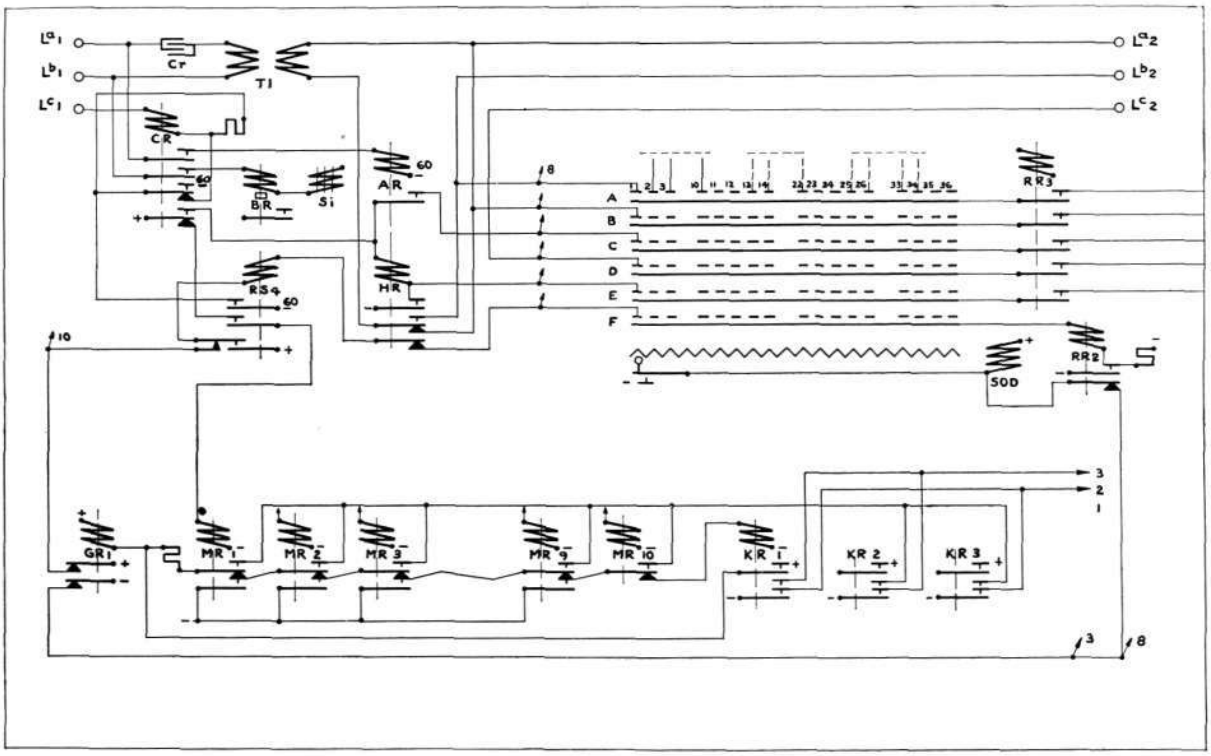
which — under the former conditions — gives six registers, or a total of thirty-six instead of forty-two. According to this principle, an exchange of 10,000 lines will require 120 registers and 160 cord circuit finders. The schematic diagram for such a plant is shown in fig. 7. The control relays *KR* prevent the connecting of the registers *ARr* to a set of cord circuits which already has five registers at its disposal, i. e. when the set in question is fully occupied.

B. Traffic from the Siemens & Halske automatic Strowger system to the Ericsson automatic system.

I. This connection passes over the first group selector of the S & H exchange, by means of which — with a 5-digit system — the desired ten-thousand group is selected. The first group selector hunts for the first idle cord circuit in a set of ten. The required number of registers for a set of ten cord circuits is obtained from the following:

$$R_n = 0.44 \times S \times \sqrt[3]{x^2} = 0.44 \times 1.5 \times \sqrt[3]{10^2} = 3.$$

Since an S & H exchange subscriber can immediately dial the second and remaining digits of the desired number, the register must be ready to start functioning and only those lines — in a ten cord circuit set — to which a register is already connected shall be indicated as occupied. These are the three above-mentioned registers and it is only between these three that a first group selector in an S & H exchange can choose. When the selecting process is finished, this cord circuit is indicated as occupied. As soon as the connection between the subscribers is completed, the register leaves this cord circuit and seeks another idle one to which no register has yet been connected.



R 774

Fig. 8.

II. A set of ten cord circuits seems to be rather insufficient. With a standard construction of cord circuit finders it is possible to group together three ten-circuit sets, these thirty cord circuits then being connected to common registers. The necessary number of common registers will then be

$$R_n''' = 0.44 \times 1.5 \times \sqrt[3]{30^2} = 7$$

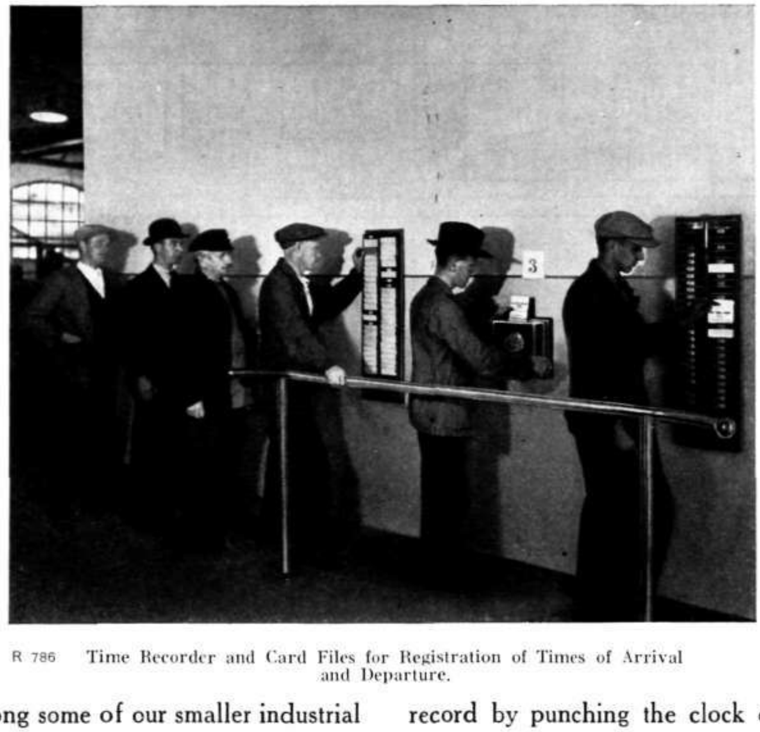
instead of nine. Such a connection is shown in the diagram in fig. 8. Two registers for each set of ten cord circuits is maximum, the seventh register being held in reserve to handle the excess traffic loads in the various sets, the right of precedence being given by means of the relay *KR* to that set of cord circuits which for the moment has the least number of connected registers at its disposal.

Time Recording.

Paper read by Mr. H. Josephsson at the regular fall meeting of the Swedish Cotten Mfrs. Association held at Borås December 10, 1927.

In the same measure as working hours have become shorter and wages higher, so also has it become more and more necessary to replace the rather primitive methods of bygone days with other and more efficient ones for supervising the times of arrival and departure of the employees.

Probably the most primitive method to have found application was to close the factory gates at the beginning of working hours so that those workers who arrived late were forced to return home. Formerly, when working hours were longer and wages lower than they are now, a system of this sort might be tolerated; at the present day, however, it is altogehter condemnable. Already the loss of a few minutes time at the beginning of the day is expensive and to be avoided as far as possible, but to willingly forego a half or probably a whole days work is much worse. The excuse that the worker receives no pay for this time most certainly does not justify the adoption of such a system, since it is the factory itself that suffers most from a reduced output, less effective utilization of machines etc.



R 786 Time Recorder and Card Files for Registration of Times of Arrival and Departure.

Notwithstanding, the method of closing the factory gates is still to be found among some of our smaller industrial plants. The day can not be far distant, however, when it will be substituted by something better; if not before, so at least when the owner awakens to the fact that this system, which seems so simple and cheap, in reality is very costly.

Another system — also condemnable, but more generally used than the one just mentioned — is the well known arrangement with numbered brass checks.

The check system can be used in a number of ways. The most common is to let the workers on their arrival hang their checks up in a cabinet placed at the factory entrance, the cabinet being closed and locked when the whistle blows. Those workers who arrive late must hand in their checks to the time-keeper, who writes down their numbers. This system has many disadvantages, one of them being all the writing which it occasions and in which mistakes may occur; another disadvantage is the fact that this method gives no information as to the exact length of the working time. Also, the worker is at the mercy of any ill feeling on the part of the time-keeper and may be subjected to unfair treatment.

It is now more than twenty years since time clocks were introduced in an attempt to remedy these various disadvantages. One or more such time clocks by means of which a record of the workers' times of arrival and departure was obtained on a list or card were set up within a factory, the workers themselves making this record by punching the clock on their arrival at and departure from the factory. The introduction of time punching constituted a considerable advance towards the ultimate goal — an accurate and absolutely impartial recording system.

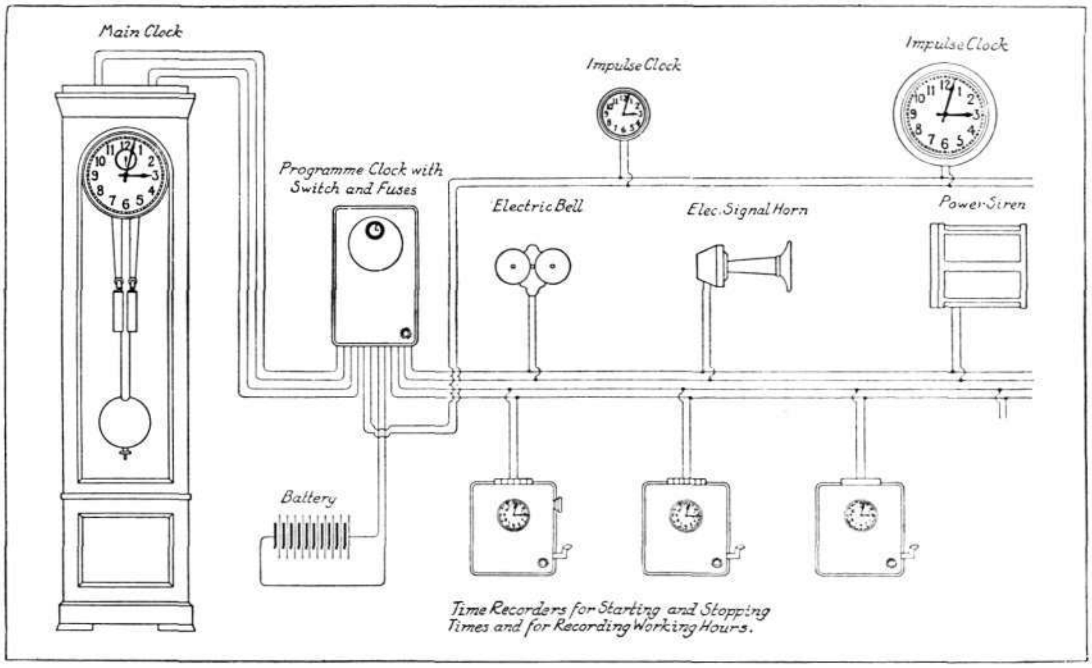
The first apparatus that came into use were for the punching of lists and were so constructed that the worker — by the manipulation of a lever handle — stamped the time in a certain column on the list.

A reversing device permitted the apparatus to be set for the stamping of either time of arrival or time of departure.

Before making a closer investigation of the developments in this branch, we will make an abstract of the various requirements which, from a point of view of organisation, must be met by the system which is to provide an absolutely satisfactory solution of the time recording problem.

The above-mentioned time clocks for recording the time on lists were equipped — this being the next step in their development — with bi-coloured inked ribbons with an automatic switching device arranged so that tardiness as well as time off was stamped in red, other time figures being stamped in blue, an arrangement which facilitated the inspection and calculation of the working times.

The next step was to introduce cards instead of the previously mentioned lists so that every worker had his own card. In this way all the various working times for a worker during a one week period were grouped



Schematic Diagram for Time Recording Plant with Signalling Devices.

In the first place the system shall function with perfect accuracy. Since each worker's time as well as eventual irregularities, such as tardiness, time off, overtime etc., are based on the data obtained by means of the time clock, it is an imperative necessity that these data are absolutely correct and do not become incorrect and misleading through any fault in the functioning of the time clock.

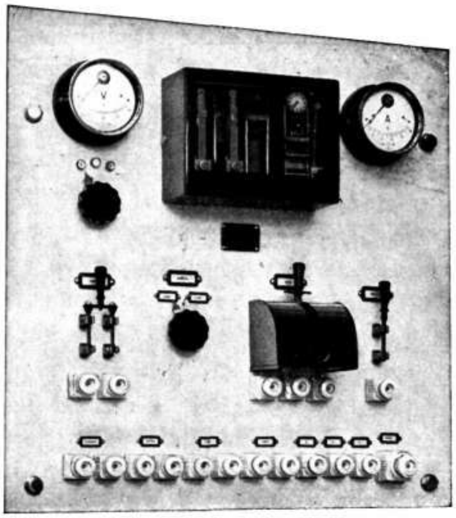
Further, it shall be required that the punching can be done quickly and simply so as to eliminate all mistakes. The stamped figures shall be arranged so as to permit the quick and accurate calculation of required data, such as working time, etc., for the pay roll as well as for statistical purposes. In addition, the time clock shall be so constructed as to permit the recording of time of arrival as well as time of departure, time off or overtime, without having to be 'reset' either by the worker himself or by the shop foreman.

together on a single card, this latter being subsequently used to figure out the total working time and also — in many cases — the wages.

In the beginning, it was customary to place the time clocks close to the factory entrance; now, however, it is becoming more and more costomary to place them in the respective shop departments. In the former case more or less time must elapse between the punching of the clock and the moment when work can actually begin at the workbench or machine, these being often at quite some distance from the factory entrance.

The aim, therefore, is to place the time clock as near as possible to the spot where the work is actually carried on and to let the stamping of the cards take place — wherever practicable — after the completion of various preliminaries, such as change of clothing, etc. In this way the recorded time will correspond to the actual working time. If, when the punching takes place at the factory entrance, an average of five minutes is lost, this means ten minutes per man and day, which, with a force of 200 men, will amount to a loss of 10,000 working hours per year.

When such a tremendous loss of time can ensue merely from the unsuitable placing of the time clock, the importance of paying close attention to this detail is apparent enough without having to be additionally accentuated.



Switchboard for a Large Time Recording Plant.

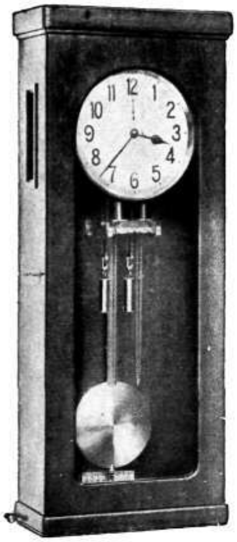
The workers do not suffer any inconvenience by having to record their time near the spot where their work is accomplished instead of at the factory entrance, but — as already pointed out — this method can be of the utmost importance to the company. In this connection it may be of interest to point out that the replacement of the old check system by a modern time recording system is of just as great advantage to the workers as to the employer. It must quite naturally be equally satisfactory to both parties that the time recording takes place without friction and in such a manner that all chance of unfairness will be eliminated. With a system of this kind every worker becomes his own timekeeper and there is no occasion for disputes.

As a result, the use of time clocks is being more and more appreciated by the workers themselves and there are several instances when, during negotiations between labour and employers, the workers have come with direct proposals for the introduction of time recording in the factory where they were employed.

We will now return to the time clocks themselves and their construction, and see to what extent existing types meet the enumerated requirements.

To begin with, it is rather interesting to follow the development of the time clock with reference to its reliability.

The first time clocks were pendulum-clocks combined with a mechanism which permitted the recording of the time. Such time clocks are still being manufactured, in spite of their many disadvantages, one of these being the serious strain to which the clock works — always more or less delicate — are subjected by the constant jarring resulting from the recurrent punching. Another disadvantage is that in a factory in which a number of time clocks are installed, it is extremely difficult to make them all keep exactly the same time, this — in turn — giving rise to other disadvantages. For instance, let us assume that a whistle or siren sounds when work is to start. The punching of the clock should have taken place before the whistle blows. If one of the time clocks goes say two minutes ahead of the one by which the whistle is blown, the condition can arise that the workers who punch this clock *before the whistle blows* — consequently *in time* — still may have a time card which shows a tardy arrival.



Main Clock with Automatic Electric Winding.

In order to remedy these two disadvantages — the damage to the clock-works and the difficulty in making several clocks run exactly alike — a system with central control was finally devised.

This system is provided with but one real clock with clock-works, a so-called main or control clock. Electric impulses, which actuate electromagnets in the various time recording instruments connected to the system, are sent out from the main clock at the rate of one per minute. The time recorders are not regular clocks with delicate clock-works but instruments provided with a simple but sturdy stamping device and directly actuated by the impulses from the main clock.

The desired uniformity in the time indicated by the various recorders is also obtained, since there is but one set of clock-works.

It has been claimed that electric time recording systems are combined with a certain degree of uncertainty due to the danger of broken circuits and line trouble between the main clock and the time recorders. In actual practice, however, this danger has been found to be negligible, as trouble of this kind very rarely occurs. Also, electric time recording systems are becoming increasingly popular.

With reference to the speed and accuracy with which the recording operation is performed, it is characteristic for the majority of systems that the time card must be inserted in the recording apparatus with the reverse side turned outwards, in some cases upside down as well. This must be considered as a decided disadvantage, partly because the time card — if the worker forgets to turn it around — is easily stamped on the wrong side.

Impulse Clock.

The entering of the recorded time in the correct column usually takes place in the following manner. That portion of the card which will receive the stamped time records is divided into six vertical columns and seven horizontal spaces. These latter are one for each day of the week, three vertical columns being for arrivals and three for departures. The vertical setting is automatic in that on each consecutive day the card is stamped in the space below that of the preceding day. For the horizontal setting, the apparatus is adjusted by hand so that the first record in the morning is stamped in the first column to the left. Before stamping the second time record for the day, the apparatus is set so that the time record shall come in the second column, and so forth.

In some concerns, this setting of the apparatus is done by the worker himself, but more generally by the foreman. In the former case numerous mistakes occur, while in the latter it is necessary that the foreman pay close attention to the setting of the apparatus at the

Automatic Time Recorder.

right times. If a worker is granted time off, the foreman must accompany the worker to the time recorder in order that the worker be able to stamp his card, and when he returns to work the foreman's presence is again necessary for the stamping of the card. This condition holds good also with regard to overtime. In those cases when the work is carried on in shifts the disadvantages are even greater, since it can occur that time cards must be stamped alternately for arrival and departure in the same time clock.

The ideal time recorder would naturally be one with automatic vertical as well as horizontal setting.

It was just such an apparatus that L. M. Ericsson set out to design when it was decided, some ten years ago, to take up the manufacture of time recording instruments. The construction was completed and approved a few years ago, enabling L. M. Ericsson to place a full automatic time recording system on the market.

The problem of automatic setting in a horizontal as well as a vertical direction had been solved in a both simple and efficient manner. The time card was divided into seven vertical columns and eight horizontal spacings, the former for the seven days of the week and the latter for four sets each of times of arrival and of departure. The horizontal setting takes place automatically at midnight. The vertical setting is taken care of by means of a hole which is punched in the card simultaneously with the stamping of the time, this hole determining the position of the card for the next stamping.

The result of this arrangement is that each card is handled individually by the time recorder. Thus, the same recorder can stamp a card *'In'* the moment after

Electric Signal Horn.

having stamped another one *'Out'* or a third for *'Time off'*, etc. Also, the manner in which the card is spaced gives such a clear arrangement of the time records that the calculation of the working time is greatly facilitated.

The recording apparatus constructed for coöperation with the main clock are enclosed in a casing of lacquered sheet iron and are comparatively small, requiring much less wall space than the old fashioned time clocks. The face of the recorder is provided with a clock dial, an indicator behind a small apperture showing whether the inked ribbon is set for blue or red stamping. The colour shifting device is constructed so that the shifting of the ribbon on Saturdays can take place at a different time than on the other week days.

These recorders differ from older types also in that the card is stamped on the front side without having to be reversed during the stamping operation.

The Clock in the Tower is Actuated by the Same Main Clock as Some Ten Time Recorders.

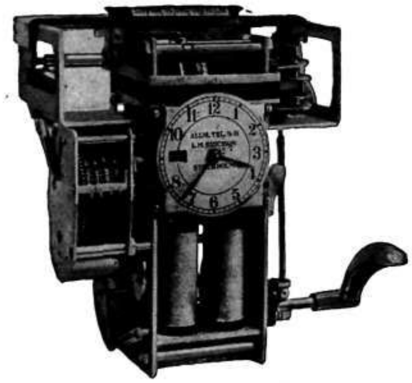
The card files are made in sections, each section for twenty-five time cards; thus the files can easily be extended for twenty-five cards at the time.

In addition to the above described time recorders, apparatus for actuating automatic signal devices at the beginning and end of working hours, secondary or impulse clocks for indicating the time, time recorders for piece work and watchmen's tell-tale clocks can be connected to the main clock.

The automatic signal device consists of either an impulse signal clock or a program clock. It is possible to set the signals for different Saturday times with either the one or the other of these devices.

Signals are given by means of electric bells, horns or sirens, these devices being adjusted to conform with the desired volume of sound.

The impulse clocks are driven by means of minute-impulses, in the same manner as the time recorders. The works are of a simple and very sturdy construction, and consist of an electromagnet placed between two permanent magnets and provided with two arma-



Automatic Time Recorder with Cover Removed.

tures which are actuated by the current impulses from the main clock and which drive the hands with a perfectly silent movement. The movement is transferred from the driving magnet to the hands of the clock by means of a worm gear, thus doing away with the large number of gear wheels which are usually to be found in clock works and ensuring a smooth movement in spite of the generously proportioned bearings.

The number of time recorders and impulse clocks which can be actuated by the same main clock is practically unlimited, although one or more relays are necessary with larger numbers.

The standard types are designed for 24-volt direct current, power being obtained from a storage battery.

The charging instruments, meters, fuses and program clock — if such a one is used — for the entire plant are all mounted on a common switchboard.

From what has here been said, it is apparent that a modern time recording plant functions with such accuracy that it must be a most effective aid to the employer, whose chief aim it always is to operate his factory in the most efficient manner.

The accompaying table shows how long time it takes for a time recording plant for a factory with two-hundred employees to pay for itself through time saved.

The first cost is assumed to be 3500 Swedish crowns and the value of the time saved to be one crown per hour and employee.

Calculated time saved in minutes per day & employee	Value per year at 1 crown per hour	First cost of time recording plant calculated at 3500 crowns; with 200 employees this amount is saved in
1	1000 crowns	$3\frac{1}{2}$ years
2	2000 »	2 »
3	3000 »	$1\frac{1}{2}$ »
4	4000 »	1 »
5	5000 »	3/4 »

There certainly is no exageration in the assumption that five minutes per man and day are lost in a factory that cannot boast an efficient time recording system.

Moreover, we must not forget that the values given in the table do not include anything except the direct loss or saving in time. The indirect gains which accompany the use of modern time recording methods must also be taken into consideration, and these are often of no small importance. We allude to the foremens time, which can be put to better use than to keep track of the arrivals and departures of the employees, to the elimination of time disputes between the foremen and the workers, to the absolutely reliable statistical information obtained, etc.

In this connection it may be well to point out that it is of no less importance to keep accurate records of time used on piece work than for regular time work. Here we are up against the fact that shorter working hours mean reduced production. The total cost of production is not diminished, consequently it becomes greater per manufactured unit or figured in percentage of the value of the article.

In addition to the manufacture of time recording apparatus, L. M. Ericsson executes the work of installation, the plants being delivered under the company's guarantee. Also, L. M. Ericsson is in a position to prepare complete projects for time recording installations, special attention being given existing local conditions in order to obtain the highest possible degree of efficiency. Industrial concerns who are desirous of obtaining more detailed information or advice on this subject are requested to apply at our nearest agency, a step which incurrs no obligations but may lead to most profitable results.

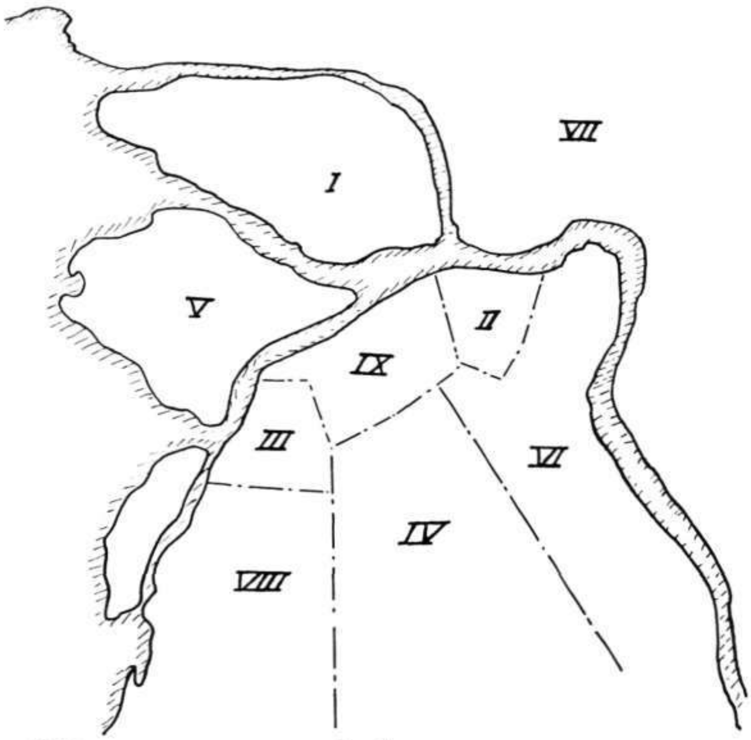
During What Length of Time and with how Large a Capacity shall a Manual Exchange be Retained in an Otherwise Automatic Telephone Net?

There is no doubt but that it is practically impossible to answer this question in a general way, since each separate case has its own individual and local factors, which must be taken into consideration and which are of the utmost importance.

These factors — among others — are as follows:

1. The desire to retain P. B. X. and other subscribers with a heavy outgoing traffic at the manual exchange.
2. The age of the manual exchange.
3. The possibilities for obtaining the capital required for a sufficiently speedy automatization.
4. The restriction of the cost of junction traffic between manual and automatic subscribers and the possibility of installing the equipment and switchboards necessary for the junction traffic.
5. The possibility of using the special junction traffic equipment for subsequent automatic traffic.
6. The growth of the net.
7. The number of subscribers which can be simultaneously cut over from the manual to the automatic exchanges.

In order the better to illustrate the viewpoints to which this article desires to call special attention, the following fictitious example from a city with a manual telephone exchange will be treated.



R 837 Fig. 1.

An approximate layout of the city is given in fig. 1.

All of the city's telephone subscribers are at the beginning of 1928 connected to a manual exchange in the centre of the city. The exchange has a capacity of 54 000 lines, the present number of subscribers being 44 000. The exchange comprises 320 local positions.

It is taken for granted that automatic exchanges will be provided for handling the future development of the net. For projecting these exchanges, the city is divided into nine sections (see fig. 1), each section with a final capacity of twenty to forty thousand subscribers' lines.

The manual exchange has recently been completely renovated and modernized with respect to all the relays, cables and switchboards, so that the telephone administration is desirous of retaining the same as long as possible.

The call frequency is 1.5 per subscriber during the busy hour. Of this number, 1.1 calls result in conversations with a net average duration of two minutes, 0.4 calls being lost on account of busy subscribers' lines.

The requirements and formulae necessary for the analysis of the problem in hand are given in the following.

The growth of the number of subscribers in the city is studied by means of the graph in fig. 2. The straight line represents an increase of 6000 subscribers per annum.

The full-drawn curve represents an increase of 50 % in the number of subscribers during a five year period. This curve probably represents the actual growth more accurately, but — in order to simplify the proposition — the increase curve is assumed to coincide with the straight line until the beginning of the year 1938, after which it follows the dot-and-dash line until it meets and coincides with the full-drawn curved line.

available through the discontinuance of a subscription cannot immediately be given to a new subscriber. This is taken into consideration in the following formulae.

By factor of interest is meant that number with which the traffic, divided in proportion to the number of subscribers, shall be multiplied in order to obtain the actual traffic in a given direction.

For traffic from *automatic* to *manual*, a factor of interest of 1.23 is assumed, while for traffic from

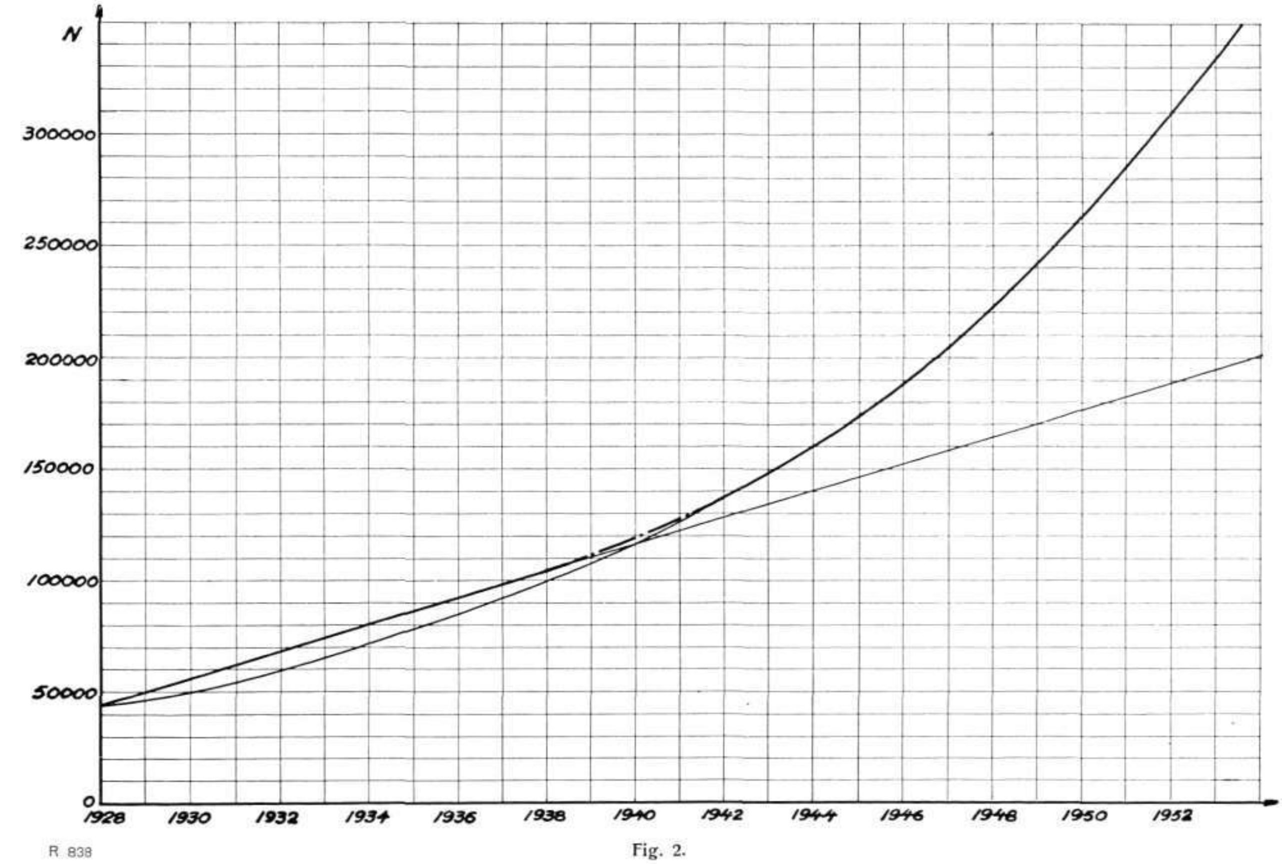


Fig. 2.

In the following diagrams the years are denoted in a corresponding manner.

A call to an engaged subscriber is assumed to take $^1/_{10}$ of a minute.

For the junction traffic from the manual exchange to the automatic exchanges the switching devices and junction lines are assumed to be engaged during 3 minutes for the establishing and disconnecting of one connection.

The corresponding time for the traffic from the automatic exchanges to the manual exchange is assumed to be .125 minutes.

In a well planned telephone net, at least 10 % of the total capacity of the exchanges should always be in reserve, since a telephone number which has become

manual to *automatic* the corresponding value is assumed to be .9, the traffic from the outlying districts to the more central parts of the city being proportionately greater than that in the opposite direction.

The capacity of the manual exchange is represented by M, that of the combined automatic exchanges by A, while the total capacity of the entire net is represented by N.

The traffic from *manual* to *automatic* is assumed to be TMA speaking minutes and the traffic from *automatic* to *manual* TAM speaking minutes.

For the manual subscribers, the number of speaking minutes per subscriber during the busy hour is

$$1.1\,(2 + .3) + .4\,(.1 + .3) = 2.69,$$

the number of speaking minutes for all the manual subscribers being

$$.9 \times M \times 2.69;$$

while with proportional division

$$\frac{A}{A+M} \times .9 \times M \times 2.69$$

speaking minutes go to the automatic exchanges.

Therefore:

$$TMA = .9 \times \frac{A}{A+M} \times .9 \times M \times 2.69$$

or

$$TMA = 2.18 \times \frac{AM}{A+M}.$$

Analogously, we obtain

$$TAM = 2.69 \times \frac{AM}{A+M}.$$

Further,

$$N = A + M.$$

Each operator at the manual exchange is allotted a certain number of jacks for the junction traffic to the automatic exchanges. A certain number of these are individual for a certain operator and consequently need not be provided with test circuits; the remainder, on the other hand, are multiplied over several positions, wherefore testing is necessary.

In this manner each operator is alloted K junction lines, on an average. We figure here with 31.2 useful minutes per junction line during the busy hour, which — with 320 operators — gives us

$$K = \frac{2.18 \times AM}{31.2 \times 320\,(A+M)} \text{ or}$$

$$K = 2.18 \times \frac{M}{10000} \times \frac{A}{A+M}.$$

We can assume ten B-operators (with key sets) per two hundred lines for the traffic from *manual* to *automatic*. (How we arrive at this figure is of no interest in this connection.) The number of B-operators is therefore

$$B = K \times 320 \times \frac{10}{200} \text{ or}$$

$$B = 16K.$$

The traffic from *automatic* to *manual* is assumed to pass over connectors at the manual exchange. If we assume 108 500-groups for the manual exchange we obtain

$$\frac{TAM}{108} = 2.49 \times \frac{M}{100} \times \frac{A}{A+M}$$

speaking minutes per group.

The number of connectors LV is obtained by means of Erlang's curves (see *The L. M. Ericsson Review*, Vol. I, nos 5—6: "Calculation of the Required Number of Switches for Automatic Telephone Exchanges") with an assumed grade of service of 3 ‰.

As a second alternative, it is assumed that the traffic from *automatic* to *manual* is handled over call indicator positions by operators at the manual exchange. The number of operators LAT is determined on the basis that each operator can handle 600 calls during the busy hour.

The number of incoming calls during the busy hour is

$$1.66 \times \frac{AM}{A+M}$$

and

$$LAT = \frac{1.66}{600} \times \frac{AM}{A+M} = 2.77 \times \frac{M}{1000} \times \frac{A}{A+M}.$$

In the following table I the values of K, B, LV, LAT, A and N are based on the assumption that the manual exchange has a constant capacity of 54 000 lines.

An auxiliary factor $= f\,\frac{A}{A+M}$ has been used for calculating the values in the table.

The corresponding curves for K, B, LV and LAT are plotted in fig. 3 with the total number of subscribers N as an independent variable, therefore

$$K = F(N)$$
$$B = F(N)$$
$$LV = F(N)$$
$$LAT = F(N)$$

We see from both table I and fig. 3 that if the manual exchange is retained at a constant capacity, the required number of switching units and positions increases with the total number of subscribers.

Already with an equal number (54 000) of subscribers at the manual and automatic exchanges, $94 + 75 = 169$ positions are required for the junction traffic if this traffic is handled by operators in both directions.

With twice as many (108 000) automatic as manual subscribers (54 000), the required number of positions for the junction traffic is $126 + 100 = 226$, and with three times as many automatic as manual subscribers $113 + 142 = 255$ positions.

Table I.

$f = \frac{A}{A+M}$	$A = \frac{54000}{\frac{1}{f} - 1}$	$N = 54000 + A$	$K = 11.77\ f$	$B = 188.3\ f$	Speaking minutes for calculating LV $1345 \times f$	LV	$LAT = 149.6 \times f$
$\frac{1}{20}$	2800	56800	0.6	9.4	67	5	7.5
$\frac{1}{10}$	6000	60000	1.2	19	135	7.2	15
$\frac{1}{5}$	13500	67500	2.4	38	269	11	30
$\frac{1}{3}$	27000	81000	3.9	63	448	16	50
0.4	36000	90000	4.7	75	538	17	60
0.5	54000	108000	5.9	94	673	21	75
0.6	81000	135000	7.1	113	807	25	90
0.7	126000	180000	8.2	132	942	29	105
0.8	216000	270000	9.4	151	1076	32	120
0.9	486000	540000	10.6	170	1211	36	135
1	∞	∞	11.8	188	1345	40	150

Thus, it is plain that in the long run it cannot be economical to retain the manual exchange with a capacity of 54 000 lines after the city net has attained such proportions that almost as many junction positions are required as A-positions, especially since the arrangements and equipment for the junction positions are quite expensive.

How then shall the capacity of the manual exchange be **reduced?**

If the method with call indicators had been chosen,

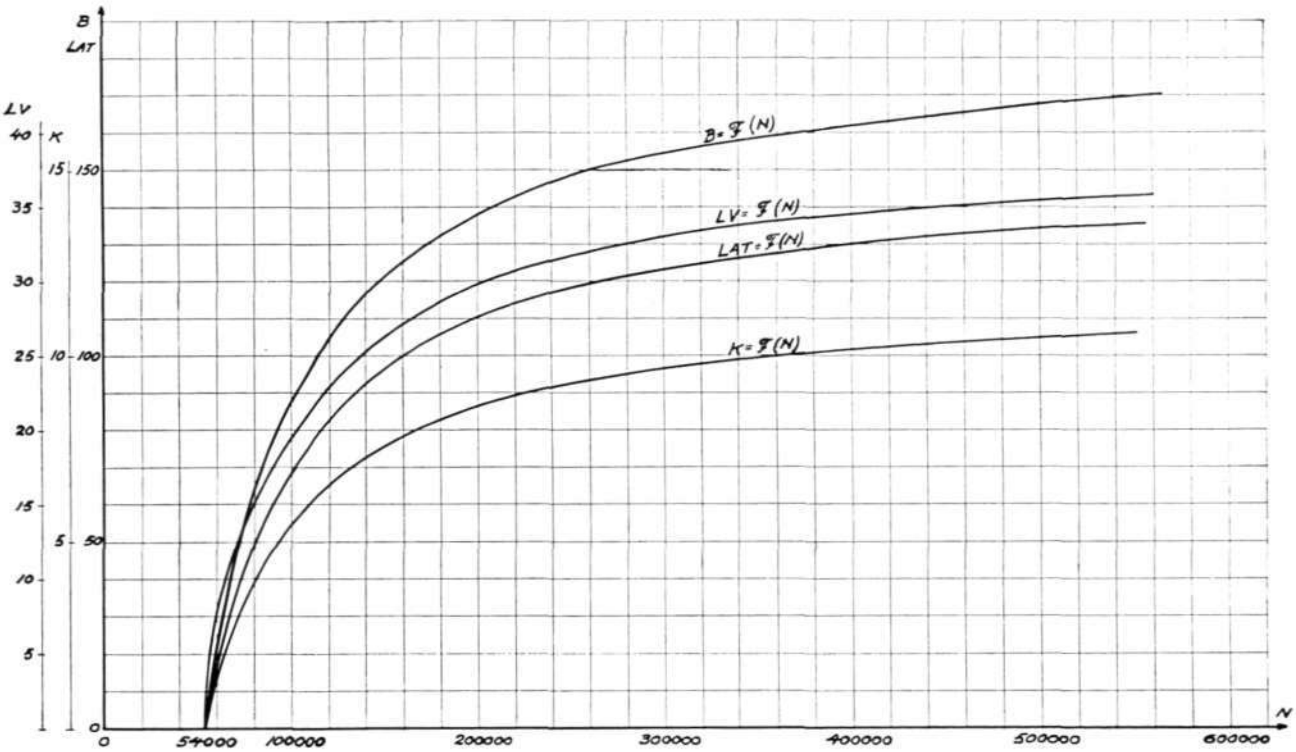


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Fig. 3.

it is plain that the sum of the number of A-positions, CA, and the number of call indicator positions, LAT, could not exceed the total number of available positions.

The number of B-positions need not be treated in this connection since they contain no subscribers' multiple and can consequently be placed in an entirely separate room or building than the A-positions.

If all the A-positions are in use already at the beginning of the automatization, it is necessary to be able to set up a certain number of call indicator positions in order to begin the automatization.

To begin with, let us assume that 54 000 subscribers can be given service by 300 positions CA — corresponding to 180 lines per operator — and that an additional 60 call indicator positions can be erected.

We then have

$$CA + LAT = \frac{M}{180} + 27.7 \times \frac{M}{10000} \times \frac{A}{A+M} = 3.60,$$

from which we obtain

$$M\left(2 + \frac{A}{A+M}\right) = 130000$$

or

$$M(2+f) = 130000.$$

By assuming different values for f we arrive at the following table II.

f	M	A	$A+M$	CA	LAT
0.41	54000	37000	91000	300	60
0.50	52000	52000	104000	289	71
0.60	50000	75000	125000	278	82
0.70	48000	113000	161000	267	93
0.80	46500	186000	233000	258	102
0.90	45000	403000	448000	249	111

However, if it is found that 320 CA positions are required for 54.000 subscribers — which means 169 subscribers' lines per A-operator — only 40 call indicator positions can be erected.

This proposition presents itself in the following form:

$$CA + LAT = \frac{M}{169} + 27.7 \times \frac{M}{10000} \times \frac{A}{A+M} = 360,$$

from which we obtain

$$M(2.14+f) = 130000.$$

By means of this formula we obtain table III.

f	M	A	$A+M$	CA	LAT
0.26	54000	19500	73500	320	40
0.40	51000	34000	85000	303	57
0.50	49000	49000	98000	292	68
0.60	47500	71500	119000	281	79
0.70	46000	107000	153000	271	89
0.80	44000	177000	221000	262	98
0.90	43000	385000	428000	253	107

As a third alternative we will assume that 320 A-positions are required for 54 000 subscribers at the manual exchange and that it is not possible to increase the number of multiple positions above 320.

From this we obtain the formula

$$CA + LAT = \frac{M}{169} + 27.7 \times \frac{M}{10000} \times \frac{A}{A+M} = 320$$

or

$$M(2.14+f) = 115500,$$

which gives the following table IV.

f	M	A	$A+M$	CA	LAT
0	54000	0	54000	320	0
0.20	49500	12500	62000	292	28
0.40	45500	30500	76000	270	50
0.50	44000	44000	88000	259	61
0.60	42000	63500	106000	250	70
0.80	39500	157000	197000	233	87
0.90	38000	342000	380000	225	95
0.94	37500	588000	626000	222	98

If a maximum value for the sum of the operators' positions $(CA + LAT)$ is given, it is an easy matter to determine the theoretical curve representing the gradual reduction of the capacity of the manual exchange.

This is shown in fig. 4, the three curves a, b and c corresponding to the above tables II, III and IV respectively.

These curves give the number of manual subscribers M as a function of the total number N of subscribers in the entire net.

Let us now consider the second case with table III.

We will assume that the manual exchange will remain in existance for another fifteen years; also, that the total capacity of the net by that time will be about 150 000 subscribers.

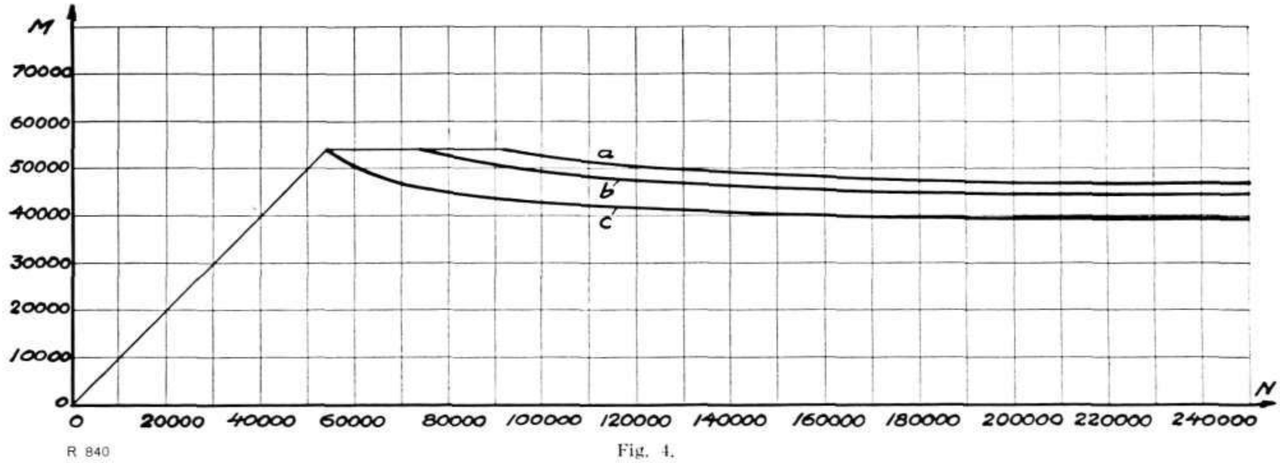


Fig. 4.

By that time 88 call indicator positions would be required and the manual exchange would have about 46 000 subscribers.

However, it is impossible from a practical point of view to put a manual exchange with 46 000 lines out of commission at one stroke, but the cutting over of the subscribers to the automatic exchanges must take place successively in groups of not more than four to five thousand lines per half or whole year.

At this rate the evacuation of the manual exchange would take at least five or ten years for 54 000 lines.

During this time the junction traffic will be considerably reduced as compared with the calculated figures; consequently, it would be very uneconomical to install the large calculated number of call indicator positions, which would soon be of no value.

Thus, we must determine the maximum number of call indicator positions that we wish to install.

If connectors are used for the traffic from *automatic* to *manual*, the same restrictions must be observed with regard to them also.

With regard to call indicator positions as well as connectors, economical reasons prevent their being installed in unlimited numbers merely for the sake of retaining the manual exchange as long as possible, since these organs for the greater part become valueless when the manual exchange finally is bound to disappear.

We will now consider the capacity of the manual exchange as a function of the capacity of the automatic exchanges, ignoring the special assumptions on which the tables II, III and IV and the curves in fig. 4 are based.

Both in the case with a determined maximum number of *call indicator positions*, and with a determined number of *connectors* for each 500-group, a certain maximum value for the junction traffic obtained.

The previously derived formula

$$TAM = 2.69 \times \frac{AM}{A+M}$$

gives a certain relation between A and M for every value of TAM.

This function can be expressed.

$$A \times M - \frac{TAM}{2.69} \times A - \frac{TAM}{2.69} \times M = 0.$$

This equation evidently signifies a number of hyperbolic curves whose axes form angles of 45° with the axes A and M. The locus for the vertices of these hyperbolic curves is the line

$$A = M.$$

We then obtain

$$A = M = 2 \times \frac{TAM}{2.69}.$$

In the following table V A is calculated for different values of M after having determined a certain value for TAM.

The table gives also the corresponding values for N, LAT, TMA, K, B and LV.

TAM	M	A	$N = A + M$	
	11 150	∞	∞	$LAT = 31$
	13 000	80 000	93 000	$TMA = 24300$
	15 000	43 500	58 500	$K = 2.4$
	20 000	25 000	45 000	$B = 39$
30 000	22 300	22 300	44 600	$LV = 11$
	25 000	20 000	45 000	
	43 500	15 000	58 500	
	54 000	14 000	68 000	
	80 000	13 000	93 000	
	∞	11 150	∞	

TAM	M	A	N=A+M	
40 000	14 900	∞	∞	$LAT = 41$
	20 000	58 000	78 000	$TMA = 32400$
	25 000	37 000	62 000	$K = 3.2$
	29 800	29 800	59 600	$B = 52$
	37 000	25 000	62 000	$LV = 14$
	54 000	20 500	74 500	
	58 000	20 000	78 000	
	∞	14 900	∞	
50 000	18 600	∞	∞	$LAT = 52$
	20 000	263 000	283 000	$TMA = 40500$
	25 000	73 000	98 000	$K = 4.1$
	30 000	49 000	79 000	$B = 65$
	35 000	39 700	74 700	$LV = 16$
	37 200	37 200	74 400	
	39 700	35 000	74 700	
	49 000	30 000	79 000	
	54 000	28 500	82 500	
	73 000	25 000	98 000	
	263 000	20 000	283 000	
	∞	18 600	∞	
54 000	20 100	∞	∞	$LAT = 56$
	25 000	102 000	127 000	$TMA = 43800$
	30 000	61 000	91 000	$K = 4.4$
	32 000	54 000	86 000	$B = 70$
	36 000	45 400	81 400	$LV = 17$
	40 200	40 200	80 400	
	45 400	36 000	81 400	
	54 000	32 000	86 000	
	61 000	30 000	91 000	
	102 000	25 000	127 000	
	∞	20 100	∞	
60 000	22 300	∞	∞	$LAT = 62$
	25 000	207 000	232 000	$TMA = 48600$
	30 000	87 000	117 000	$K = 4.9$
	33 000	69 000	102 000	$B = 78$
	40 000	50 400	90 400	$LV = 18$
	44 600	44 600	89 200	
	50 400	40 000	90 400	
	69 000	33 000	102 000	
	87 000	30 000	117 000	
	207 000	25 000	232 000	
	∞	22 300	∞	

TAM	M	A	N=A+M	
75 000	27 900	∞	∞	$LAT = 80$
	30 000	295 000	425 000	$TMA = 60800$
	40 000	93 000	133 000	$K = 6.1$
	45 000	73 500	118 500	$B = 92$
	54 000	57 700	111 700	$LV = 22$
	73 500	45 000	118 500	
	93 000	40 000	133 000	
	395 000	30 000	425 000	
	∞	27 900	∞	

In fig. 5 A is drawn as a function of M for four different values of TAM, viz., 30 000, 40 000, 60 000 and 75 000 speaking minutes.

We assume a number of junction switching possibilities corresponding to $TAM = 40\,000$ speaking minutes. We see from the corresponding curve that the manual exchange can be retained with a capacity of 54 000 lines if the capacity of the automatic exchanges does not exceed 20 500, or the total capacity does not exceed 74 500.

This is represented by point C in fig. 5.

When the total number of lines now increases, the capacity of the manual exchange must be reduced in order to avoid an increase in the number of junction lines.

For instance, if we reduce the capacity of the manual exchange by 9000 lines, we cannot increase the automatic exchanges by more than about 2000 lines, and if we reduce the manual exchange by 20 000 lines we can only increase the automatic exchanges by about 6000 lines.

Thus, the total number of subscribers' lines would suffer a reduction, since the limited number of junction lines makes it necessary that the gradual reduction of the manual exchange take place faster than the extension of the automatic exchanges.

This condition brings us to point D on the curve.

The total number of subscribers' lines has now been reduced from 74 500 at C to 59 000, however. Not until we reach E does the total capacity come up to 74 500, the capacity of the manual exchange then having gone down from 54 000 to 20 500 lines.

In order to increase the total capacity of the exchanges above 74 500 lines it would therefore be necessary to make a jump from C to E, after which the curve $TAM = 40\,000$ could again be followed.

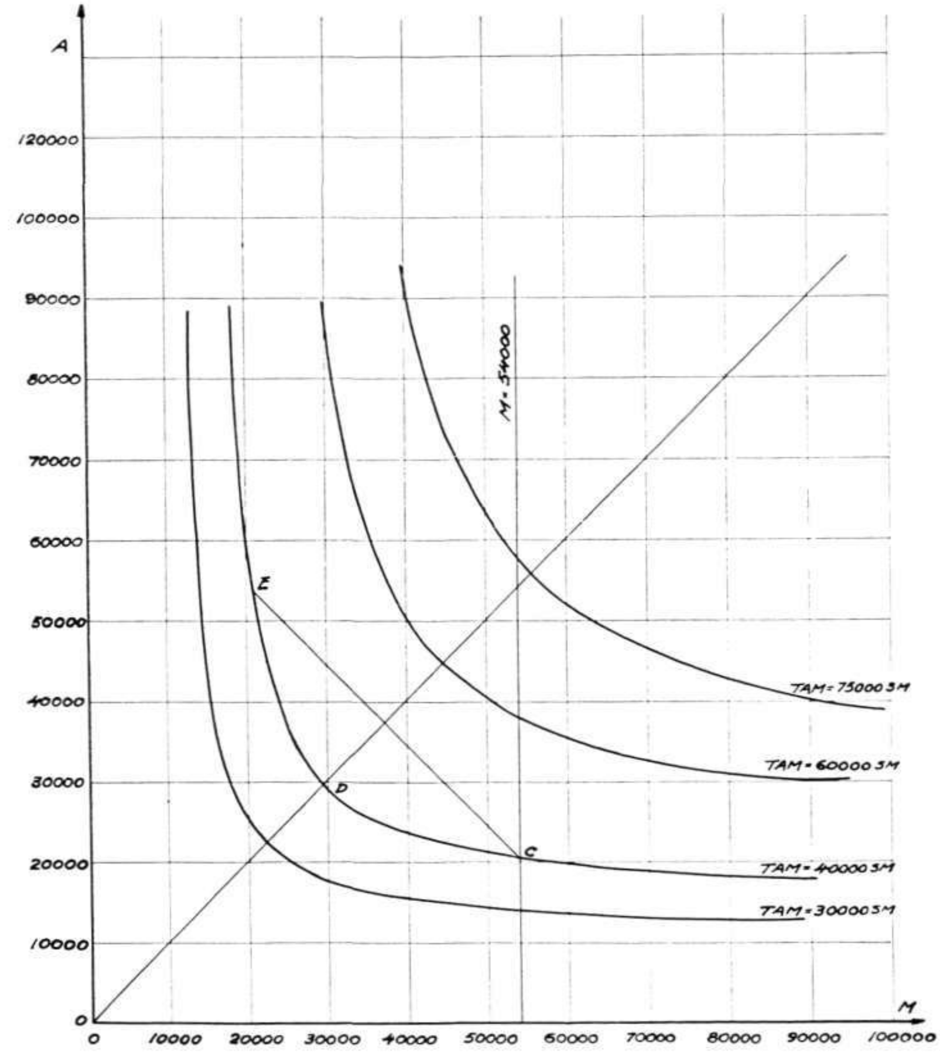
Consequently, if we have restricted the possibilities for junction traffic and wish to retain the manual exchange as long as possible, the number of subscribers which must be cut over at the same time from the manual to the automatic exchanges will be so large as to make this operation practically impossible.

In the case we have chosen for discussion it would be necessary to simultaneously cut over 54 000 — 20 500 = 33 500 subscribers.

Here we also obtain hyperbolic curves.

The line OF intersects the curves in those points through which the tangents to the curves are vertical.

Thus, it is plain that the intersection between OF and a certain curve will give a point from which one may follow the curve in either direction, the total number of subscribers' lines increasing in either case.



R 831

Fig. 5.

In order to be able to carry out this operation in successive stages, junction lines must be provided in sufficient number for a traffic corresponding to a hyperbolic curve whose vertex lies in the intersection between the lines $A = M$ and with $M = 54\,000$.

In the present example this would mean that $TAM = 72\,500$ speaking minutes.

The above discussion is probably still better illustrated by fig. 6 which shows how the capacity of the manual exchange varies with the *total* number of subscribers N for different values of TAM.

Analogously with the method depicted in fig. 5, we find that if the manual exchange is retained with a capacity of 54 000 lines along the line PA and with TAM restricted to 40 000 speaking minutes we are forced to cut over at one time from the manual to the automatic exchanges a number of lines corresponding to AB (abt. 33 500) since, after having reached A, an increase in the total number of subscribers' lines cannot take place without entering the area for higher TAM than 40 000.

Another factor to be taken into consideration is the speed with which the cutting over of subscribers from the manual to the automatic exchanges can take place.

The line PK in fig. 6 represents a cut over of 4000 subscribers per year, which value for all practical purposes can be taken as a maximum value for a plant of this size.

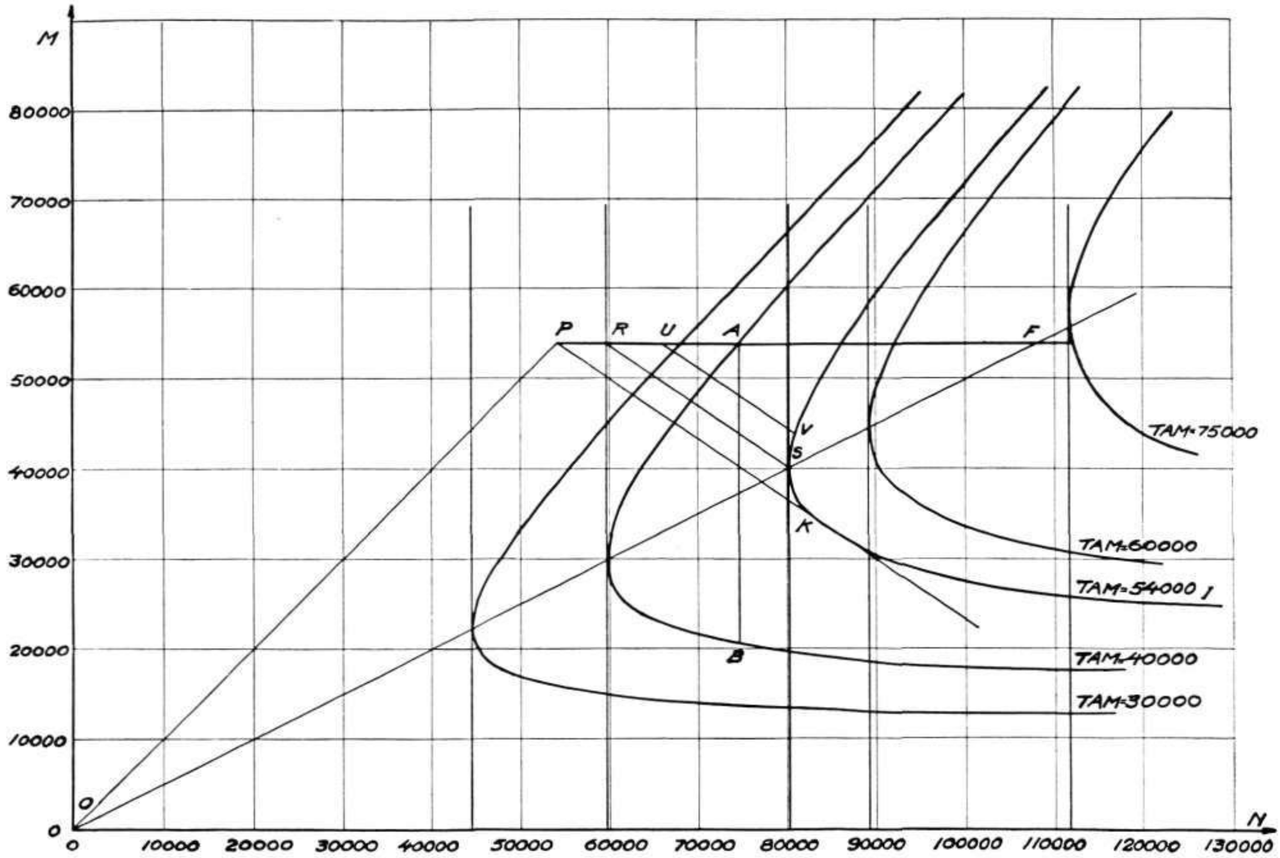
As will be noticed, PK is tangent to the curve which represents $TAM = 54\,000$ speaking minutes or fifty-six call indicator positions. Therefore, if we reduce the number of manual subscribers along $PK\ I$, we would be certain not to overstep the given maximum speed for cutting over and that the junction traffic would never exceed a value corresponding to fifty-six call indicator positions.

Should it be found desirable at some certain time to risk the cutting over of a larger number of subscribers, there is naturally nothing to prevent ones following the line RS or VV, for instance.

According to the author, it is most important that a manual exchange be not retained for too long a time at its full capacity. Should the manual exchange be retained for long time at maximum capacity, it will result in the expenditure of an unreasonably large amount of capital — which will later on be an almost complete loss — for the extension of junction lines, or else a cut over of such magnitude would have to be made as to be practically impossible from a technical point of view or, if cut overs take place in successive stages, the existing traffic possibilities will be the cause of serious losses or congestions.

We will now consider fig. 7 in which the curves in figures 4 and 6 have been combined.

We will suppose that the telephone administration is of the opinion that the manual exchange is in such good condition that it can well be retained at full capacity (54 000 lines) for at least eight years.



R 842

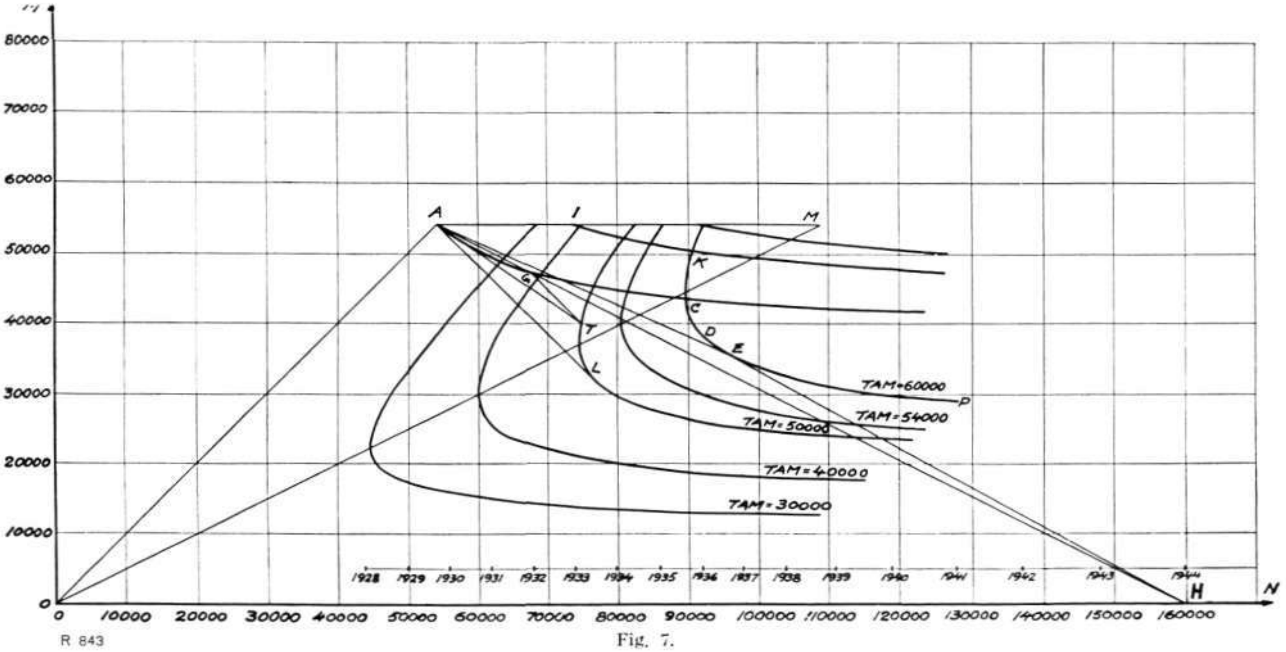
Fig. 6.

Instead, we let the number of subscribers at the manual exchange grow up to 54 000 and after that decrease successively so that after sixteen years (Jan. 1, 1944) it is 0. From fig. 7 and table V we find that this can be done without increasing the number of call indicator positions above fifty-eight or, say, sixty.

For example, if we should decide to cut over the manual subscribers along the line AEH, corresponding to a maximum number of sixty call indicator positions, the entire number of such positions would be of use for but a very short time.

Furthermore, it must be accentuated that if the junction traffic is handled over call indicator positions with a maximum of 320 positions, it is not possible to follow the line *AE* from the start, but the curve *AGC* must then be followed.

In order to increase the effective service time for the sixty call indicator positions and also the effective utilization of the manual exchange, it is apparent that the curve *AGC* can be followed up to C and that we then continue along the curve *CDE*. However, this would result in the cutting over of 6000 subscribers in 1935.



R 843

Fig. 7.

tiple is to be extended, the line *AGCDP* will no doubt serve the purpose to equal advantage.

This problem is treated in a similar manner if call indicator positions are not taken into consideration but instead the number of jacks and junction lines from the manual positions to the automatic exchanges, or the fact that there is room for but a limited number of connectors for the incoming traffic at the manual exchange if this traffic is to be handled altogether automatically without call indicators. In such a case one is not so restricted, since no consideration need then be taken to the curves *AGC* and *IK*, or the like, but only to the speed with which the cutting over of the lines is to take place and to the absolute maximum of junction traffic.

Naturally, it is possible to get along with fewer call indicator positions, say fifty-two, for instance — corresponding to $TAM = 50\,000$ — if one follows the line *AL*, *AT* or *ATG*, depending on the speed with which one is willing to effectuate the cutting over.

In such a case, the number of manual subscribers decreases rapidly and this exchange is not put to effective use. On the other hand, it can be retained in operation much longer, if desired, but it will in all probability be uneconomical in the long run to give manual service to only a small percentage of subscribers.

If it were possible to erect forty call indicator positions in addition to the 320 positions required for the local traffic, the cutting over could be effectuated along the line *AIKCDP* or something similar, which would permit a much better utilization of the manual exchange. To what extent this would pay depends on the cost of the extra positions. If the entire multiple is to be extended, the line *AGCDP* will no doubt serve the purpose to equal advantage.

In the foregoing we have discussed only the practical aspects of the problem. In addition to these, however, we have the previously mentioned economical aspects, such as the difficulty of raising the necessary capital, the possibility of getting new exchanges delivered and installed in sufficiently short time, etc., all of which lie outside of the bounds of the present article.

As a conclusion of the above, it is apparent that the natural desire to retain a good manual exchange for the longest possible time and at its full capacity within an automatic net must not only meet with difficulties of a purely practical nature but also lead to serious and unfavourable consequences from an economical point of view.

H. T—i.

F 1 Exchange Buildings in Moscow Erected by the Swedish-Danish-Russian Telephone Company.

CONTENTS: Suburban Telephone Traffic in a Large City. — Call Order Service at the Stockholm Toll Exchange. — Making Register Connections by Means of Cord Circuit Finders. — Time Recording. — During What Length of Time and with how Large a Capacity shall a Manual Exchange be Retained in an Otherwise Automatic Telephone Net?