E. A. GRAY.

METHOD OF AND MEANS FOR CONNECTING TELEPHONE APPARATUS.

APPLICATION FILED JULY 30, 1907.

1,002,388.

Patented Sept. 5, 1911.

5 SHEETS—SHEET 1.

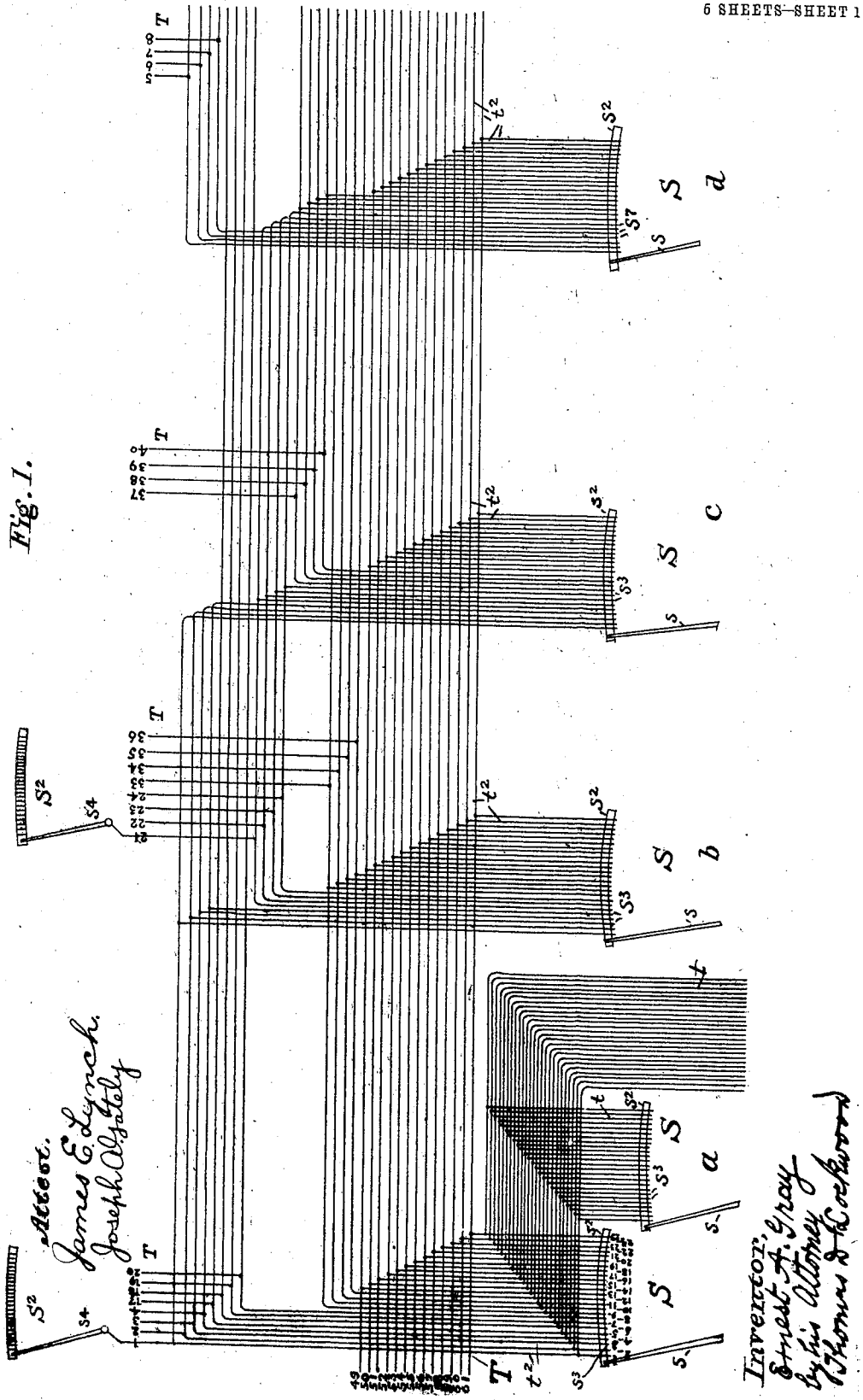

Fig. 1.

Witnesses:
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Inventor:
Ernest A. Gray
by his Attorney
Thomas & Coleman

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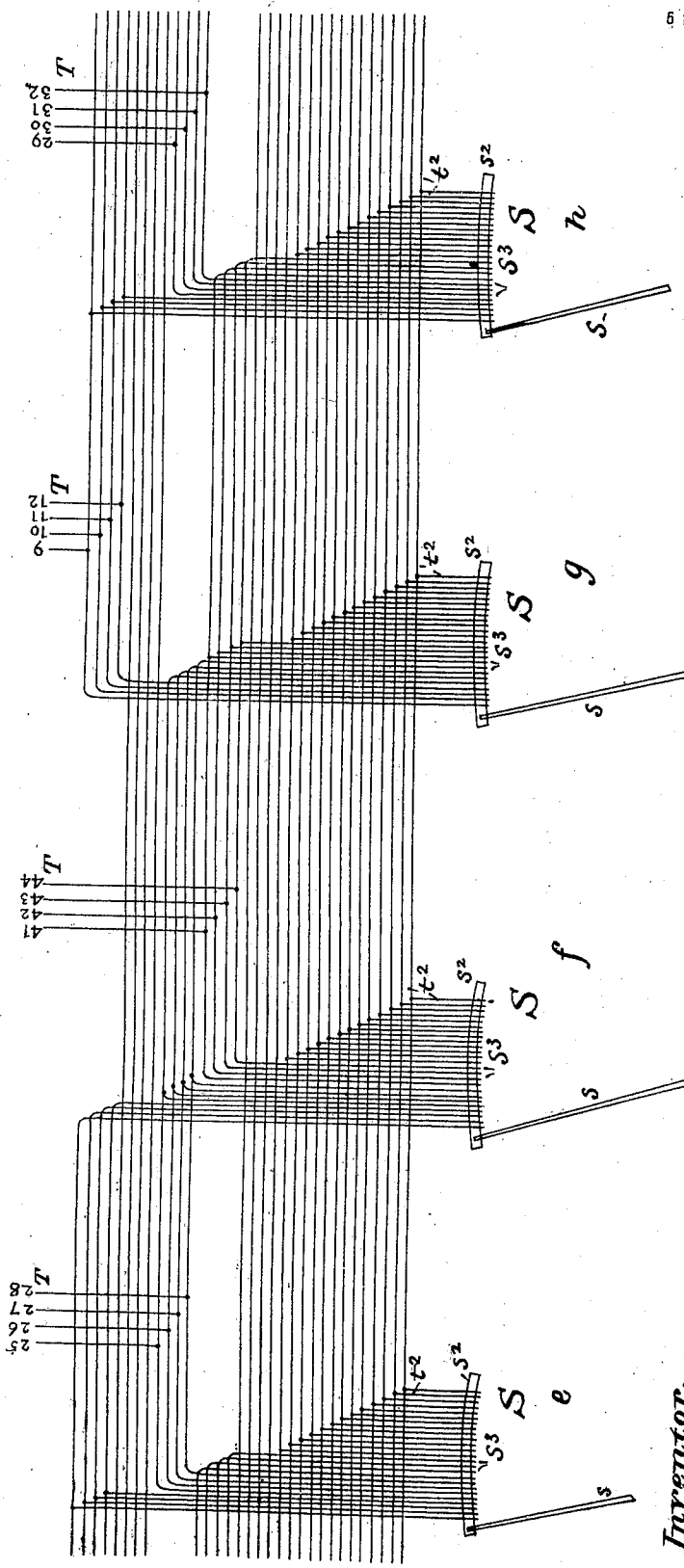

Fig. 2.

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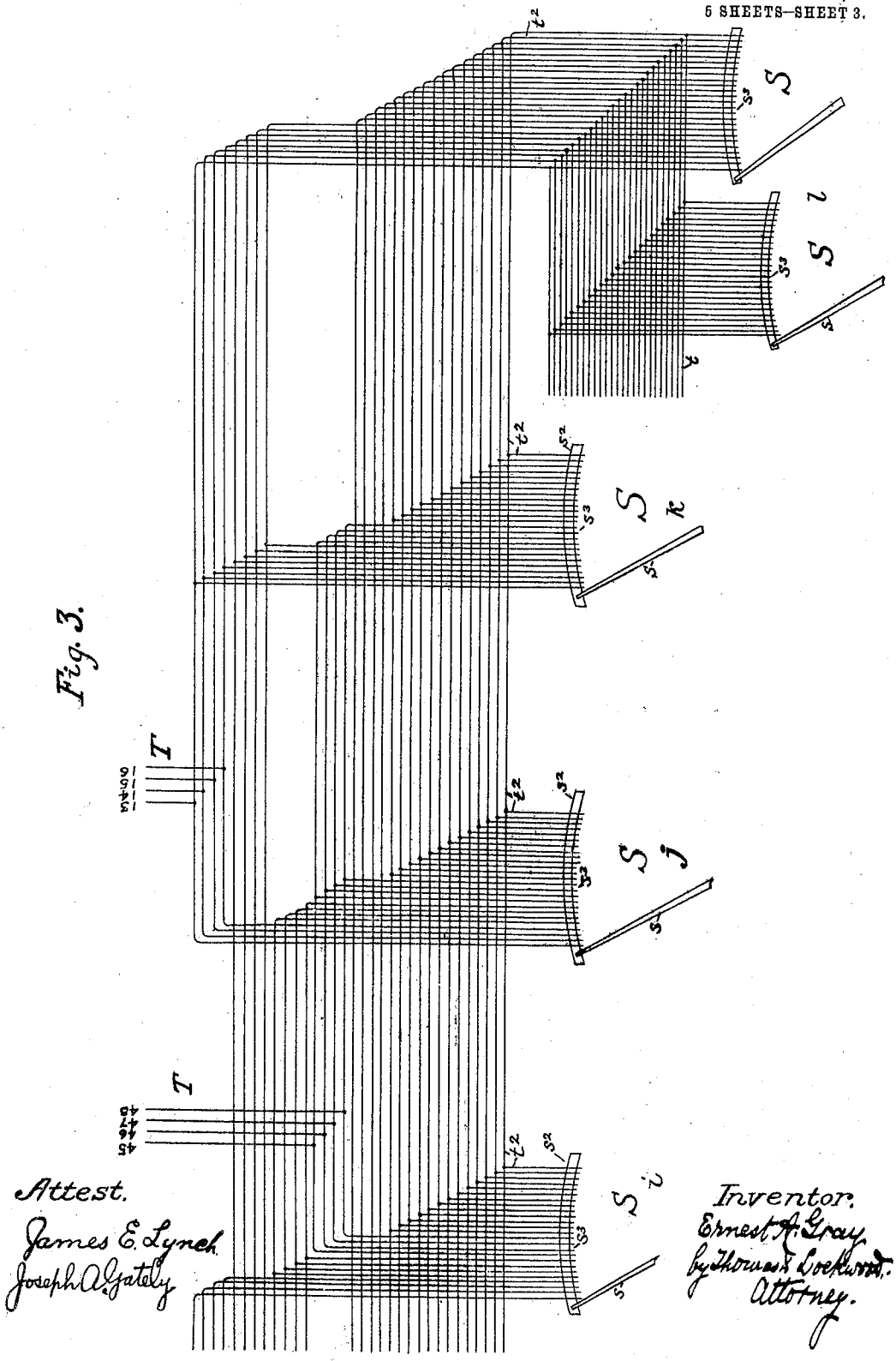

Fig. 3.

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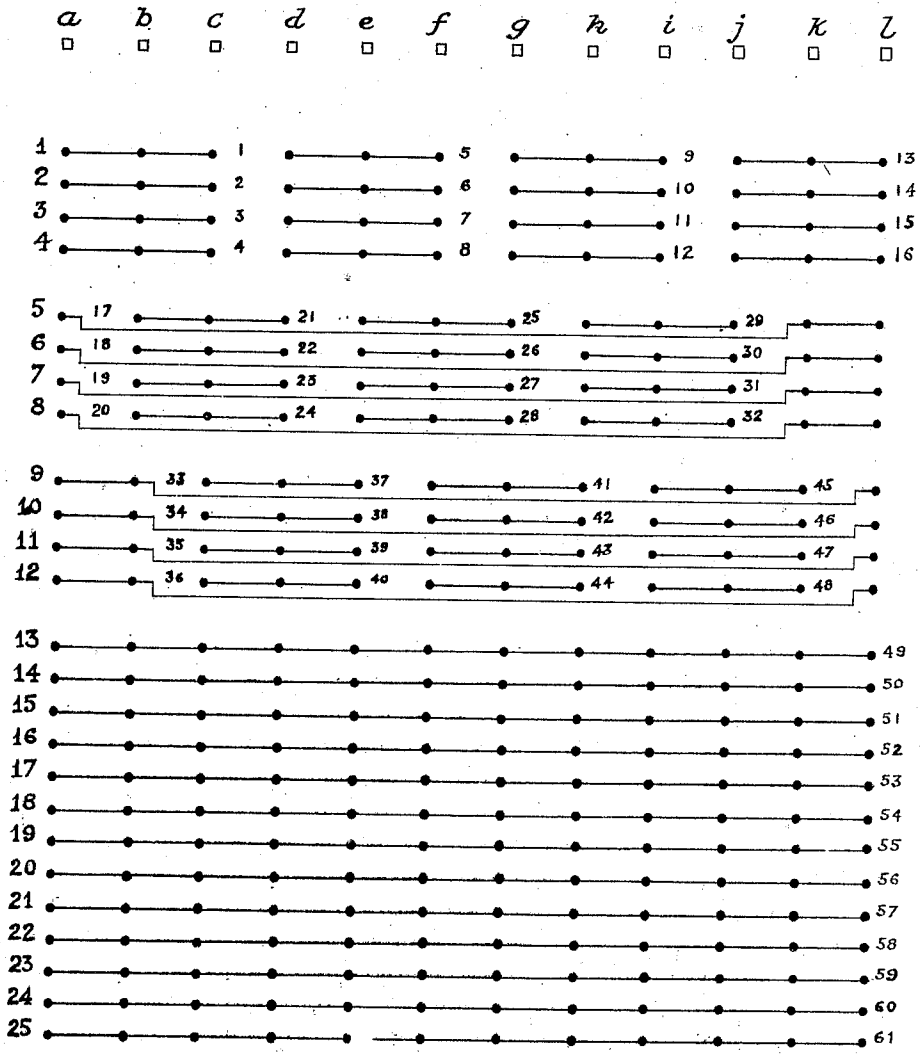
5 SHEETS—SHEET 4.

Fig. 4.



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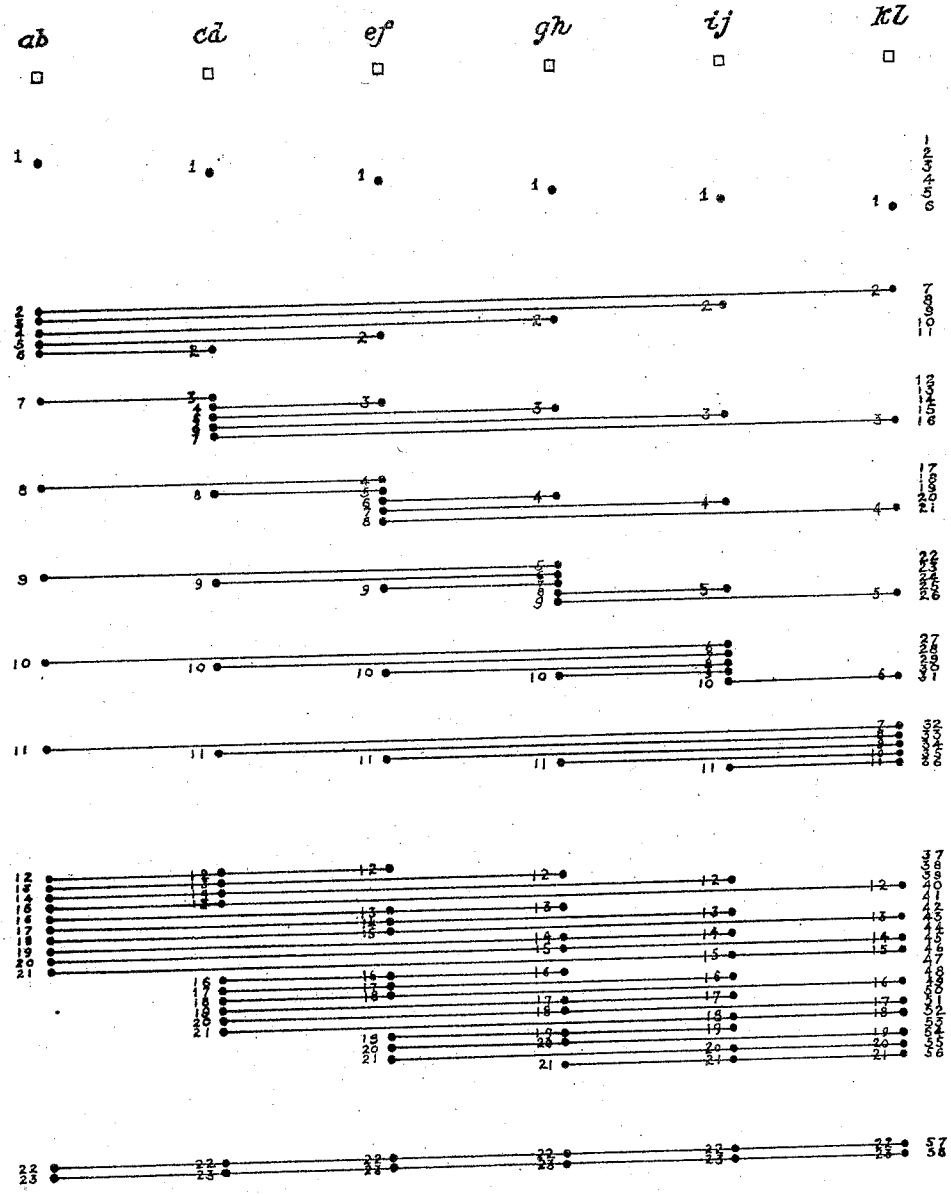
5 SHEETS—SHEET 5.

Fig. 5.



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UNITED STATES PATENT OFFICE.

ERNEST A. GRAY, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, OF BOSTON, MASSACHUSETTS, A CORPORATION OF NEW YORK.

METHOD OF AND MEANS FOR CONNECTING TELEPHONE APPARATUS.

1,002,388. Specification of Letters Patent. Patented Sept. 5, 1911.

Application filed July 30, 1907. Serial No. 386,249.

To all whom it may concern:

Be it known that I, ERNEST A. GRAY, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain Improvements in Methods of and Means for Connecting Telephone Apparatus, of which the following is a specification.

In telephone systems, in furnishing connecting paths between a plurality of primary points and other or secondary points, it is customary to so employ the intermediate trunks or conductors that each primary point has access to every trunk, or that separate and uniform groups of primary points are similarly multipled to independent groups of trunks equal in number. For example, if there be ten trunks connecting a manual switchboard of twenty sections with a private branch exchange, each of the trunks will appear, that is, will be represented by a switch terminal at each section, so that the total number of such appearances will equal two hundred; or, referring to a like group of ten trunks for uniting succeeding points in an automatic switching system, if one hundred primary electromechanisms are to make use of the trunks they must be multipled thereto one thousand times. But in such an automatic or electromechanical switching system, it is often found that any class of switches must be separated into divisions with independent groups of multipled trunks, on account of the limitations of available commercial machines. The latter case is one in which the present invention may be used with great advantage and an application of my improved method to a generally similar arrangement will hereinafter be more particularly described. Therefore, the arrangement of this divided multiple will be made clearer by a specific instance. Assume that the largest selecting switch that can be efficiently employed has five hundred sets of fixed terminals, to each of which sets a trunk or subscriber's line may be connected, and that they are to be installed in a ten-thousand-line exchange. The wanted line will be finally reached through some one of twenty groups of secondary selectors of five hundred lines each.

We will here specifically consider the primary selectors, which would pick out the proper one of these five-hundred groups and then an idle trunk leading thereto. As each primary selector must have access to each group, its five hundred sets of terminals must be divided into twenty sections, and, assigning the same number of trunks to each section, this would give twenty-five trunks by means of which all of the ten thousand subscribers could be connected with a called subscriber in a particular five-hundred group. But, obviously, many more than twenty-five simultaneous calls for five-hundred subscribers must often be expected. Therefore, it becomes necessary to segregate the primary selectors into such divisions that if satisfactory service is to be given the probability of more than twenty-five calls coming into any one division at the same time will be slight. A typical case of call distribution in an exchange of this character will now be presented, for use in illustrating existing conditions and in explaining my invention.

Let it be assumed that the average length of telephone conversations is two minutes, and that sufficient trunks must be provided to handle without delay all the calls of the busiest two-minute period. Considering now any one of the twenty final groups of five hundred lines, suppose that traffic studies of such an exchange as that in question show that for it fifty-seven calls may be expected during said busiest period, these falling by chance as regards their distribution through this period and also among the primary points through which they are to come. It will be evident that if the machines permitted, fifty-seven trunks multipled through all the primary selectors and each terminating in a connector would meet the demands. But since, as previously indicated, the primary selectors obtainable have but twenty-five terminals for each five-hundred group, they must be separated into divisions. Of course the number of divisions must be such that no one will receive more than twenty-five calls during the busiest period. Assume twelve of these designated

by the letters *a* to *l*, inclusive, through which the fifty-seven calls are fortuitously distributed as tabulated below:

Divisions	a	b	c	d	e	f	g	h	i	j	k	l
Calls	6	1	4	7	8	10	6	5	3	0	5	2

From this it appears that three is the minimum number of divisions from which twenty-five calls would originate. Consequently twenty-five trunks can only be depended upon to care for any three divisions, through which they will be multipled, and since there are altogether four groups of three divisions each, a total of one hundred trunks would be necessary. For two reasons the efficiency of a trunking system thus divided is low. First, there is an excess of trunks for carrying the maximum load, since evidently those joined to the last terminal in the sections of twenty-five, say the twentieth to the twenty-fifth, with which the movable switching members last coöperate, will be seldom used in any one group and never in two simultaneously, yet they appear in every division. Second, there is a needlessly frequent multipling of the more busy trunks. This is due to the fact that those, over the terminals of which the movable contact arms first sweep, would invariably be used during busy periods of multipled through only a portion of the selectors of a group, are, nevertheless, connected to all.

The purpose of this invention is to so connect primary or transmitting points (by which is meant any apparatus in a series through which a telephone call progresses, other than that to be ultimately reached) and any apparatus later in the series (which may be termed secondary or desired points) that the intermediate trunks or conductors will be highly efficient. A condition is at least approached in which the minimum number of trunks will provide without delay for the calls of the busiest period and with a symmetrical distribution of load. To accomplish this, instead of splitting the trunks into uniform divisions determined by the maximum number of simultaneous calls originating at the primary points which they serve, I divide the trunk multiple, varying the number of appearances at different primary points, this depending upon their order of use. Moreover, these divisions of the multiple are arranged in sections with respect to the terminals to which the trunks are united in the primary apparatus, the multiple groups of successive sections being rotated or progressively varied. A concrete case of this graded multiple will now be described, in its application to a system in which the same general conditions of machines and their terminals obtain as have just been set forth. Although no attempt has been made to present an example giving the greatest efficiency, the gain resulting from the employment of my method is clearly shown.

In the accompanying drawings, Figures 1, 2 and 3, taken together, furnish a diagrammatic illustration in detail of my improved system of connection; Fig. 4 is a schematic representation of the same; and Fig. 5 is a schema of another embodiment of the invention.

Referring to Figs. 1, 2 and 3, switches S' are illustrated which may be considered as primary selectors of any convenient type, these switches having the usual movable arms or members *s*, commonly arranged in sets of three, of which but one appears, and these sets and their coöperating contacts will hereinafter be referred to as though there were but one of each. The arms are adapted under the control of some calling point to choose a section s^2, of which there are twenty corresponding to the five-hundred groups in the ten thousand lines of the exchange, but one of said sections in each switch being shown. Each arm after reaching the proper section s^2 picks out a fixed contact member or terminal s^3, of which there are twenty-five, numbered consecutively from one to twenty-five in the order in which the arms coöperate with them. The selected terminal has connected to it a trunk or set of conductors T leading to the arm s^4 of a secondary selector or connector S^2. Only two of these secondary switches are illustrated, and with but a portion of their five hundred fixed terminals. To said terminals are joined the substation lines, among which is that of the called subscriber. For present purposes we need only consider the calls intended for a single five-hundred group reached through the section of the primary switches which has been illustrated. As is the case in the ordinary divided multiple, it is necessary to make some such preliminary separation of the primary switches that divisions will be obtained from which the calls into the selected five-hundred group will not exceed the trunk capacity of the section (25) during the busiest two-minute period. As before, twelve have been taken, over which the calls are distributed as already tabulated. The letters from *a* to *l* inclusive, also designate these divisions, and within each the apparatus is multipled in the usual manner by conductors *t*, this being indicated only at *a* and *l*, so that any switch may appropriate any unused trunk of those multipled to its division. But now instead of maintaining these divisions in four rigid groups of three each, with twenty-five trunks multipled throughout the series of twenty-five contacts of their sections, the terminals which come first in the sections and are therefore most used, this being here shown as the sets numbered from one to twelve in-

clusive, are multipled to the trunks T in groups of three divisions by conductors t^2. The remaining thirteen sets of terminals or those numbered from thirteen to twenty-five, which are less frequently employed or which are needed to carry the peaks of the load, are similarly multipled but in larger groups. In this specific instance a single trunk serves all of a set of terminals of one number through the twelve divisions. It will be seen that the trunks available to continue the circuit from the later terminals are not multipled unduly, the extent of the multipling in each case bearing a definite relation to the amount which the particular set of terminals is used and therefore tending to give a uniform load upon all trunks. As to the first twelve sets of terminals, the load is distributed and any tendency to congestion within their groups of divisions is relieved by rotating the multipled groups with respect to one another. Thus, while for the first four sets of terminals beginning with terminal 1, divisions, *a*, *b*, *c*; *d*, *e*, *f*; *g*, *h*, *i*; *j*, *k*, *l* are multipled to separate trunks, for the second section comprising the sets of terminals 5, 6, 7 and 8 the multipled groups consist of *b*, *c*, *d*; *e*, *f*, *g*; *h*, *i*, *j*; *k*, *l*, *a*, and for the third four sets of terminals 9, 10, 11 and 12 they comprise divisions *c*, *d*, *e*; *f*, *g*, *h*; *i*, *j*, *k*; *l*, *a*, *b*; all groups being uniform in the number of divisions but varying with respect to the particular divisions constituting the groups of different terminal sets. So a call from division *a* may not only find its way over a trunk used with *b* and *c*, and in the last thirteen sets of terminals with all the divisions in common, but also in the earlier busy groups with the divisions *k* and *l*. As it is improbable that the busy period of these various divisions will coincide, the load on the trunks is equalized. The service is now handled by sixty-one trunks where one hundred were necessary with the simple divided multiple. When it is remembered that each trunk must have at its termination a comparatively costly automatic machine, the gain in economy in dispensing with thirty-nine trunks in one hundred will be appreciated.

The grading of the multiple in regard to both the different number of appearances of the trunks and the rotating of the groups is very clearly brought out in Fig. 4 of the drawings, in connection with which the previous description of the first three figures may be easily read. Here the horizontal row of squares *a* to *l* indicate the primary points or divisions. Each of the horizontal straight lines corresponds to a trunk multipled to the set of terminals in the primary switches the number of which is shown in the vertical column of figures at the left, and through the divisions below which dots are placed upon the lines. The figures at the right of each line indicate the numbers of the trunks and correspond to those of Figs. 1, 2 and 3. Considering any particular trunk, say No. 48, a glance at Fig. 4 shows that it is multipled to the twelfth terminal through divisions *i*, *j*, and *k*, while the trunk next in number, 49, is connected to the thirteenth terminal in all twelve divisions. A similar scheme for the divided multiple as previously practiced and with which my invention has been herein compared, would consist of four columns of lines each extending beneath three primary points. That is, four sections of twenty-five trunks each, instead of sixty-one trunks with which I am able to handle the same volume of traffic. By my organization there is attained a trunk-efficiency of ninety-three per cent., while by the arrangement of previous practice an efficiency of only fifty-seven per cent. is secured. To demonstrate that the fifty-seven calls actually can be disposed of over sixty-one trunks during the busy two-minute period, said period will be divided into eight fifteen-second intervals and each call will be considered to originate at the beginning of some one of these intervals. To still more closely approach the conditions of practice a preceding two-minute period will be assumed during which forty-five calls will occur which may overflow into the busy period and which are distributed through the divisions as follows:

Divisions	a	b	c	d	e	f	g	h	i	j	k	l
Calls	6	7	4	6	1	1	0	1	1	6	7	5

We therefore have sixteen fifteen-second intervals during which one hundred and two calls must be cared for. These have been allowed to fall by chance as shown in the following list, in which each call is designated by a numeral and a letter, the former indicating in which of the fifteen-second intervals it occurs and the latter the division in which it originated. A serial number in brackets is also affixed for convenience in distinguishing the calls.

First period.	*Busy period.*	*First period.*	*Busy period.*	*First period.*	*Busy period.*
(1) 1—b	(46) 9—g	(20) 4—d	(65) 12—f	(39) 7—j	(84) 14—e
(2) 1—b	(47) 9—g	(21) 4—d	(66) 12—f	(40) 7—a	(85) 14—h
(3) 1—j	(48) 9—d	(22) 4—k	(67) 12—h	(41) 7—d	(86) 14—f
(4) 1—j	(49) 9—c	(23) 4—k	(68) 12—a	(42) 7—a	(87) 14—d
(5) 1—a	(50) 9—l	(24) 4—l	(69) 12—k	(43) 8—b	(88) 14—a
(6) 1—l	(51) 9—g	(25) 4—a	(70) 13—f	(44) 8—l	(89) 14—a
(7) 1—i	(52) 10—k	(26) 4—b	(71) 13—i	(45) 8—b	(90) 15—k
(8) 2—d	(53) 10—f	(27) 5—c	(72) 13—d		(91) 15—g
(9) 2—c	(54) 10—f	(28) 5—h	(73) 13—e		(92) 15—e
(10) 2—a	(55) 10—g	(29) 5—l	(74) 13—i		(93) 15—c
(11) 2—c	(56) 11—d	(30) 5—k	(75) 13—h		(94) 16—h
(12) 2—a	(57) 11—c	(31) 6—k	(76) 13—k		(95) 16—f
(13) 3—e	(58) 11—d	(32) 6—d	(77) 13—l		(96) 16—d
(14) 3—f	(59) 11—f	(33) 6—d	(78) 13—a		(97) 16—f
(15) 3—j	(60) 11—e	(34) 6—k	(79) 13—a		(98) 16—e
(16) 3—k	(61) 11—b	(35) 6—j	(80) 13—b		(99) 16—e
(17) 3—k	(62) 11—i	(36) 6—c	(81) 13—g		(100) 16—k
(18) 3—b	(63) 11—e	(37) 6—b	(82) 14—d		(101) 16—i
(19) 4—i	(64) 11—e	(38) 7—j	(83) 14—f		(102) 16—a

These calls are disposed of as shown below, the first column giving the number of

the trunk used and the second the designation of the call or calls passing over it. The four call spaces in which the word "Idle" appears indicate the only available trunks which are not taken up during the busy period.

Trunks.	Calls.				Trunks.	Calls.			
1.	(5)	1—a.	(49)	9—c.	32.	(15)	3—j.	(61)	11—h.
2.	(1)	1—b.	(57)	11—c.	33.	(37)	6—b.	(102)	16—a.
3.	(2)	1—b.	(68)	12—a.	34.	(26)	4—b.	Idle.	
4.	(10)	2—a.	(78)	13—a.	35.	(29)	5—l.	Idle.	
5.	(8)	2—d.	(53)	10—f.	36.	(24)	4—l.	Idle.	
6.	(13)	3—e.	(56)	11—d.	37.	(27)	5—c.	(73)	13—e.
7.	(20)	4—d.	(65)	12—f.	38.	(36)	6—c.	(92)	15—e.
8.	(14)	3—f.	(58)	11—d.	39.	(32)	6—d.	(87)	14—d.
9.	(47)	9—g.			40.	(33)	6—d.	(84)	14—e.
10.	(46)	9—g.			41.	(59)	11—f.		
11.	(28)	5—h.	(81)	13—g.	42.	(66)	12—f.		
12.	(19)	4—i.	(67)	12—h.	43.	(70)	13—f.		
13.	(3)	1—j.	(69)	12—k.	44.	(83)	14—f.		
14.	(4)	1—j.	(76)	13—k.	45.	(31)	6—k.	Idle.	
15.	(6)	1—l.	(52)	10—k.	46.	(30)	5—k.	(71)	13—i.
16.	(7)	1—l.	(50)	9—l.	47.	(23)	4—k.	(100)	16—k.
17.	(12)	2—a.	(79)	13—a.	48.	(22)	4—k.	(90)	15—k.
18.	(16)	3—k.	(77)	13—l.	49.	(40)	7—a.	(96)	16—d.
19.	(17)	3—k.	(88)	14—a.	50.	(42)	7—a.	(91)	15—g.
20.	(25)	4—a.	(89)	14—a.	51.	(43)	8—b.	(99)	16—c.
21.	(9)	2—c.	(80)	13—b.	52.	(45)	8—b.	(98)	16—e.
22.	(11)	2—c.	(74)	13—c.	53.	(97)	16—f.		
23.	(21)	4—d.	(82)	14—d.	54.	(41)	7—d.	(93)	15—c.
24.	(18)	3—b.	(72)	13—d.	55.	(48)	9—d.		
25.	(60)	11—e.			56.	(63)	11—e.		
26.	(55)	10—g.			57.	(64)	11—e.		
27.	(54)	10—f.			58.	(75)	13—h.		
28.	(51)	9—g.			59.	(62)	11—i.		
29.	(39)	7—j.	(94)	16—h.	60.	(34)	6—k.	(86)	14—f.
30.	(38)	7—j.	(101)	16—i.	61.	(44)	8—l.	(95)	16—f.
31.	(35)	6—j.	(85)	14—h.					

The arrangement of multipling which has just been described is a simple one, in which the division groups of the earlier terminals are uniform, and are equal in number to those in the instance from previous and standard practice of dividing the multiple already mentioned, it having been chosen for the purpose of more clearly illustrating the feature of rotation. It does not, however, exemplify the reduction in the multipling of the busier sets of terminals by assigning the trunks to the service of a less number of divisions. Such a system more intricate in character but attaining greater economy in trunks is illustrated schematically in Fig. 5 of the drawings, which generally follows the plan of Fig. 4, the twelve divisions, however, having been reduced to six, in which it may be considered that the apparatus of the previous case is consolidated as indicated by the pairs of reference letters. As the sets of terminals now involved are not the same throughout all the multipled groups, each terminal dot has its own number placed at the left, there being now assumed to be twenty-three of these in each five-hundred section of the primary switches. An inspection of this figure will make it plain that the first or busiest terminal has the exclusive use of a trunk in every division, the column of numerals at the right of the sheet showing that there are six of these. Then the divisions are joined in all possible permutations of two. First the terminals 2, 3, 4, 5 and 6 of division *a b* have trunks multipled to the second terminal set of the other divisions: Then the succeeding terminals of division *c d* are similarly connected, this being to the seventh of division *a b* and the third set of the others, and so on until 7, 8, 9, 10 and 11 of division *k l* are united to the eleventh terminal set of the companion divisions. This requires thirty more trunks. Next the divisions are multipled in all the combinations of three, thus adding twenty trunks. Finally two trunks are each joined to the twenty-second and twenty-third sets of terminals throughout the divisions. This arrangement of the multiple is even more efficient than that first described, for it will be found that but fifty-eight trunks connected to twenty-three terminals will enable the previously assumed set of calls to be cared for. The improved result, however, flows from the same broad principle of providing for a different number of appearances of the trunks in the multiple in accordance with the order in which they are used, and of progressively varying the multiple groups which contain certain divisions in common.

I claim:

1. The method of connecting telephone conductors between primary points and other points which consists in causing each conductor to appear at one or more of the primary points, the number of such appearances differing with different conductors and arranging said appearances so that conductors are used only in a definite order with reference to other conductors.

2. The method of multipling a series of telephone conductors connecting primary points and secondary points which consists in causing each conductor to appear at one or more of the primary points, the number of such appearances varying according to the order of use of the conductor and arranging said appearances so that conductors are used only in a definite order with reference to other conductors.

3. The method of connecting conductors between primary points and other points, consisting in rendering said conductors available at groups of primary points arranged in permutations and arranging said conductors to be available at their primary points in a definite order with reference to the availability of other conductors.

4. The method of multipling telephone trunks connecting a series of transmitting points with other points of the system which consists in causing each trunk to appear at one or more transmitting points, the number of such appearances differing with different trunks, and in rendering certain of the trunks available at a plurality of progressively varying groups of transmitting points, substantially as set forth.

5. A telephone system comprising a series of switching apparatus, other apparatus to which said switching apparatus are to be connected, and conductors joined to said other apparatus and with different con-

ductors multipled through different numbers of switching apparatus, the total number of these multiples or appearances at each switch being the same, and each conductor multipled to a switching apparatus being arranged to be there used in a definite order with reference to other conductors multipled to said apparatus.

6. A telephone system comprising switching apparatus arranged in a series of divisions, secondary apparatus to which said switching apparatus are to be connected, and intermediate conductors extending to the secondary apparatus, different conductors being multipled through different groups of divisions but with certain of the divisions common to a plurality of groups.

7. A telephone system comprising divisions of selecting apparatus provided with contacts, other apparatus to which said selecting apparatus are to be connected, and conductors extending to the last-named apparatus and being multipled to sets of contacts through groups of divisions of the selecting apparatus, said groups being arranged in rotation with respect to successive contacts.

8. A telephone system comprising divisions of selecting apparatus, other apparatus, and conductors extending to the last-named apparatus, certain of said conductors being multipled through equal groups of divisions of the selecting apparatus and with the groups arranged in rotation and having divisions common to certain groups, and other of the conductors being multipled through groups including a different number of divisions, substantially as described.

9. The combination with a series of switches each having a series of terminals and a movable member for successive cooperation therewith, of trunks for extending the circuit from the switches, with different trunks multipled to a different number of terminals in the various switches, the total number of terminals at each switch to which the trunks are thus multipled being the same for all of the switches.

10. The combination with a series of switches each having a series of terminals and a movable member for successive cooperation therewith, of trunks for extending the circuit from the switches and being multipled to the terminals, the multipling of the terminals with which the movable member first coöperates being less frequent than to those later in the series.

11. In a telephone exchange system, the combination with a series of electromechanical switches each having a series of terminals and a movable contact member for cooperation therewith, of trunks for extending the circuit from the switches, certain corresponding terminals in the series of a portion of the switches being connected to trunks in groups, while other corresponding terminals in the series are connected to other trunks in groups differing in the number of terminals from the first-named groups.

12. In a telephone exchange system, the combination with switching mechanisms each having a movable contact member and a series of terminals with which the movable member coöperates in a definite order, of trunks connected to groups of terminals formed among sets of terminals which occupy corresponding positions in the series, the groups of different terminal sets being differently arranged with respect to the switches the terminals of which are included therein.

13. In a telephone exchange system, the combination with switching mechanisms each having a movable contact member and a series of terminals with which the movable member coöperates in a definite order, of trunks connected to groups of terminals formed among sets of terminals which occupy corresponding positions in the series, a group of one terminal set including the terminals of switches belonging to a plurality of groups in another set.

14. In a telephone exchange system, the combination with switching mechanisms each having a movable contact member and a series of terminals with which the movable member coöperates in a definite order, of trunks connected to groups of terminals formed among sets of terminals which occupy corresponding positions in the series, said groups being also arranged in sections consisting of a plurality of terminal sets, the corresponding groups in all the terminal sets of one section including the terminals of the same switches and the groups of another section being differently constituted.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses, this twenty-third day of July 1907.

ERNEST A. GRAY.

Witnesses:
THOMAS D. LOCKWOOD,
WILLIAM C. PEARSON.