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P. P. COGGINS

TELEPHONE EXCHANGE SYSTEM

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FIG. 1.

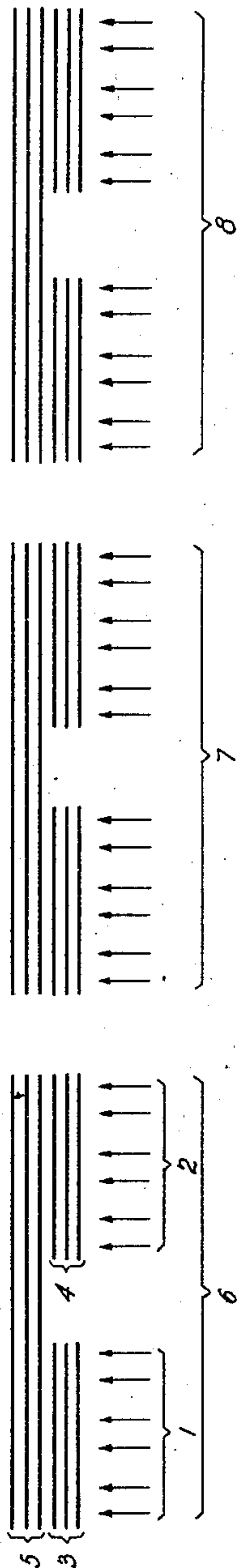
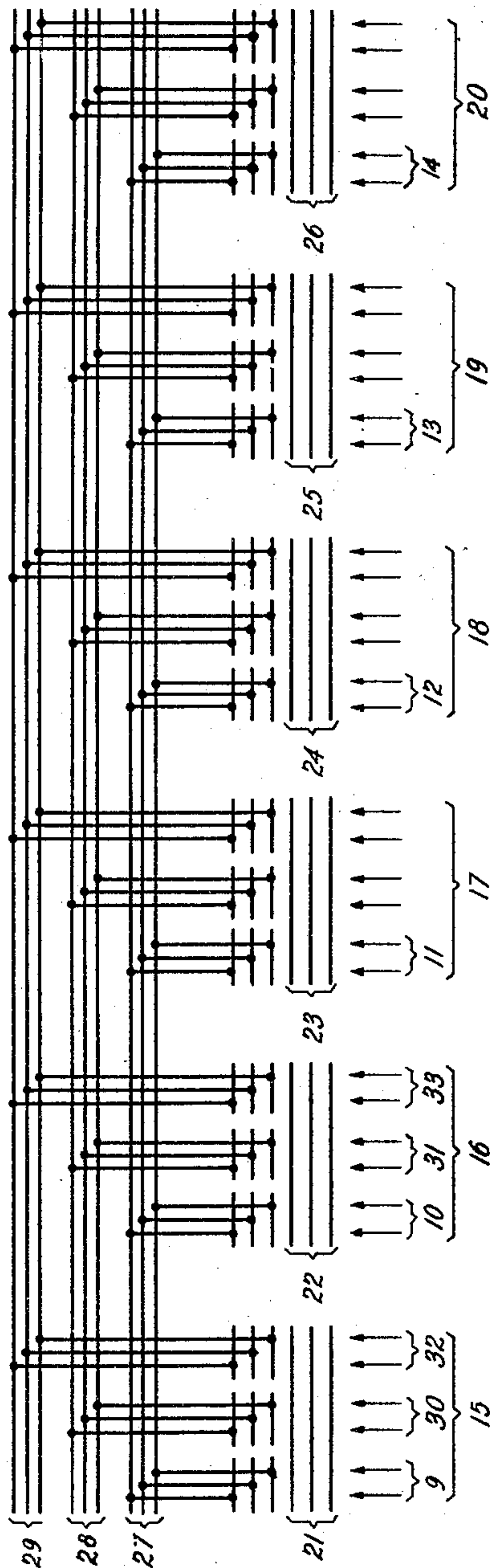


FIG. 2.



INVENTOR:
PAUL P. COGGINS

By

g. e. y. o. r.

ATTORNEY

UNITED STATES PATENT OFFICE.

PAUL P. COGGINS, OF NEWARK, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed September 16, 1927. Serial No. 219,906.

This invention relates to telephone exchange systems and more particularly to trunking arrangements therefor, its object being to increase the efficiency of trunking means without impairing the service rendered.

Heretofore various methods of slipping and grading multiples for the purpose of equalizing traffic have been proposed and certain of these schemes have been commercially adopted. The most common form of graded multiple is that in which a certain number of groups of incoming lines are each provided with a number of individual first choice outlets and a number of common second choice outlets. The present invention is a novel variation of this scheme and consists essentially in making the second choice outlets common to a subgroup of each group of incoming lines, not only of the said certain number of groups but to a plurality of such certain numbers of groups. By means of this arrangement, the assumptions on which one of the approximate mathematical formulæ for graded multiples is based become more consistent with the basic equipment arrangement with the result that a smaller factor of safety need be provided to take care of the peak traffic loads. In other words, the present invention leads directly to a saving in the number of trunks that must be provided for an equal volume of traffic.

In the drawings Figure 1 is a schematic representation of a standard scheme of graded multiple in commercial use and Fig. 2 is a schematic representation of a graded multiple in accordance with the present invention.

Numerous attempts have from time to time been made to devise multiple arrangements of trunks whereby the probability of any one group becoming overloaded will be equal to the probability of any other group becoming overloaded. A fair discussion of some of these arrangements is contained in Aitken's book on "Automatic Telephone Systems," Vol. 3, page 299 et seq. and in numerous patents contained in the prior art. Among these patents, No. 1,488,691 to Lundquist shows the graded multiple worked out more elaborately than is necessary but nevertheless showing fundamentally the standard commercial arrangement.

Clausen in his Patent No. 1,192,165 states that where trunk hunting switches have ac-

cess to a group of regularly disposed trunks that the traffic is distributed about as follows:

1st trunk-----	32%	56%	74%	86%	60				
2nd trunk-----	24%								
3rd trunk-----	18%								
4th trunk-----	12%								
5th trunk-----	7%								
6th trunk-----	3%	2%			65				
7th trunk-----	2%								
8th trunk-----	2%								
9th trunk-----									
10th trunk-----									

Realization of these facts has given rise to schemes known as the graded multiple in which the number of switches having access to the various trunks increases with the distance over which the switch has to travel. Probably the most complete graded multiple that has been worked out is disclosed in Patent No. 1,311,432 to Aitken and also described in his book on "Automatic Telephone Systems" above noted. Graded multiples of this nature, however, are open to the very serious objection that from the very random nature of the trunk appearances the tracing of the call becomes difficult and this objection is considered great enough to preclude the use of such a scheme in most commercial telephone systems.

The ordinary type of graded multiple shown for instance in Patent No. 1,488,691 to Lundquist comprises essentially a number of individual first choice trunks and a certain number of common second choice trunks. This scheme is to a certain extent, a compromise, for while it does not grade the multiple according to the most complete theoretical considerations it actually results in a saving of trunks and still renders calls capable of being easily traced.

A number of more or less approximate formulæ have been proposed for calculating this type of graded multiple. Some of them are more complicated than others, and empirical determination of the efficiency of a wide range of graded multiple arrangements is extremely laborious and has not yet been carried out at any great length. One of the simpler approximate formulæ is the result of a combined application of the well known Erlang B formula and the Poisson summation. The Erlang B formula is based on the

assumption that in the group of trunks under consideration such calls as fail to find an idle trunk within that trunk immediately will not reappear before the group. This formula is applied to the first choice trunks individual to a group of incoming lines. This assumption may fairly be made because it is assumed that any call not being absorbed in the first choice individual trunks will be taken care of in the second choice common trunks. When, however, we come to calculate the traffic for the common trunks, that is to say the traffic which overflows from the individual trunks, we should take into account the fact that a lost call may reappear to complicate the traffic. The Poisson summation formula takes this fact into account. It is based, however, on the assumption that the traffic originating before the group to which it is applied originates at random in time and from a large number of independent sources. These formulæ are as follows:

$$\text{Erlang B } P = \frac{\frac{a^x}{x!}}{1 + \frac{a}{1} + \frac{a^2}{2!} + \frac{a^3}{3!} \cdots \frac{a^x}{x!}}$$

$$\text{Poisson } P = \frac{a^x e^{-a}}{x!} + \frac{a^{x+1} e^{-a}}{(x+1)!} + \frac{a^{x+2} e^{-a}}{(x+2)!} \cdots$$

Where P = the proportion of lost calls. For instance, if P results in the figure .002 it means that two calls out of a thousand in the long run will be lost. a = the average load per unit of time expressed as the number of calls submitted per group per unit of time, the unit of time being equal to the average holding time. x = the number of trunks provided to carry the traffic a and $e = 2.718$, the base of Napierian logarithms. The Erlang B formula may be found in *The Post Office Electrical Engineers' Journal* for January 1918 (pages 189 to 197). Erlang's formula is also given in Smith and Campbell's "Automatic Telephony" 2nd edition, page 388 and the bibliography on pages 402 and 403 gives references to other publications where this formula is discussed. Discussions of the Poisson formula may be found, first, in a paper printed in the *Bell System Technical Journal*, November, 1922, entitled "The theory of probabilities applied to telephone trunking problems" by Edward C. Molina; second, a paper printed in the *Bell System Technical Journal*, January, 1923, entitled "Probability curves showing Poisson's exponential summation" by George A. Campbell; and third, a paper printed in the *Bell System Technical Journal*, October, 1926, entitled "Applications of Poisson's probability summation" by Francis Thorndike.

The present invention is the result of a contemplation of these formulæ and an effort to multiple trunks in such a manner that the assumption on which they are based will more

closely correspond with the equipment arrangement. The main effort is to make the calls submitted to any common trunk group originate more at random from a larger number of independent sources than heretofore. Essentially the present scheme consists in a novel modification of the standard grading shown in Fig. 1 and comprises the use of several groups of common trunks each group being accessible to a subgroup of the group of incoming lines having access to the individual outgoing lines and being multiplied not only to the groups heretofore served but to a plurality of such groups.

Calculations based on the combined application of the Erlang B formula and the Poisson formula indicate that the call carrying capacity of the proposed rearranged graded multiple should be theoretically considerably greater than that of a corresponding standard graded arrangement as estimated by theoretical formulæ and limited empirical observations. This is because the common trunks are made accessible to calls a rather larger proportion of the time by means of their appearing before a number of relatively independent subgroups of selectives.

Looking now at Fig. 1 it will be noted that there are several groups of incoming lines represented by vertical arrows. Individual to the incoming lines of group 1 is a group of outgoing trunks 3 and individual to the group 2 of incoming lines is a group 4 of outgoing lines. A group 5 of outgoing lines is common to the incoming lines of both group 1 and group 2. Group 1 and group 2 constitute what we may here term a master group indicated by the bracket 6. For purposes of explanation, three such master groups 6, 7 and 8 are shown as representing an office unit.

In Fig. 2 an equal number of groups of lines numbered 15 to 20 inclusive are shown. Each group has a set of individual outgoing trunks 21 to 26 inclusive respectively. The common trunks, however, are arranged in a different manner. There are still the same number of groups of common trunks but in this system each group of common trunks is associated with a subgroup of incoming lines. For instance, group 27 of the common outgoing trunks is associated with subgroup 9 of group 15, subgroup 10 of group 16, subgroup 11 of group 17, etc. In like manner, group 28 of common outgoing trunks is associated with subgroup 30 of group 15 of the incoming lines, subgroup 31 of group 16 of the incoming lines, etc., and group 29 of the common outgoing trunks is associated with subgroup 32 of group 15 of the incoming lines, subgroup 33 of group 16 of the incoming lines, etc.

Thus, it will be seen that the common trunks, although still the same in number and being still accessible to the same number

of lines, nevertheless receive their traffic more at random from a large number of independent subgroups without requiring that a given selector have access to any more trunks than in the former standard arrangement. Therefore, such an arrangement as the one proposed may be expected to handle the traffic more efficiently.

Wholly apart from the gains in efficiency already discussed there is an added advantage in the proposed rearrangement in that even if the traffic is not properly balanced among the various groups and subgroups of incoming lines the arrangement shown in Fig. 2 is such that the effect of such unbalances would be minimized. For example, if group 15 of incoming lines consistently provided more traffic than some of the other groups, it would, to a certain extent, overload its individual group of outgoing trunks 21 but would share the common trunks with all the rest of the groups 16 to 20, among which would be the lighter loaded ones. On the other hand, if it should happen that, for example, the particular subgroups of incoming lines 9, 10, 11, 12, 13 and 14 should be unusually heavily loaded, the first choice individual trunks used by these subgroups would also be shared with less busy subgroups, so that by the time the traffic reached the common trunks it would be considerably smoothed out and no essential overload would result on any one of the groups of common trunks. This feature is of value in simplifying the administration of graded trunk groups.

What is claimed is:

1. The combination of a plurality of groups of incoming lines, a group of out-

going lines individual to each said group of incoming lines, and a group of outgoing lines common to one subgroup only of each of said groups of incoming lines.

2. The combination of a plurality of groups of incoming lines, a group of outgoing lines individual to each said group of incoming lines, and a plurality of groups of outgoing lines each group being common to one subgroup only of each of said groups of incoming lines.

3. The combination of a master group of incoming lines divided into groups and subgroups, a group of outgoing lines individual to each said group of incoming lines and common to all the subgroups thereof and a group of outgoing lines common to said master group of incoming lines and individual to one subgroup only of each said group of incoming lines.

4. The combination of a plurality of groups of incoming lines, a plurality of first choice outlets individual to each said group and a plurality of second choice outlets common to one subgroup only of each of said groups.

5. The combination of a plurality of groups of incoming lines, a plurality of first choice outlets individual to each said group and a different plurality of second choice outlets for each subgroup only of each of said groups, each said plurality of second choice outlets being common to all said plurality of groups of incoming lines.

In testimony whereof, I have signed my name to this specification this 14th day of September, 1927.

PAUL P. COGGINS.