

PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Improvements in or relating to Telephone Systems.

We, AUTOMATIC TELEPHONE & ELECTRIC COMPANY LIMITED, of Strowger Works, Liverpool 7, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to circuit arrangements in automatic telephone systems of the type using crossbar switches in the selecting stages and is more particularly concerned with circuit arrangements for subscribers' line circuits and line-selector primary switches in a so-called self-steering system such as that described in co-pending Application No. 15974/59 (Serial No. 890,235).

The main object of the invention is to provide reliable circuit arrangements as aforesaid, which will enable calls, incoming to and outgoing from subscribers' line circuits, to be dealt with in an expeditious and efficient manner.

According to the invention, in circuit arrangements comprising a primary selector and associated subscribers' line circuits of a line-selector division involving a plurality of primary selectors and secondary selectors of the crossbar type, said selectors being adapted to set up connections therethrough to subscribers' line circuits in respect of originating and terminating calls, for terminating-call marking purposes each subscriber's line circuit is provided with an individual marking lead extending from a marker serving a plurality of primary selectors, and the marking leads of each subscriber's line circuit associated with a pri-

mary selector extend individually into said primary selector which is also provided with first and second discriminating leads connected to said marker, the arrangements being such that the marking leads of those of said subscribers' line circuits which are busy (e.g. as regards call originations or established through connections) are extended over first paths within the primary selector to said first discriminating lead and the marking leads of those of said subscribers' line circuits which are idle are extended over second paths within the primary selector to said second discriminating lead, the relevant one of said first paths being utilized to extend a marking condition, applied by the marker to the marking lead of a busy subscriber's line circuit for call-terminating purposes, to said first discriminating lead to disable the marker, the relevant one of said second paths being utilized to extend a marking condition, applied as aforesaid to an idle subscriber's line circuit, to said second discriminating lead to enable the marker to condition the primary selector preparatory to the setting-up of a terminating-call connection there-through.

The invention will be better understood from the following description of the preferred method of carrying it into effect which should be read in conjunction with the drawings accompanying the Provisional Specification comprising Figs. 1—7. Of these drawings:—

Fig. 1 shows, in outline, the internal trunking arrangements of a crossbar line-selector primary switch arranged for so-called triple-group working;

Fig. 2 represents a subscriber's line circuit; and

Figs. 3, 4, 5 and 6, when arranged in accordance with Fig. 7, illustrate the circuit details of a line-selector crossbar primary switch in accordance with the invention.

THE SWITCHING PATHS THROUGH THE CROSSBAR SWITCH (Fig. 1).

The internal trunking arrangements of a crossbar switch for use as a line-selector primary switch circuit is illustrated in simplified form in Fig. 1. The switch incorporates a conventional crossbar mechanism of the 12×10 type, i.e. having twelve selecting magnets and ten bridge magnets, but is arranged for what may be termed triple-group working. With the particular arrangement, the ten "inlets", which are connected individually to links 1LK to 10LK and which are preferably distributed over eight line-selector secondary switches, may be selectively switched to any one of 26 "outlets" upon which subscribers' line circuits SLC1 to SLC26 are terminated. The ten bridges BR1 to BR10 are represented vertically, and the positions of references 1SM to 9SM are indicative of the effective positions of the nine select magnets with respect to the switch crosspoints which they control in each bridge, and likewise the references 1AM to 3AM, correspond to the effective positions of auxiliary select magnets with respect to other crosspoints in each bridge.

The mechanism of the switch is preferably of the conventional type in which an individual axially-pivoted select bar, carrying a selecting finger for each bridge, is

associated with each pair of selecting magnets 1SM and 2SM, 3SM and 4SM...9SM and 3AM, 2AM and 1AM. The operation of a selecting magnet swings the select bar in the appropriate direction whereby the fingers are so positioned, with respect to corresponding crosspoints in each bridge, as to enable one of said crosspoints to be actuated by subsequent operation of a bridge magnet. In this conventional type of switch mechanism the crosspoint remains operated under control of the operated bridge magnet when the selecting magnet has been released.

In the simplified illustration, each bridge is represented by three bridge commons (long vertical lines), with three co-pending contact points (short vertical lines) for each of the select magnets 1SM to 9SM, together with individual contact points controlled by the auxiliary magnets 1AM to 3AM. Thus it would appear that single conductor connections are effected by the switch. In fact, however, a path through the switch involves three conductors, namely + and - (speech) and P (private) conductors. Accordingly the bridges actually have nine bridge commons and a similar number of contact points are provided at each of the crosspoints associated with select magnets 1SM to 9SM, whereas three contact points are provided in each bridge for each of the auxiliary magnet crosspoints.

The 26 subscribers' line circuits, SLC, are multiplied through all 10 bridges in the manner shown so that they are associated with the crosspoints of select magnets 1SM to 9SM as follows:—

75	SLC	...	...	1	4	7	10	13	16	19	22	25
				2	5	8	11	14	17	20	23	26
				3	6	9	12	15	18	21	24	
	Select Magnets			1SM	2SM	3SM	4SM	5SM	6SM	7SM	8SM	9SM

80 The ten links 1LK to 10LK are associated with bridges BR1 to BR10 respectively and are each connected to contact points relevant to crosspoints controlled by the auxiliary magnets 1AM to 3AM. It can

be deduced that the subscribers' line circuits are related, by the bridge commons, to the crosspoints of the various auxiliary magnets in the following manner:—

90	SLC	...	1	4	7	10	2	5	8	11	3	6	9	12
			13	16	19	22	14	17	20	23	15	18	21	24
			(group 1)				(group 2)				(group 3)			
	Auxiliary Magnets		1AM				2AM				3AM			

95 To assist in the understanding of the arrangement of the switch, the method of establishing a connection between link 4LK and subscriber's line circuit SLC10 will be

outlined. Firstly auxiliary magnet 1AM (which appertains to all line circuits of group 1) and select magnet 4SM are operated, and subsequently the bridge magnet 100

of bridge BR4 is operated. The latter in conjunction with magnet 4SM connects line circuits SLC10, SLC11 and SLC12 to the three groups of bridge commons in bridge BR4, whereas the same bridge magnet in conjunction with magnet 1AM connects link 4LK to the particular group of bridge commons to which line circuit SLC10 is connected. Thus it can be seen that the switching principal is such that a select magnet 1SM to 8SM, (9SM is an exception) operated in conjunction with a bridge magnet, connects three line circuits to three groups of commons of the particular bridge, whereas an auxiliary select magnet 1AM to 3AM, having enabled an auxiliary crosspoint in the same bridge to be operated, effects a selection whereby the link is connected to one of the three groups of commons and so to the particular subscriber's line circuit.

The switch would be controlled so that the auxiliary and select magnets are released immediately a connection has been set up, whereupon the connection is maintained solely by the operated bridge magnet. It will be appreciated that although the actual setting-up of connections through the switch must proceed on a one-at-a-time basis, each of the ten bridges may be occupied in respect of individual through-connections to different line circuits at the same time.

It will be observed that one group of contact points relevant to magnet 9SM in each bridge is not wired and may be omitted since it is not available for use. It is not possible to use these contact groups to provide a twenty-seventh outlet, because auxiliary magnet 3AM and select magnet 9SM control the same select bar, and consequently both magnets cannot be operatively effective at the same time.

Before proceeding with a detailed description of the operation of the circuits some general remarks will be directed to the representation of the circuit of the line-selector primary switch shown in Figs. 3 to 6. As mentioned in connection with Fig. 1 the switch is capable of serving 26 subscribers' line circuits SLC1 to SLC26. However, in general, if the line circuits are to be provided with both call origination and call termination facilities, only 25 e.g. SLC1 to SLC25 would be accommodated. This arises out of the fact that a line-selector division in a telephone system of the kind disclosed in co-pending Application No. 15974/59 (Serial No. 890,235) involves 20 primary and 8 secondary switches arranged for link working, and it is convenient to use a line marker, in each division, which will serve 500 (20 x 25) subscribers' line circuits in respect of incoming calls. However, the 26th line circuit, and indeed any other, of each primary switch may be used for a subscriber's station, e.g. coin collecting box,

which does not require the incoming call facility.

Referring to the primary switch circuit it will be appreciated that a certain amount of skeletonisation has been effected to simplify the drawing. Thus only the first of the ten bridges BR1 to BR10 is represented together with its associated link access path 1LK. The remaining bridges and link access paths would be arranged similarly. Again although each of the subscribers' line circuits SLC1 to SLC26 is connected to the switch circuit over a nine-conductor path, only those paths relevant to line circuits SLC1, SLC2 and SLC3 are fully represented and terminated. Thus it should be appreciated that, just as the -, + and P conductors of line circuits SLC1 to SLC3 are terminated upon the bridges in the manner outlined with respect to Fig. 1, the corresponding conductors of the remaining line circuits would also be terminated in accordance with the same drawing.

When the line-selector primary switch is available for use, relay G is in the operated state and accordingly its contacts are represented in this condition. Relay G is so operated over the following circuit: battery, resistor R2, select-magnet contacts 1SM2, 3SM2, 5SM2, 7SM2, 9SM2, 2SM2, 4SM2, 6SM2 and 8SM2, relay contacts OC2, MK12 and M11, left-hand winding of relay G, auxiliary magnet contacts 3AM3, 2AM3 and 1AM3 and the switch-busy test jack TJ1 to earth. The operation of relay G in this manner effectively ensures, *inter alia*, that none of the auxiliary and select magnets have remained operated, say due to mechanical failure, after use in respect of an earlier call.

With relay G operated, it is to be observed that contacts G1 direct the MA leads of the first group of subscribers' line circuits, SLC1, 4, 7, 10, 13, 16, 19, 22 and 25, to auxiliary magnet 1AM, whereas contacts G2 and G3 are similarly effective as regards the second (SLC2, 5, 8, 11, 14, 17, 20, 23 and 26) third (SLC3, 6, 9, 12, 15, 18, 21 and 24) line circuit groups. Relay G also, at contacts G4, connects earth over the left-hand winding of the originating call discriminating relay OC to lead OC of all subscribers' line circuits. Contacts G5 disconnect the fault alarm lamp LP.

CALL ORIGATION.

Referring to the typical subscriber's line circuit shown in Fig. 2, when the subscriber originates a call, the loop applied to the subscriber's line SL, and extending over the line intermediate distribution frame (LIDF) with its directory number side (DIR) and its equipment side (EQ), enables the slow-to-release line relay LR to operate over a circuit involving contacts P1, K3 and K2.

Thereupon contacts LR1 together with contacts P5 establish a connection between leads OC and MA of the access path LSP to the line-selector primary switch, whereas
 5 contacts LR2 connect leads AM and TO of the same path together, lead TM being disconnected. Contacts LR4 connect the originating class-of-service terminal CO to the forwardly extending-speech conductor.
 10 It should be mentioned that this terminal would be connected to one of leads OCA, OCB, OCC and OCD in the primary switch according to the class-of-service to be given to the caller. The strapping facility would
 15 be used, for instance, in the determination of particular grades of route-barring. Contacts LR3 besides preparing holding circuits for relays LR and P, connect earth to lead S and the latter condition would only be
 20 utilised in the case of two-party shared service.

The subscriber's line circuit remains in the present condition with relay LR operated until such time as the calling subscriber has been connected successfully by way of the relevant line-selector primary switch and a secondary switch to a transmission relay set and thence to a register.

Consider the effect of a single call origination upon the line-selector primary switch, and assume that this is in respect of line circuit SLC1 which is in the first group of line circuits and is therefore related to auxiliary magnet 1AM. It may be taken that relay G is already operated as described, and now a circuit is completed as follows: earth, contacts G4 and TC8, left-hand winding of relay OC, leads OC and MA (connected over contacts P5 and LR1 in the calling line circuit SLC1), contacts MA1, G1, MC9 and auxiliary magnet 1AM to battery. Also the lower winding of relay OS is connected in parallel with magnet 1AM, by way of auxiliary magnet contacts
 45 1AM4, 2AM4 and 3AM4. Relays OC and OS are therefore operated, but magnet 1AM will not operate in series with relay OC.

It is to be noted that prior to the present operation of line relay LR, a path existed between the line circuit marking wire M (accessible from line marker) and lead PA of the path MKR extending from the primary switch to the marker. The path may be traced from lead M, over lead SM, contacts MAR1, lead AM, contacts LR2, lead TM, contacts TM2 to lead PA. When none of the line circuits are in a call originating condition, it can be deduced that their marking wires would all be directed to lead PA of the marker over contacts TM2, TM4 or TM6 according to whether contacts of relay MAR, MBR or MCR are interposed between leads SM and AM of the line circuit, access paths, relays MAR, MBR and MCR being related to the afore-

said line circuit groups 1, 2 and 3 respectively. Under those conditions any of the line circuits could be successfully marked in respect of a call termination (incoming call).

However, now that a call has been originated typically over line circuit SLC1, the operation of relay LR thereof diverts lead AM to lead TO, and accordingly the path between the marking wire and lead PA is disconnected and the marking wire is extended over contacts TM1 to lead PB. This condition is indicative of the particular subscriber's line circuit being busy.

A similar condition would apply in the case of a call origination over another line circuit, contacts TM1, TM3 or TM5 being involved dependent upon the group appearance of the particular line circuit.

Reverting to the operation of relays OC and OS by a call origination over subscriber's line circuit SLC1, a perusal of the primary switch circuit shows that contacts G1 are identically connected with respect to all line circuits comprising group 1 (i.e. SLC1, 4, 7, 10, 13, 16, 19, 22 and 25) over contacts MA1 to MA9. Therefore a call originated over any line circuit of this group would be effective in operating relays OC and OS. A further study of the circuit shows that if a line circuit in group 2 or group 3, instead of group 1, had originated a call, the originating-call-discriminating relay OC would have been presented over contacts of relay MB or MC to auxiliary magnet 2AM or 3AM respectively, and in either event relay OC would operate although the magnet remains unoperated. In the case of group 2 or 3 call originations, relay OS is not concerned and would remain unoperated at this juncture.

Proceeding with the call origination in respect of line circuit SLC1, with relay OS operated contacts OS1 disconnect a point in the path to auxiliary magnet 2AM. The disablement of magnet 2AM in this manner is necessary to prevent a state of magnetic balance arising with respect to magnets 1AM and 2AM, which are oppositely effective on a common select bar, as would otherwise be the case if calls were concurrently originated by line circuits in groups 1 and 2.

With relay OC operated, contacts OC1 (Fig. 6) extend earth to lead AE of the start shift circuit SSC which is primarily concerned with the equitable distribution of traffic in the exchange. Contacts OC1 would initiate an alarm if relay OM failed to operate in due course. Contacts OC2 disconnect the original operate circuit of relay G, but meantime earth is returned to lead GP by the start shift circuit and is extended over contacts OC5, G7, TM8 and MK11 to retain relay G over its right-hand winding. The same earth also provides for the

holding of relay OC of its right-hand winding, and also operates relay OM, and is moreover extended over select magnet contacts 1SM3, 3SM3, 5SM3, 7SM3, 9SM3, 2SM3, 4SM3, 6SM3 and 8SM3 to operate relay M which is shunted by resistor R3. Relay OC is also effective at contacts OC3, OC4, OC7 and OC8 in applying different class-of-service potentials to leads OCA, OCB, OCC and OCD respectively, and, as already mentioned, one of these leads is connected to the class-of-service terminal in the subscriber's line circuit. Contacts OC6 prevent operation of relay TM.

With relay OM operated, contacts OM1 prepare to apply a forward marking earth to lead MO (originating call) of link 1LK, lead MT (terminating call) being disconnected. Bridges BR2 to BR10 are related to links 2LK to 10LK, in the same manner as bridge BR1 is related to link 1LK, and accordingly contacts OM2 to OM10 (not shown) prepare for the forward marking of leads MO of links 2LK to 10LK respectively. Contacts OM12 connect earth to lead DP of the start shift circuit, and furthermore disable the alarm lead AE of the latter. Contacts OM11 short-circuit the original operate winding of relay OC, and consequently auxiliary magnet 1AM operates.

With relay M operated by relay OC, contacts M11 disconnect a further point in the original operate path for relay G, contacts M12 prepare a holding circuit for relay M, and very importantly contacts M1 to M10 (of which M1 only is shown) complete the connection of forward marking earth to leads MO of those links which are not involved in other already established connections through the switch. It is to be noted that such busy links would be signified by the operated state of the relevant bridge magnets, and in these circumstances the bridge magnet contacts such as 1BM1 would prevent application of forward marking earth to the MO leads of the particular links.

Thus each available link has its MO lead forwardly marked by earth, and it may be taken that the line-selector secondary switches terminating these links, will proceed with the selection of one idle transmission relay set and an associated idle register.

Now that auxiliary magnet 1AM is operated, its contacts 1AM1 extend earth, over contacts TM9, to operate relay MA. Contacts 1AM3 disconnect a further point in the original operate path of relay G. Contacts 1AM2 provide a holding circuit for magnet 1AM, initially from earth at contacts G5. Contacts 1AM4 bring about the release of relay OS, and additionally con-

nect the lower winding of relay OS to select magnet 1SM. It may be mentioned that if the present call had been proceeding from group 2 or group 3 subscribers' line circuits, contact 2AM4 or 3AM4 of auxiliary magnets 2AM and 3AM respectively, would also have connected the lower winding of relay OS to select magnet 1SM. In any event the remaining windings of relay OS are individually connected to the odd-numbered select magnets 3SM, 5SM and 7SM.

With relay MA operated, contacts MA10 disable magnet 3AM, in case a call had been simultaneously originated in group 3, whereas contacts MA1 to MA9 divert the MA leads of the group 1 subscribers' line circuits (SLC1, 4, 7, 10, 13, 16, 19, 22 and 25) from auxiliary magnet 1AM to select magnets 1SM to 9SM respectively. In the present case where it is assumed that only line circuit SLC1 of the particular group has originated a call, select magnet 1SM operates over both windings, which are connected in series by contacts MK1, and the magnet duly self-holds over contacts 1SM2 to battery at resistor R2. Likewise if only line circuit SLC4, 7, 10, 13, 16, 19, 22 or 25 were calling, then select magnet 2SM, 3SM, 4SM, 5SM, 6SM, 7SM, 8SM or 9SM would operate over contacts MK2 to MK9 respectively, and duly self-hold to earth at resistor R2 over the relevant operated contact unit of 2SM2 to 9SM2 and the earlier unoperated contacts of the chain. It is to be observed that the contacts of the chain are arranged in the following order:— 1SM2, 3SM2, 5SM2, 7SM2, 9SM2, 2SM2, 4SM2, 6SM2, 8SM2. This is one of the factors which determines that in the event of simultaneous call originations over subscribers' line circuits of group 1, the order of priority of the line circuits is SLC1, 7, 13, 19, 25, 4, 10, 16, 22.

It is also important to note that the four windings of relay OS are individually connected to select magnets 1SM, 3SM, 5SM and 7SM so that this relay is operated whenever any one or more of these select magnets is energised. Thereupon contacts OS2, OS3, OS4 and OS5 disable the operate circuits of select magnets 2SM, 4SM, 6SM and 8SM respectively. This arrangement is to prevent a state of magnet balance arising in respect of the pairs of select magnets, 1SM and 2SM, 3SM and 4SM, 5SM and 6SM, 7SM and 8SM. Thus, if one or more calls are originated over line circuits SLC1, 7, 13 and 19 the operation of relay OS, by disabling the magnets 2SM, 4SM, 6SM and 8SM, renders any calls originating over line circuits 4, 10, 16 and 22 ineffectual for the time being. A call is therefore permitted to proceed from one of the complementary line circuits (SLC1, 7, 13 and 19), the order or priority being observed if two calls have

been originated simultaneously over the latter line circuits.

The windings of relay OS are not in any way associated with select magnet 9SM, since there is no possibility of this magnet, which is related to line circuits SLC25 and SLC26, being involved in a state of magnet balance at this juncture.

Continuing again with the assumption that subscriber's line circuit SLC1 has originated a call, the condition of the primary switch circuit at this point is that relays G, OC, OM and M and auxiliary magnet 1AM are operated, and moreover select magnet 1SM and relay OS are operated, the former self-holding. With magnet 1SM operated, contacts 1SM1 operate relay MK, while contacts 1SM3 disconnect relay M which is, however, rendered slow-to-release by the shunt resistor R3. Contacts 1SM3 also hold relay G independently of relay MK.

It may be noted that if instead of line circuit SLC1 a call were proceeding from another line circuit in group 1, contacts of the appropriate select magnets 2SM to 9SM would operate relay MK and disconnect relay M in a similar manner to that described.

In the normal course of events relay MK will operate before the forward-marking relay M has had time to release, and accordingly relay M holds over the following path, earth, lead GP (start shirt circuit), contacts OC5, G7, TM8, 1SM3, MK11 and M12, relay M to battery. Relay MK also, at contacts MK10 provides a holding circuit for itself to earth at contacts MA11, and at contacts MK1 to MK9 disables the operating paths of all the select magnets, leaving the operated select magnet maintained in series with resistor R2.

Again under normal circumstances, at this stage a transmission relay set and register will have been appropriated for the present call, and a particular line-selector secondary switch completes a connection from these two equipments to the -, + and P conductors of one of the primary switch links. The particular link, i.e. for instance 1LK, is backwardly marked by earth on the P wire. This condition operates the relevant bridge magnet 1BM, which now effects closure of the crosspoints in bridge BR1 which are relevant to the already operated auxiliary magnets 1AM and 1SM. Therefore the -, + and P conductors of the link are switched through to corresponding conductors of the calling subscriber's line circuit SLC1. The rectifier MR1 is included in the P-wire path to prevent holding of bridge magnets under certain conditions appertaining to trunk-offering by an operator.

Of the directly-operated bridge magnet contacts, 1BM1 remove earth from lead MO

and effectively busies-out link 1LK for the duration of the present call, and contacts 1BM2 open a branch path to the group-busy lead GB which would be de-energised, for example, when all the bridges of the primary switch are occupied.

With the register now connected to the calling line circuit, it proceeds to test the negative speech conductor for continuity whilst also determining (over the same conductor) the class-of-service to be accorded to that line circuit. The register then applies a potential to the positive speech conductor, whereby relay K in the line circuit is operated if the continuity of this conductor is in order.

Upon relay K in the line circuit operating, contacts K1 and K3 switch-through the speech conductors to the subscriber's line, contacts K1 and K3 also disconnecting the originating class-of-service path and disconnecting earth from the positive wire respectively. Contacts K2 disconnect relay LR from the negative speech conductor and enable it to hold over contacts LR3. Contacts K4 bring about operation of relay P which thereupon self-holds over contacts P3. Contacts P2 disconnect relay K from the positive speech conductor and enable it to hold to the backward earth on the P-wire, to which the subscriber's meter MTR and its series rectifier MR are connected. Contacts P5 break the connection between leads OC and MA in the path to the primary switch, and as a result of this the operated select magnet (1SM) in the primary switch is released, and, in the particular example where relay OS has been operated, this relay also releases.

When the typical select magnet releases, relays G and M are released by the appropriate contacts of 1SM3 to 9SM3. With relay G released, contacts G4 prevent possible premature completion of the operate circuit of relay OC, contacts G5 release auxiliary magnet 1AM and light lamp LP over the alarm lead AL, whereas contacts G7 release relays OM and OC. The release of relay M removes the remaining forward marking conditions from the primary/secondary links.

Upon select magnet 1AM releasing, its contacts 1AM1 release relay MA and this brings about the release of relay MK. The latter is effective at contacts MK12 together with contacts OC2 in enabling relay G to re-operate over its left-hand winding.

It is to be noted that relay G can only re-operate if all the auxiliary and select magnets are released as evidenced by the released state of contacts 1AM3 to 3AM3 and contacts 1SM2 to 9SM2. With relay G only operated of all the relays of the primary switch, and the particular call through the switch maintained solely by the

operated bridge magnet, the line-selector primary switch is available for use in the setting-up of another connection either for call originating or call terminating purposes.

In the meantime the calling subscriber would proceed with dialling over the speech pair and the register would respond in the control of the setting of the call to the wanted party. In due course, the register would be released and the connection with the calling party would be maintained by earth returned over the P lead from the transmission relay set. Moreover any positive battery metering pulses returned over P lead would be operative on the subscriber's meter MTR in the line circuit, said signals also serving to hold the bridge magnet.

The rectifier MR in series with the meter prevents relay K from being held in series with the meter when the holding earth is removed from the P lead when the call is duly cleared.

25 *Call originations from group 2 subscriber's line circuits.*

Upon a call being originated exclusively by a subscriber in group 2 (SLC2, 5 8, 11, 14, 17, 20, 23 and 26), the operation of the line relay LR (line circuit) causes the OC relay to be presented to auxiliary magnet 2AM by way of the relevant one of contacts MB1 to MB9. Relay OC operates, without the auxiliary magnet, and thereupon relay OM is operated from lead GP of the start shift circuit. Relays G and OC are retained from lead GP and moreover relay M is operated to initiate forward marking of idle ones of links 1LK to 10LK. The short circuit applied to the left-hand winding of relay OC on the operation of relay OM, enables auxiliary magnet 2AM to operate over contacts G2, OS1 and MC12, whereupon contacts 2AM1 extend earth from busying jack TJ1 over contacts TM10 to operate relay MB. Also contacts 2AM3 prevent the operation of relay MC, if a group 3 subscriber should initiate a call, the same contacts also disconnecting the original circuit of relay G. Contacts 2AM2 provide a holding circuit for auxiliary magnet 2AM, whereas contacts 2AM4 connect the lower winding of relay OS to select magnet 1SM so that relay OS will duly operate if any of the subscribers' line circuits SLC2, 8, 14 and 20 happen to be calling. In this respect the operation of relay OS, together with the chain arrangement of select magnet contacts 1SM2 to 9SM2 gives the order-of-priority viz: SLC2, 8, 14, 20, 26, 5, 11, 17, 23 to the line circuits of the group in the event of simultaneous call originations. With relay MB operated, contacts MB10 disable auxiliary magnet 3AM to that priority is

given to a group 2 subscriber in the event of a simultaneous call origination by a group 3 subscriber. Relay MB also at contacts MB1 to MB9 diverts the MA lead of the access paths of group 2 (SLC2, 5, 8, 11, 14, 17, 20 23 and 26) subscribers from magnet 2AM to the individual select magnets 1SM to 9SM. Therefore in the present case of a single call origination, the appropriate one of the select magnets operates, but it is to be observed that if more than one call had been originated in the group, the beforementioned order-of-priority would be made use of. The operated select magnet self-holds in series with resistor R2, provides a holding circuit for the operated auxiliary magnet, and brings about operation of relay MK as before, the latter disabling the remaining select magnets. Relay MK provides a duplicate circuit for itself from earth at contacts MB11, and also holds relay M.

When a transmission relay set and register has been associated with the present call, earth, returned over the P wire of one of the links, operates the relevant bridge magnet so that the connection is switched through the primary switch after the manner previously described, relay G and the bridge magnet finally remaining in the operated state.

Call originated from group 3 subscribers' line circuits.

In the case of a call being exclusively originated from a group 3 subscriber (SLC3, 6, 9, 12, 15, 18, 21 or 24) the operation of the line relay presents relay OC to auxiliary magnet 3AM by way of one of contacts MC1 to MC8. Relay OC operates, and as before relays OM and M also operate, the former effecting operation of auxiliary magnet 3AM and the latter instituting forward marking of idle links. Upon operation of magnet 3AM, contacts 3AM1 operate relay MC, contacts 3AM3 disconnect the original circuit of relay G which nevertheless holds, contacts 3AM2 hold magnet 3AM, and contacts 3AM4 connect relay OS to select magnet 1SM. With relay MC operated, contacts MC9 and MC12 prevents the possibility of "call-stealing" at this late juncture by calling group 1 and group 2 subscribers, whereas contacts MC1 to MC8 divert the incoming MA leads appropriate to group 3 subscribers from magnet 3AM to the individual select magnets 1SM to 8SM. The select magnet appropriate to the calling line circuit operates and from this point the call proceeds as before. However, in the case of simultaneous call originations within group 3 the arrangement of relay OS in conjunction with the chain of select magnet contacts 1SM2 to 9SM2, provides for the

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- of -



present



happens

order-of-priority viz: SLC3, 9, 15, 21, 6, 12, 18, 24.

Simultaneous call originations from different subscribers' line circuit groups served by line-selector primary switch.

The primary switch is arranged to deal with call originations on a one-at-a-time basis, the connection of each calling line circuit to a transmission relay set and register taking considerably less than 1 second. The question of simultaneous call originations within each of groups 1, 2 and 3 separately has already been described, the calls being dealt with in accordance with the priority arrangements within the particular group.

However, it will be apparent that calls might well be originated simultaneously by subscribers in different groups. Consider first the case of calls being originated in all groups simultaneously. Relay OC is then presented to auxiliary magnets 1AM, 2AM and 3AM (relay G being in its normally operated state). Relay OS operates in parallel with magnet 1AM and so magnet 2AM is disabled to obviate the magnetic balance condition of magnets 1AM and 2AM. This also effectively gives group 1 callers priority over group 2. Relay OC operates and as already described is followed by relay OM and the link-marking relay M. With relay OM operated, auxiliary magnets 1AM and 3AM operate. Thereupon relay OS releases, and contacts 1AM1 bring about operation of relay MA, whereas contacts 1AM3 prevent operation of relay MC so that any call from a group 3 subscriber cannot proceed for the time being. Magnet 1AM self-holds as already described and relay OS is connected to select magnet 1SM. Upon relay MA operating, contacts MA10 release the unwanted auxiliary magnet 3AM, so that any calls from group 3 line circuits must remain in abeyance. Contacts MA1 to MA9 direct the incoming MA leads of group 1 line circuits SLC1, 4, 7, 10, 13, 16, 19, 22 and 25, to select magnets 1SM to 9SM individually, and therefore, one of these magnets now operates, the "within-the-group" order-of-priority arrangements coming into effect if more than one call has been originated in group 1. From this point the response of the primary switch follows the lines of that described with respect to a single call origination in group 1.

In the event of simultaneous call originations in groups 1 and 3 only the operational procedure is identical with that just described, in that group 1 takes priority.

The example of simultaneous call originations in respect of line circuits in groups 2 and 3 only will now be considered briefly. In this case, subsequent to the operation of

relays OC, OM and M, auxiliary magnets 2AM and 3AM operate, but although relay MB operates over contacts 2AM1, contacts 2AM3 prevent the operation of relay MC so that calls from group 3 are temporarily rendered ineffectual. Contacts MB10 release auxiliary magnet 3AM, whereas contacts MB1 to MB9 complete paths between group 2 line circuits and their respective select magnets. If a single call origination is awaiting attention in group 2, the particular line circuit is duly switched through to the selected link, or if more than one call is awaiting attention the order-of-priority arrangements within the group come into effect as already described.

CALL TERMINATION.

A 500-line marker is provided on the basis of one for each line-selector division of the exchange, for defining a called line circuit of the particular division in a one-at-a-time manner, in accordance with dialled hundreds, tens and units digits of the called number which has been stored in a register.

As previously mentioned, if the primary switch is available to be taken into use, relay G therein is the only relay in the operated condition. When it is required to set up a call to a subscriber, the marker applies earth to the M terminal (LIDF directory number side) of the particular line circuit, and the earth is extended to lead SM of the relevant primary-switch access path which is looped back to lead AM by way of contacts of relay MAR, MBR or MCR.

Assume that subscriber's line circuit SLC2 is concerned, two conditions may apply. Firstly the line circuit may be engaged as evidenced by the operated condition of relay LR, and in this event the marking earth returned to lead AM is extended over contacts LR2 operated, lead TO and contacts TM3 to the busy lead PB of the marker. Under these circumstances the call termination does not proceed, the marker is released, and busy tone would be returned to the caller.

If, however, the called subscriber's line circuit is not busy, the marking earth is directed by the unoperated LR2 contacts to lead TM and then over contacts TM4 to lead PA of the marker. As a result of this, earth is returned to lead PC of the marker to operate relay TC over its right-hand winding. Relay TC holds over its second winding from earth at lead PH and extending over contacts TC6 and G6. With relay TC operated, relay TM is operated from earth over contacts G4, OM11, TC5 and OC6. Contacts TC8 disconnect a point in the operating path of the originating-call discriminating relay OC to guard against intrusion by calling subscribers. Contacts

TC4 apply earth to lead PBXM which is common to all primary switches of the line selector arrangement, but this lead would only be of concern if the present called number related to a P.B.X. (private branch exchange) group of lines. Contacts TC1, TC2 and TC3 prepare to extend the TM and TO leads of group 1 (SLC1, 4, 7, 10, 13, 16, 19, 22 and 25) group 2 (SLC2, 5, 8, 11, 14, 17, 20, 23 and 26) and group 3 (SLC3, 6, 9, 12, 15, 18, 21 and 24) line circuits to auxiliary magnets 1AM, 2AM and 3AM respectively.

When relay TM operates, contacts TM1, TM3 and TM5 divert all the incoming TO leads from the busy lead PB, in such manner that the TO leads of each of the aforesaid groups are connected to their respective auxiliary magnets. Contacts TM2, TM4 and TM6 are similarly effective with respect to leads TM of the access paths, the marker lead PA being disconnected. Therefore in the present example, where line circuit SLC2 (group 2) has been marked, auxiliary magnet 2AM is caused to operate over the following circuit:—marking earth, lead SM, contacts MBR1, lead AM, contacts LR2, lead TM, contacts TM4, TC2, OS1 and MC12, magnet 2AM to battery.

It will be appreciated that if a group 1 or 3 line circuit had been marked, auxiliary magnet 1AM or 3AM would have operated in a similar manner to magnet 2AM, and in the former case relay OS would also have operated but without effect.

Also with relay TM operated, contacts TM7 prepare a holding circuit for relay MK, whereas contacts TM8, together with contacts TC7, hold relay G on its right-hand winding whilst also completing a circuit, over select magnet contacts 1SM3 to 9SM3, to operate the link-marking relay M. Contacts TM9, TM10 and TM11 prepare paths to relays MAR, MBR and MCR in place of relays MA, MB and MC.

With auxiliary magnet 2AM operated, contacts 2AM1 effect operation of relay MBR, just as contacts 1AM1 or 3AM1 would have operated relay MAR or MCR if the present call were destined for a group 1 or group 3 subscriber. The operated auxiliary magnet also provides a self-holding circuit, in this case contacts 2AM2 being so effective.

Relay M is operative at this juncture in applying forward-marking earth to lead MT (terminating call) of all idle links, i.e. links appropriate to un-operated bridges, so that all available paths through the line-selector secondary switches, and available paths from the latter which extend into and through the exchange trunk-switching sub-section containing the calling transmission relay set and register, are marked. Subsequently the through-marked path which terminates upon

said transmission relay set and register is taken into use, and as a result of this, earth is duly returned to the P wire of one of the links such as 1LK extending from the primary switch.

Meantime, relay MBR in the primary switch has been operated, and this at contacts MBR1 to MBR9, diverts leads SM appropriate to group 2 line circuits individually to select magnets 1SM to 9SM. Again if the called party had been in group 1 or 3 the operation of relay MAR or MCR respectively would have connected the SM leads of the appropriate group to the relevant select magnets. In the present case, however, relay MBR enables select magnet 1SM to operate over both windings in series. Relay MBR, at contacts MBR10 provides a holding circuit for relay TM, just as contacts MAR10 or MCR9 would hold that relay in other circumstances.

The operated select magnet provides (contacts 1SM2) a self-holding circuit over its upper winding in series with resistor R2, operates relay MK (contacts 1SM1), disconnects the slow-to-release relay M (contacts 1SM3) whilst also providing a holding circuit for relay G independently of relay MK, and provides a holding circuit for the operated auxiliary magnet (contacts 1SM4).

With relay MK operated, contacts MK1 to MK9 disable the unoperated select magnets, but that which is operated remains so over its upper winding in series with resistor R2. Contacts MK10 complete a holding circuit of relay MK, whereas contacts MK11 prevent relay M releasing.

At this point in the setting-up procedure, earth is returned, in the manner already described to the P wire of the link (for instance 1LK) which has been selected for use, and moreover the + and - speech conductors of the link are connected through to the register by way of the various switching stages and the transmission relay set. The P-wire earth operates the appropriate bridge magnet (1BM) whereupon the cross-points related to the operated auxiliary and select magnets 2AM and 1SM are actuated to complete the connection between +, - and P wires of the called subscriber's line circuit SLC2 and the link 1LK. The operation of the bridge magnet is also effective at contacts 1BM1 in busying the chosen link, at contacts 1BM2 in disconnecting a branch path to the group busy lead GB, and at contacts 1BM3 in momentarily extending earth from the link P wire, over contacts TM12, to lead RI. The latter lead terminates in the so-called route indicator, and as a result of the earth pulse a cold-cathode tube would be fired, the arrangement being that this tube and other tubes relevant to the switches involved in the call route on the terminating side of the transmission relay

set would remain fired, for tracing purposes, only if the call is abortive due to a fault being encountered during the setting-up process.

5 Now that the link and subscriber's line circuit are connected, the register concerned in the call determines the terminating class-of-service to be accorded, by testing the condition of the negative conductor which, 10 in the line circuit, is extended over contacts K1 and LR4 to terminal CT which is strapped to one of the common class-of-service terminals TCA, TCB, TCC and TCD. The register also tests continuity of 15 the positive speech conductor, and in so doing earth applied over that conductor causes relay K in the line circuit to operate.

With relay K operated, contacts K1 and K3 effect switching-through of the speech conductors to the called line, the class-of-service wire being disconnected. Contacts K4 operate relay P, whereupon contacts P3 enable relay LR to operate, and also connect earth to terminal S which would be connected to 20 an external circuit if the line circuit related to a two-party shared service line. Contacts P5 isolate lead OC before relay LR operates, to prevent a spurious call origination. When relay LR operates, contacts 30 LR3 provide holding circuits for relays P and LR. Contacts LR2 connect lead AM of the primary-switch access path to lead TO which is concerned with offering of trunk calls by an operator.

35 At this juncture the register is removed from the connection and ringing of the called subscriber would proceed under control of the transmission relay set which also maintains the holding earth on the P wire. In due course, when the called party answers, 40 the conversational connection between the two subscribers would be established.

Meanwhile the marker has been released at the first opportunity, and accordingly relay TC in the primary switch releases, and 45 marking earth is removed from lead SM of the switch access path. With lead SM disconnected the operated select magnet releases, and the release of relay TC brings about the release of relays G and M. Relay 50 G then releases the operated auxiliary magnet, and lights the alarm lamp LP which would remain so under certain fault conditions. Relay MBR releases due to the 55 release of the auxiliary magnet, and then relays TM and MK release in turn. With all the auxiliary and select magnets now released, contacts MK11 complete a circuit for the re-operation of relay G, and therefore 60 the alarm condition is removed.

65 The connection through the switch persists under control of the operated bridge magnet, which remains operated from the holding earth returned over the link P wire by the transmission relay set.

TERMINATING CALL DEMAND WHILE SWITCH IS DEALING WITH CALL ORIGINATION.

When the primary switch is dealing with the setting-up of a connection from a calling subscriber, as indicated by the operated state of relay OC, another subscriber's line circuit 70 served by the switch may be marked by the marker for call termination purposes. Under these circumstances, the setting-up process is not interfered with, but the 75 terminating-call demand is given priority over any other subscriber who may have initiated a call. Assuming the marked line circuit is idle, as evidenced by the released state of relay LR, the marking earth is extended as previously described to lead PA 80 of the marker. As a result relay TC in the primary switch is operated over lead PC, and is effected in disabling the operate circuit for relay OC which, is however, held 85 over its right-hand winding.

When the switch has established the necessary originating call connection, relay G finally re-operates to signify that the switch is again available for use. Thereupon relay 90 TC holds and relay TM operates and the terminating call proceeds as already described. It is to be noted, however, that contacts TC8 in the normal operate path of the relay OC ensures that the present 95 terminating call has priority over any line circuit which may be waiting in respect of another call origination. Such a line circuit would be dealt with when the switch again becomes available in a relatively short 100 time.

TRUNK OFFERING.

When a wanted subscriber is busy, as indicated by the operated state of his line relay LR, an operator may offer a trunk 105 call. In this case the marker is specially conditioned so that when the required line circuit (say SLC1) is marked, the marking signal, now extended over lead SM, contacts MAR1, lead AM, contacts LR2, lead 110 TO, and contacts TM1 to lead PB, is effective in operating relay TC. Accordingly the setting-up of a connection between the calling register and the required line circuit proceeds as for a normal call termination, so 115 that the operator can intrude upon the existing call and offer the trunk call. It will be apparent that the operator's connection is provided with its own holding earth from the particular transmission relay set. This 120 holding earth is isolated, by rectifier MR1, from the operated bridge magnet, e.g. IBM, of the primary switch concerned in the original connection of the trunk-offered party, so that this connection is not held 125 by the operator's connection when that party clears. It may be noted that a similar rectifier, in the primary switch used in the operator's connection, would likewise be effective in permitting the operator to release 130

her connection when the original connection is maintained.

CALL CLEARING.

The line-selector primary switch and subscriber's line circuit are held during the conversation by earth returned to the P conductor by the transmission relay set and this applies in respect of both calling and called parties. At the end of the conversation the relay set is released, and the consequent removal of holding earth releases relay K in the subscriber's line circuit, and also releases the appropriate bridge magnet of the primary switch, whereby the relevant operated crosspoints are released and the link is again made available for use. Relay K enables relay LR to release after a short delay, whereupon relay P also releases and the line circuit is again available for use.



SUBSCRIBER'S LINE CIRCUIT—"DROP-BACK BUSY" AND P.G. ALARM FEATURES.

When a subscriber makes a call to a local subscriber who is already engaged, the marking of the called subscriber's line circuit is unsuccessful, and apparatus which is no concern of the present invention brings about the release of the transmission relay set and register. As a result of this the P-wire holding earth is removed from the line-selector primary switch and secondary switch, involved in the particular call origination, to release them. The removal of this earth also releases relay K in the calling subscriber's line circuit. Thereupon contacts K2 connect the slow-to-release relay LR to the negative conductor of the subscriber's line and contacts K3 connect the other line conductor over contacts P1 to the busy-tone-earth supply lead. Relay LR therefore remains operated over the loop, and busy tone is made audible to the subscriber. Relay P remains operated over contacts LR3 and P3. With contacts K4 released, earth is extended over the high-value resistor R1 and contacts P4 to alarm PG lead, so that an appropriate alarm is initiated. The operated condition of contacts P5 prevent another call origination being effected. Relays LR and P would release when the subscriber eventually clears.

If when a subscriber's line circuit has been taken into use on a call, the holding earth is not duly forthcoming upon the P conductor, due to some condition of fault, relay K would again release with results similar to those just described.

Moreover in the case of a spurious call origination (i.e. short circuit of the line wires, or subscriber failing to dial with the telephone instrument in the off-hook state) the maturing of a time-delay throw-out by the register would bring about the release of the transmission relay set and the primary

and secondary switches involved, and again the removal of earth from the P lead of the line circuit would be effective as outlined.

BUSYING-OUT THE PRIMARY SWITCH.

The switch may be busied-out by removal of the link from jack TJ1. This releases relay G which at contacts G5 lights lamp LP and initiates a general alarm over lead AL. Contacts G4 disable the operating circuit of the originating-call discriminating relay OC and of relay TM. Contacts G1, G2 and G3 prevent the operation of any auxiliary magnet. Therefore, the switch cannot be used for originating or terminating calls.

A similar state of affairs would be brought about if relay G failed to re-operate, after the switch had been used in the establishment of connection, due to relay MK or OC or any of the select or auxiliary magnets failing to release.

The switch is arranged to automatically busy-out itself and initiate alarms under various other conditions of fault. Thus for instance, if a fault earth appears on the MA lead of an access path, the relevant auxiliary magnet would be operated. This operates relay MA, MB or MC and disconnects the operate circuit for relay G. With relay G now released contacts G1, G2 or G3 disconnect the operate path of the auxiliary magnet, while contacts G5 disconnect its hold circuit and initiate alarms. The release of the auxiliary magnet releases relay MA, MB or MC. Although earth is again connected to one side of the operate winding of relay G by the auxiliary magnet contacts, the fault earth on the MA lead extending over released contacts G1, G2 or G3 is applied to the other side, so that relay G remains unoperated and the alarm and busying-out conditions persists until the fault is cleared.

WHAT WE CLAIM IS:—

1. In an automatic telephone system, circuit arrangements comprising a primary selector and associated subscribers' line circuits of a line-selector division involving a plurality of primary selectors and secondary selectors of the crossbar type, said selectors being adapted to set-up connections there-through to subscribers' line circuits in respect of originating and terminating calls, wherein for terminating-call marking purposes each subscriber's line circuit is provided with an individual marking lead extending from a marker serving a plurality of primary selectors, and the marking leads of each subscriber's line circuit associated with a primary selector extend individually into said primary selector which is also provided with first and second discriminating



her connection when the original connection is maintained.

CALL CLEARING.

5 The line-selector primary switch and subscriber's line circuit are held during the conversation by earth returned to the P conductor by the transmission relay set and this applies in respect of both calling and called parties. At the end of the conversation the relay set is released, and the consequent removal of holding earth releases relay K in the subscriber's line circuit, and also releases the appropriate bridge magnet of the primary switch, whereby the relevant operated crosspoints are released and the link is again made available for use. Relay K enables relay LR to release after a short delay, whereupon relay P also releases and the line circuit is again available for use.



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50 If when a subscriber's line circuit has been taken into use on a call, the holding earth is not duly forthcoming upon the P conductor, due to some condition of fault, relay K would again release with results similar to those just described.

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and secondary switches involved, and again the removal of earth from the P lead of the line circuit would be effective as outlined.

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WHAT WE CLAIM IS:—

1. In an automatic telephone system, circuit arrangements comprising a primary selector and associated subscribers' line circuits of a line-selector division involving a plurality of primary selectors and secondary selectors of the crossbar type, said selectors being adapted to set-up connections there-through to subscribers' line circuits in respect of originating and terminating calls, wherein for terminating-call marking purposes each subscriber's line circuit is provided with an individual marking lead extending from a marker serving a plurality of primary selectors, and the marking leads of each subscriber's line circuit associated with a primary selector extend individually into said primary selector which is also provided with first and second discriminating

leads connected to said marker, the arrangements being such that the marking leads of those of said subscribers' line circuits which are busy (e.g. as regards call originations or established through connections) are extended over first paths within the primary selector to said first discriminating lead and the marking leads of those of said subscribers' line circuits which are idle are extended over second paths within the primary selector to said second discriminating lead, the relevant one of said first paths being utilized to extend a marking condition, applied by the marker to the marking lead of a busy subscriber's line circuit for call-terminating purposes, to said first discriminating lead to disable the marker, the relevant one of said second paths being utilized to extend a marking condition, applied as aforesaid to an idle subscriber's line circuit, to said second discriminating lead to enable the marker to condition the primary selector preparatory to the setting-up of a terminating-call connection there-through.

2. Circuit arrangements as claimed in Claim 1, wherein the primary selector is provided with first and second relay means the first of which is adapted to be operated in response to a call origination by any subscriber's line circuit associated with said selector to initiate the setting-up of a connection through the line selector whereas the second is adapted to be operated under control of the marker upon the marker applying a marking condition to an idle one of the subscribers' line circuits and receiving a signal at said second discriminating lead, the operation of said second relay means being preparatory to the setting-up of a terminating-call connection through the primary selector.

3. Circuit arrangements as claimed in Claim 2, wherein the primary selector is provided with third relay means operable by said second relay means and adapted when operated to disable the operating circuit of said first relay means and to complete the

initiation of the setting-up of the terminating-call connection, the operation of the third relay means being prevented by said first relay means when the latter is already in the operated condition as evidence that the primary selector is occupied in the setting-up of an originating-call connection.

4. Circuit arrangements as claimed in Claim 3, wherein means are provided whereby following establishment of an originating-call connection the first relay means is released and in the event of said second relay means being operated, the first relay means is prevented from re-operating to initiate a subsequent originating-call connection until after a terminating-call connection has been established in response to the waiting demand.

5. Circuit arrangements as claimed in any preceding claim, wherein the primary switch is arranged for triple-group working and the subscribers' line circuits are multiplied over corresponding crosspoints of all the bridges and the links which are connected to secondary selectors are associated with individual bridges.

6. Circuit arrangements as claimed in Claim 5, wherein the primary switch is adapted for operation under self-steering principles and each link incorporates speech and private conductors and first and second forward-marking conductors, the first forward-marking conductor being adapted to be marked if the link is idle when a call origination is initiated and the second being adapted to be marked if the link is idle when a call termination is initiated.

7. In an automatic telephone system, circuit arrangements substantially as described with reference to the drawings accompanying Provisional Specification.

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