

Oct. 7, 1930.

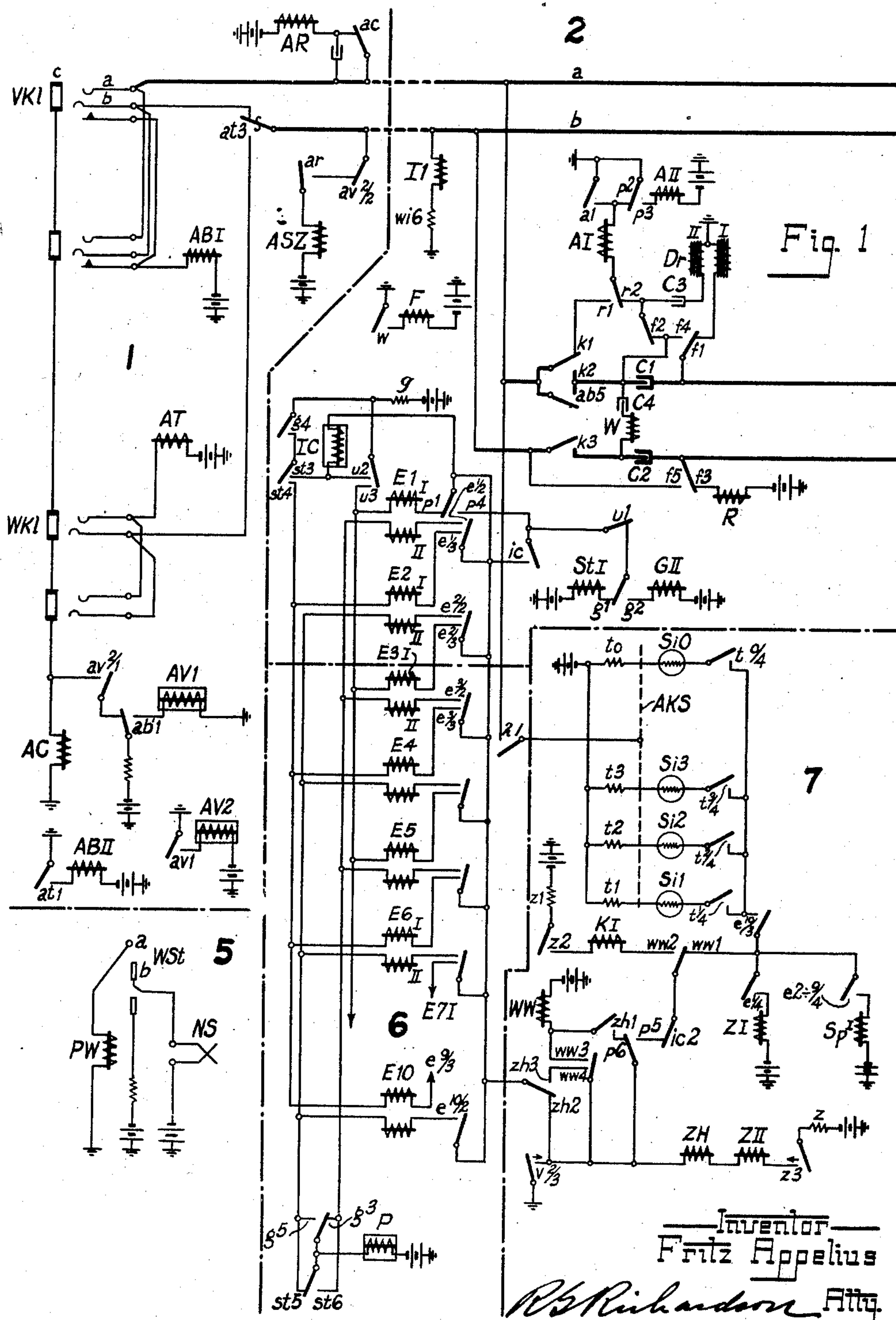
F. APPELIUS

1,777,709

TELEPHONE SYSTEM

Original Filed Jan. 21, 1928

2 Sheets-Sheet 1



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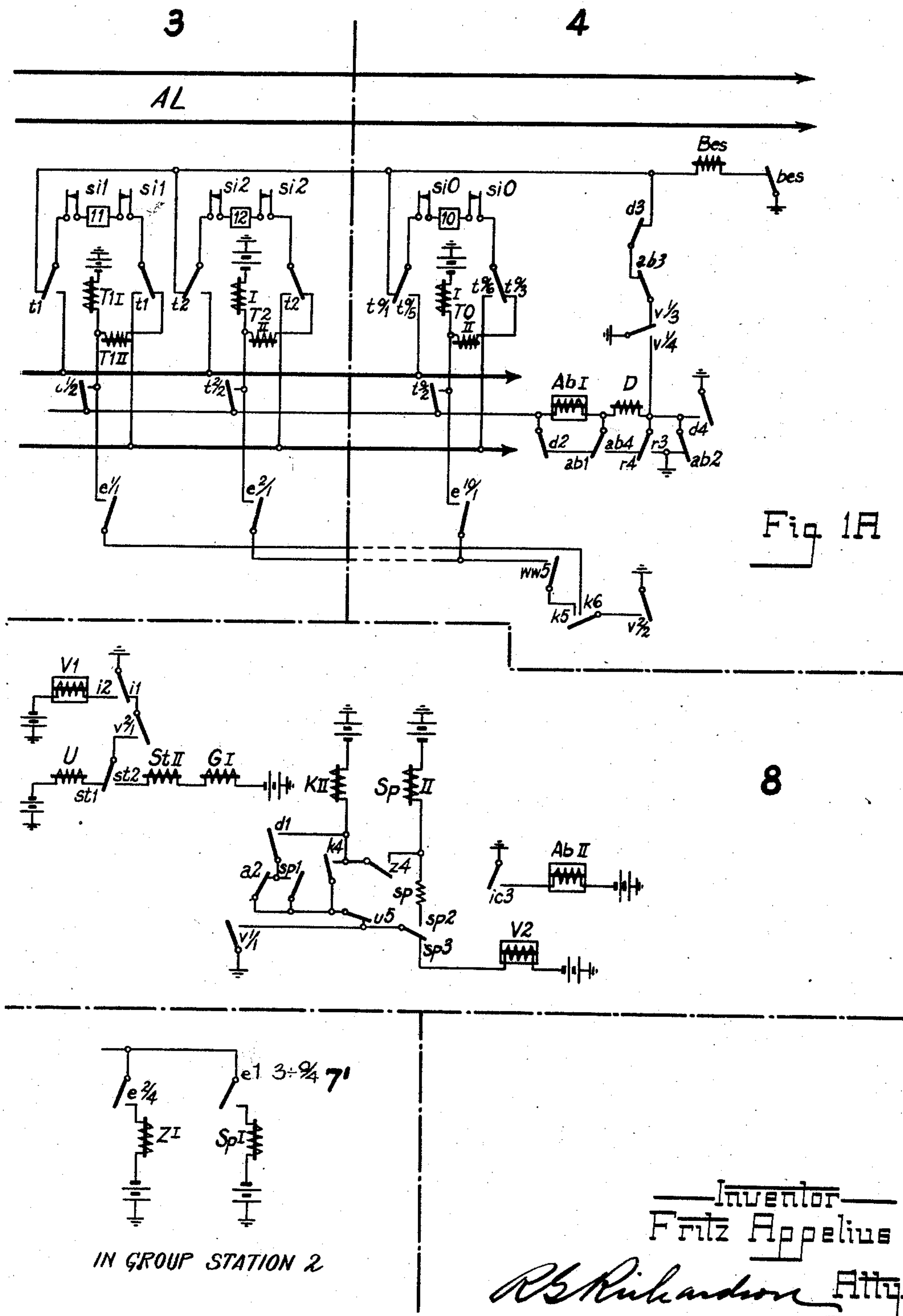
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# UNITED STATES PATENT OFFICE

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## TELEPHONE SYSTEM

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February 28, 1930.

In telephone systems with automatic work-  
ing it is known to so connect several sub-ex-  
changes to a line outgoing from a main ex-  
change that in their different positions the  
switches, which are connected up in every  
sub-exchange, take into use the further cir-  
cuits for connecting up the subscribers' lines,  
see for example the German Patent 360,610.  
Now the invention relates to small sub-ex-  
changes and it consists in that one and the  
same switch, when it is positioned for the  
first positioning, in the wanted sub-exchange,  
connects up the other connecting up circuits,  
and after its release during the succeeding  
train of impulses it hunts for the wanted line.  
The invention also enables this switch to be  
used for finding and if required for discon-  
necting the faulty lines.

The use of the same switch for several pur-  
poses enables the sub-exchanges to be most  
economically installed. This advantage is  
of particular importance for sub-exchanges  
with the relay system.

In the drawings Figs. 1 and 1A when  
placed end to end with Fig. 1A at the right  
of Fig. 1 there is shown one main exchange  
line AL, which connects a manual main ex-  
change (field 1) with several sub-exchanges,  
of these is shown the one taken into use with  
the numbers (10-19).

Semi-automatic working is shown by way  
of example, but the invention is not limited  
to this type of working.

The drawing is divided into eight fields  
and in the description for example 8 Sp II  
means the winding II of relay Sp in field 8.  
The designation 4 v 1/3 means the third con-  
tact of relay V 1 and shown in field 4.

### I. Outgoing call

1. The subscriber number 10 takes down  
his receiver. The relay T 0 (zero) is oper-  
ated over: earth, back contact 4 v 1/3, 4 ab 3,  
4 d 3, 4 t 0/1, subscriber's loop of the station  
10, back contact 4 t 0/3, relay T 0 windings  
II and I, battery, earth.

The relay T 0 is operated. Its contact  
4 t 0/2 is closed before the contacts 4 t 0/1  
and 4 t 0/3 are opened.

The relay D is operated over: earth, bat-

tery, relay 4 T 0 winding I, front contact  
4 T 0/2, back contacts 4 d 2 and 4 ab 1, relay  
4 D, back contact 4 ab 2, earth.

The contact 4 d 4 again earths the c-lead,  
while the contact 4 d 2 opens the short circuit  
across the relay Ab winding I, hence the lat-  
ter is operated.

The contacts 4 d 3 and 4 ab 3 open the start-  
ing circuit.

2. The feeding relay 2 R is operated over:  
earth, battery, relay 2 R, back contact 2 f 3,  
b-lead, front contact 4 t 0/6, subscriber's loop  
of the station 10, front contact 4 t 0/5, a-lead,  
back contact 2 f 1, choking coil Dr winding  
I, earth.

The front contact 4 r 3 is closed and again  
earths the c-lead; thereby the short circuit  
(4 ab 4, 4 r 4) is again opened for the D relay,  
so that it cannot fall back.

3. At the front contact 2 r 1 the following  
circuit is established: earth, back contact 2 p  
2, relay 2 A winding I, front contact 2 r 1,  
back contact 2 k 1, a-lead to the main ex-  
change, back contact 1 ac, relay 1 AR, bat-  
tery, earth.

The relays A and AR are operated (has  
no effect here). At contact 8 a/2 is opened  
the circuit for energizing the relay 8 K.

4. In the main exchange the front contact  
1 ar connects the call indicator ASZ to the  
b-lead: earth, battery, call indicator 1 ASZ,  
front contact 1 ar, back contact 1 av 2/2,  
b-lead (to the I relays in the sub-exchanges),  
relay 2 I 1, resistance 2 wi 6, earth.

5. In all the sub-exchanges the relays I  
are operated.

At the contact 8 i 2 the relay V 1 is ener-  
gized: earth, front, contacts 8 i 2, relay V 1,  
battery, earth.

In all the sub-exchanges the back contact  
4 v 1/3 opens the starting circuit for mark-  
ing engaged all sub-exchanges for outgoing  
calls. The front contact 4 v 1/4 again earths  
the c-lead for the right succession during the  
release taking place later on. The front con-  
tact 8 v 1/1 energizes the relay V 2 (in all  
the sub-exchanges) over: earth, front con-  
tact 8 v 1/1, back contact 8 sp 3, relay V 2,  
battery, earth.

The contact 8 v 2/1 prepares the number



impulse circuit, while the front contact 7 *v* 2/3 prepares the switch relays and the back contact 4 *v* 1/3 opens the starting circuit.

6. The operator in the main exchange inserts an answering plug into the jack VK 1. A front jack spring applies battery over the AB relay to the *b*-lead, in order thus to further lock the relays I in all the sub-exchanges. The contact 1 *ab'* 1 energizes a slow acting relay 1 AV 1 and this over the contact 1 *av* 1 energizes a second relay 1 AV 2 for the purposes of the release.

Over the bush of the jack, the relay AC is energized and the engaged potential (battery on the bush) is applied. The relay AC disconnects the relay AR, thus de-energizing the call indicator ASZ.

7. The operator answers the call in the usual manner and sets up the call with the calling plug in the main exchange. By throwing the answering key, she opens the direct current circuit for the relay A in the group centre. The relay A is released.

8. The switching through relay K is operated over: earth, battery, relay 8 K winding II, front contact 8 *d* 1, back contacts 8 *a*/2 and 8 *u*/5, front contact 8 *v* 1/1, earth.

In the group centre are energized the relays T 0, D, Ab, R, I, V 1, V 2, K.

The front contacts 2 *k* 2 and 2 *k* 3 switch through the speaking leads in the calling sub-exchange. This switching through does not take place in the other sub-exchanges, because there the relays D have not been energized.

9. Release of the group centre 10-19. The subscriber 10 hangs up his receiver. The relay R falls back. The back contact 4 *r* 4 short circuits the relay D, which also falls back. The back contact 2 *r* 2 closes the following circuit: earth, back contact 2 *p* 2, relay 2 A winding I, back contacts 2 *r* 2 and 2 *f* 2, front contact 2 *k* 2, *a*-lead, clearing signal in the cord circuit, relay AB winding I, battery, earth.

In response to this clearing signal the operator withdraws the plug from the jack.

10. In the main exchange the relay AB at its contact 1 *ab'* 1 opens the circuit for energizing the relay AV 1. The latter after considerable delay opens at contact 1 *av* 1 the circuit for energizing the relay AV 2, which likewise after considerable delay closes the circuit of the call indicator ASZ. The two delays of the relays AV 1 and AV 2 take longer than all the release delays in the group centres, so that all the group centres have reliably released before another seizure can take place. The contact 1 *av* 2/1 likewise keeps the busy potential on the jack bush until the release has taken place at all the group centres.

11. In the group centre 10-19 the relay I falls back when the operator withdraws the plug. The circuit changes hereafter de-

scribed are due to the fact that a falling back of the relay I is equivalent to one number impulse. Hence there is first a number impulse and then the release. The relay U is operated over: earth, back contact 8 *i* 1, front contact 8 *v* 2/1, back contact 8 *st* 1, relay 8 U, battery, earth.

On operating, the relay U energizes the relay E 1: earth, battery, resistance 2 *g*, front contact 2 *u* 3, relay 2 E 1 winding I, back contacts 2 *p* 1 and 7 *zh* 2, front contact 7 *v* 2/3, earth. The relay E 1 locks itself over: earth, front contact 7 *v* 2/3, back contact 7 *zh* 2, front contact 2 *e* 1/2, relay 2 E 1 winding II, back contact 6 *g* 3, relay 6 P, battery, earth. The relay P is operated and likewise relay IC: earth, front contact 7 *v* 2/3, back contact 7 *zh* 2, relay 2 IC, front contact 2 *u* 2, resistance 2 *g*, battery, earth. Contact 8 *u* 5 opens the circuit of the relay K, which falls back.

The following relays are energized: T 0, Ab, V 1, V 2, U, E 1, P and IC.

12. After some delay relay V 1 falls back. Contact 8 *v* 1/1 opens the circuit for energizing the relay V 2 and the contact 4 *v* 1/3 opens the locking circuit of the relay T 0. After some delay the relay V 2 falls back. At its contact 7 *v* 2/3 it opens the locking circuit of the relays E 1, IC, and P, which fall back. Relay IC takes a long time to fall back.

The contact 8 *v* 2/1 disconnects the relay U. The relay 8 Ab is the last to fall back after some delay; it has been held to the last by the contact 8 *ic* 3. The group centre can now be taken into use again for outgoing calls. As the relay V 2 falls back before the relay IC, no circuit is closed at the contact 7 *ic* 2 (see 36).

13. Release of the group centres from which no call was made. Condition during conversation (see 5). On withdrawing the plug, the relay I falls back. The contact 8 *i* 1 energizes relay U and contact 2 *u* 2 energizes the relays E 1, IC and P. The contact 8 *ic* 3 energizes the relay Ab over winding II. This condition is maintained until the relay V 1 falls back.

The contact 8 *v* 1/1 opens the circuit of the relay V 2, which then falls back after a little while.

The opening of the locking circuits causes the following relays to fall back: relays E, IC and P over contact 7 *v* 2/3, relay U over contact 8 *v* 2/1 and relay Ab over contact 8 *ic* 3.

14. The relay Ab is the last relay to fall back. The starting circuit and the contacts 4 *d* 3, 4 *ab* 3 and 4 *v* 1/3 therefore are not closed until all have fallen back. In the main exchange the relays AB, AV 1 and AV 2 fall back when the plug is withdrawn. The call indicator ASZ cannot be energized again until the relay AV 2 has fallen back. But in the means time all relays have fallen back in all the group centres.



## II. Call to subscriber 10 in group centre No. 1

20. The operator tests for a free line with the tip of the selecting plug WSt. If it be free, she inserts the selecting plug into the selector jack WK 1. Over the lead *c* the relay AC is energized and the busy potential is applied to the bush. The contact 1 *ac* disconnects the calling relay AR. Over the *a*-spring of the jack the relay AT is energized, which connects the *b*-lead to the selector jack.

In all the sub-exchanges the relay I is operated over: earth, resistance 2 *wi* 6, relay 2 1 1, *b*-lead, front contact 1 *at* 3, *b*-spring of the selector jack, selecting plug 5 WSt, number dial 5 NS, battery, earth.

21. In all the sub-exchanges the relays V 1 are operated: earth, front contact 8 *i* 2, relay 8 V 1, battery, earth. Thereupon relay V 2 is also operated over: earth, front contact 8 *v* 1/1, back contact 8 *sp* 3, relay 8 V 2, battery, earth.

In all the sub-exchanges the back contact 4 *v* 1/3 opens the starting circuit for preventing the sub-exchanges making calls to the main exchange.

22. Tens selection. First current interruption. Relay I falls back and relay U is energized over: earth, back contact 8 *i* 1, front contact 8 *v* 2/1, back contact 8 *st* 1, relay 8 U, battery, earth. The relays IC and E 1 are operated over: earth, front contact 7 *v* 2/3, back contact 7 *zh* 2 and 2 *p* 1, relay 2 E 1 winding I, front contact 2 *u* 3 resistance 2 *g*, battery, earth, and parallel thereto relay 2 IC, front contact 2 *u* 2, resistance 2 *g*, battery, earth. Being slow acting, the relay IC remains energized during the numerical selection.

Over the contact 8 *ic* 3 the relay Ab winding II is operated.

The relay E 1 locks itself over: earth, front contact 7 *v* 2/3, back contact 7 *zh* 2, front contact 2 *e* 1/2, relay 2 E 1 winding II, back contact 6 *g* 3, relay 6 P, battery, earth.

The relay P is operated and at its contact 2 *p* 1 it disconnects the relay E 1 winding I and over contact 2 *p* 3 it connects up the relay A winding II.

23. First circuit closure at the number dial. The relay I is again operated. The relay U falls back, because contact 8 *i* 2 opens the energizing circuit. The relay St is operated in the following circuit: earth, battery, relay 2 St winding I, back contacts 2 *g* 1, 2 *u* 1, front contact 2 *p* 4, back contact 7 *zh* 2, front contact 7 *v* 2/3, earth.

24. End of the tens selection. The relay I remains energized during the pause between the tens and units selection: hence the relay U is back. In the sub-exchange the relay IC therefore falls back, because its energizing circuit is opened at contact 2 *u* 2.

25. In the group centre 10-19 the relay Z is operated over: earth, front contact 7 *v* 2/3

and 7 *p* 5, back contacts 7 *ic* 2 and 7 *ww* 1, front contact 7 *e* 1/4, relay 7 Z winding I, battery, earth.

It locks itself over: earth, front contact 7 *v* 2/3, relays 7 ZH and 7 Z winding II, front contact 7 *z* 3, resistance 7 *z*, battery, earth.

Thereby the relay ZH is also operated.

The back contact 7 *zh* 2 opens the locking circuit of the relays E 1 and St and P, which fall back, P falls back slowly.

Relay WW is operated over: earth, battery, relay 7 WW, front contact 7 *zh* 1, back contact 7 *p* 6, front contact 7 *v* 2/3 earth.

The relay WW locks itself over its contact 7 *ww* 3. Relays I, V 1, V 2, Z, ZH, WW are energized.

26. In the group centre 20-29 the contact 7' *e* 2/4 is connected to the winding I of the relay 7' Z, while the winding 1 of the relay 7' Sp is connected to the contact 7' *e* 1/4 and *e* 3/4 to *e* 9/4. If two impulses had been sent during the tens selection, the relay Z of the group centre 20-29 would have been energized. But as the tens selection only comprised one impulse, the relay Sp is operated at the group centre 20-29 after the tens selection: earth, battery, relay 7' Sp winding I, front contact 7' *e* 1/4, back contacts 7 *ww* 1 and 7 *ic* 2, front contacts 7 *p* 5 and 7 *v* 2/3, earth.

The contact 8 *sp* 3 opens the circuit for energizing the relay V 2, which falls back and 8 *sp* 2 closes the locking circuit for the relay Sp: earth, front contacts 8 *v* 1/1 and 8 *sp* 2, resistance 8 *sp*, relay 8 Sp winding II, battery, earth.

The front contact 7 *v* 2/3 opens the locking circuit of the relays E 1, P and St, which fall back.

27. At the group centre 30-39 the contact 7 *e* 3/4 is connected to the relay 7 Z, while the contacts *e* 1/4, *e* 2/4, *e* 4/4 to *e* 9/4 are connected to the relay 7 Sp. Therefore after the tens selection "1" in the group centre 30-39 also the relay Sp is operated (as in 26) and in the group centre 30-39 the following relays are energized: relays I, V 1, Sp.

28. Units selection "0". First numerical selection by opening the circuit at the number dial.

Relay I falls back and relay U is operated over: earth, back contact 8 *i* 1, front contact 8 *v* 2/1, back contact 8 *st* 1, relay 8 U, battery, earth.

The relays IC, E 1 and Ab winding II are operated over: earth, front contact 7 *v* 2/3, front contact 7 *ww* 4, front contact 7 *zh* 3, relay 2 IC, front contact 2 *u* 2, resistance 2 *g*, battery, earth: earth, front contacts 7 *v* 2/3, 7 *ww* 4 and 7 *zh* 3, back contact 2 *p* 1, relay 2 E 1 winding I, front contact 2 *u* 3, resistance 2 *g*, battery, earth: earth, front contact 8 *ic* 3, relay 8 Ab winding II, battery, earth.

The relay E 1 locks itself over: earth, front contacts 7 *v* 2/3, 7 *ww* 4, 7 *zh* 3 and 2 *e* 1/2,



relay 2 E 1 winding II, back contact 6 *g* 3, relay 6 P, battery, earth.

The relay P is operated.

29. First circuit closure at the number dial.

The relay I is again operated and the relay U falls back. The relay IC remains energized, because it is slow acting.

The relay St is operated as follows: earth, battery, relay 2 St winding I, back contacts 2 *g* 1 and 2 *u* 1, front contacts 2 *p* 4, 7 *zh* 3, 7 *ww* 4 and 7 *v* 2/3, earth. The following relays are energized: I, V 1, V 2, ZH, WW (IC), E 1, P, St.

30. Second current interruption. Relay I falls back. The relay St winding II is held and the relay G is energized over: earth, back contact 8 *i* 1, front contacts 8 *v* 2/1, 8 *st* 2, relay 8 St winding II, relay 8 G winding I, battery, earth.

The latter is locked over: earth, battery, relay 2 G winding II, front contact 2 *g* 2, back contact 2 *u* 1, front contacts 2 *p* 4, 7 *zh* 3, 7 *ww* 4 and 7 *v* 2/3, earth.

25 The relay E 2 is operated: earth, battery resistance 2 *g*, front contacts 2 *g* 4 and 2 *st* 4, relay 2 E 2 winding I, front contacts 2 *e* 1/3, 7 *zh* 3, 7 *ww* 4 and 7 *v* 2/3, earth.

30 The relay E 2 locks itself over: earth, battery, relay 6 P, front contact 6 *g* 5, relay 2 E 2 winding II, front contacts 2 *e* 2/2, 7 *zh* 3, 7 *ww* 4 and 7 *v* 2/3, earth.

31. Second circuit closure. The relay I is again operated and the relay St falls back, because the winding I of the relay 2 St is open at contact 2 *g* 1 and the winding II of the relay 8 St is open at contact 8 *i* 1. The relay E 1 falls back, because the locking circuit for the relay E winding II is opened at contacts 6 *g* 3 and 6 *st* 6.

The following relays are energized: I, V 1, V 2, Z, ZH, WW (IC), P, G and E 2.

32. Third interruption. The relay I falls back again and relay U is operated: earth, back contact 8 *i* 1, front contact 8 *v* 2/1, back contact 8 *st* 1, relay 8 U, battery, earth.

Its contact 2 *u* 1 opens the locking circuit of the relay 2 G winding II, hence it falls back.

50 The relay E 3 is operated over: earth, battery, resistance 2 *g*, front contact 2 *u* 3, relay 6 E 3 winding I, front contacts 2 *e* 2/3, 7 *zh* 3, 7 *ww* 4 and 7 *v* 2/3, earth.

55 The relay E 3 locks itself over: earth, front contacts 7 *v* 2/3, 7 *ww* 4, 7 *zh* 3, 6 *e* 3/2, relay 6 E 3 winding II, back contact 6 *g* 3, relay 6 P, battery, earth.

33. Third circuit closure. The relay I is again operated and the relay U falls back again (because 8 *i* 1 is open). Relay St is operated over: earth, battery, relay 2 St winding I, back contacts 2 *g* 1 and 2 *u* 1, front contacts 2 *p* 4, 7 *zh* 3, 7 *ww* 4, 7 *v* 2/3, earth.

65 The relay E 2 falls back, because the con-

tact 6 *g* 5 is opened and 6 *st* 6 is closed and thus the locking circuit has been opened for the relay E 2 winding II.

The following relays are energized: I, V 1, V 2, Z, ZH, WW (IC), P, St, E 3.

This is exactly the same condition as at the first circuit closure (see 29, except that the relay E 3 is energized instead of the relay E 1.

34. At the succeeding number impulses when the circuit is closed after odd numbers the condition is the same (end of 33) except that E 5, E 7, E 9 is energized instead of E 3 and when the circuit is closed after even numbers the condition (end of 31) sets in with the difference that the relay E 4, E 6, E 8, E 0 is energized instead of the relay E 2. At the tenth circuit closure the following relays are energized: relays I, V 1, V 2, Z, ZH, WW (IC) P, G, E 10.

35. The unit selection does not take place at the other sub-exchanges. Although the relays I oscillate, the selecting relays are disconnected (at 8 *v* 2/1 and 7 *v* 2/3) because the relay V 2 has fallen back (see end of 26).

36. Coupling up the subscriber's line "10".

The relay I remains energized and thus the relay U is operated no more, hence the relay IC falls back after the time taken for it to fall back has elapsed. The relay K is operated: earth, battery, resistance 7 *z* 1, front contact 7 *z* 2, relay 7 K winding I, front contact 7 *ww* 2, back contact 7 *ic* 2, front contacts 7 *p* 5 and 7 *v* 2/3, earth.

The relay K locks itself over: earth, battery, relay 8 K winding II, front contact 8 *k* 4, back contact 8 *u* 5, front contact 8 *v* 1/1, earth.

The front contacts 2 *k* 2 and 2 *k* 3 switch through the speaking leads. At contact 4 *k* 5 is closed the circuit for energizing the line relay 4 T 0: earth, battery, relay 4 T 0 winding I, front contacts 4 *e* 10/1, 4 *ww* 5, 4 *k* 5, 4 *v* 2/2, earth.

The relay T 0 is operated. Its contacts 4 *t* 0/5 and 4 *t* 0/6 connect the subscriber's loop to the common speaking leads.

37. Release of the switches. As soon as the relay K is operated, the relay Sp receives current over: earth, battery, relay 8 Sp winding II, front contacts 8 *z* 4 and 8 *k* 4, back contact 8 *u* 5, front contact 8 *v* 1/1, earth.

The contact 8 *sp* 3 opens the circuit for energizing the relay V 2, which after a little while releases its armature. The contact 4 *v* 2/2 disconnects earth and the following circuit functions: earth, battery, relay 4 T 0 winding I, front contact 4 *t* 0/2, back contacts 4 *d* 2 and 4 *ab* 1, relay 4 D, front contact 4 *v* 1/4, earth.

The relay D is operated. Its contact 4 *d* 2 opens the short circuit across the relay 4 Ab winding I, which is likewise operated if it has fallen back after the release of IC. The contact 7 *v* 2/3 opens the locking circuit of



the relays Z, ZH, WW, P, E 10 and G. The contact 4 *ab* 4 short circuits the relay D, which then falls back.

After the switch has been disconnected, the following relays are energized: I, V 1, K, T 0, Ab, Sp.

38. Ringing. The operator at the main exchange inserts the calling plug into the speaking jack VK 1. Therefore the battery remains connected over the relay AB to the *b*-lead. She then withdraws the selecting plug. The interchange of the plugs has no effect on the sub-exchanges. The operator now transmits alternating current by throwing the ringing key. The relays I must not be de-energized by the alternating current.

The alternating current energizes the relay W at the group centre 10-19 where the relay K is energized. The contact 2 W energizes the ringing relay F, which at contacts 2 *f* 2 and 2 *f* 1 opens the branches to relay A and choking coil Dr, and at the contacts 2 *f* 4 and 2 *f* 5 it short circuits the condensers C 1 and C 2: hence ringing current flows from the main exchange direct to the bell of the subscriber's station 10 so long as the operator keeps the ringing key in the operated position. During the ringing pauses the contact 2 *f* 3 connects the feeding relay R to the subscriber's line and the contact 2 *f* 1 connects the choking coil Dr winding I to that line.

39. The subscriber at station 10 answers the call. During a ringing pause the relay R is operated over: earth, battery, relay 2 R, back contact 2 *f* 3, *b*-lead, subscriber's loop, *a*-lead, back contact 2 *f* 1, choking coil Dr winding I, earth.

The closing of the contact 2 *r* 1 disconnects the relay A from the *a*-lead, hence the earth disappears from this lead. This circuit change renders the supervisory signal in the cord circuit at the main exchange de-energized, thus notifying the operator that the call has been answered. The back contact 4 *r* 4 removes the short circuit from the relay D, which is again operated, without, however, now causing any circuit changes.

During the speaking condition, the following relays are energized: I, V 1, K, T 0, D, Sp, Ab, R.

40. Clearing signal to the main exchange. The subscriber hangs up his receiver. The relay R falls back. Its back contact 4 *r* 4 short circuits the relay 4 D, which falls back without having any further effect. The back contact 2 *r* 2 closes the following circuit: earth, back contact 2 *p* 2, relay 2 A winding I, back contacts 2 *r* 2, 2 *f* 2, front contact 2 *k* 2, *a*-lead, clearing signal at the main exchange, *b*-lead, relay 1 AB winding I, battery, earth.

The relay A and the clearing signal are operated. The relay 1 AB is energized over the *b*-lead and the relay 2 I 1.

41. Release. The operator withdraws the

plug. This causes circuit changes at the main exchange that have been described under 10.

At the group centre 10-19 the relay I falls back. Its contact 8 *i* 2 opens the energizing circuit of the relay 8 V 1. The relay V 1 releases its armature after a little delay, thereby opening at its contact 8 *v* 1/1 the locking circuits of the relays K and Sp. At contact 4 *v* 1/4 is opened the locking circuit of the relays 4 T 0 and 4 Ab. Relay 4 T 0 falls back quickly, while the relay 4 Ab only releases its armature after a little while has elapsed. The contact 4 *ab* 3 again closes the starting circuit.

### III. Revertive call to the own group centre

The subscriber 12 is assumed to want the subscriber 17.

42. The subscriber 12 takes down his receiver. The circuit changes are the same as those described in 1 to 8. Therefore during the answering of the call the following relays are energized in the group centre 10-19: I, V 1, V 2, K, R, T 2, D, Ab.

The demand for "17" notifies the operator that a revertive call is wanted on the line, but she does not know from which group centre the call originates.

43. The operator requests the calling subscriber to hang up his receiver. When this has been done, the relay R falls back. Its back contact 4 *r* 4 short circuits the relay D, this having no effect at present. The contact 2 *r* 2 puts earth over the relay 2 A winding I on the *a*-lead, whereupon the clearing signal appears at the main exchange. The operator knows now that the calling subscriber has hung up his receiver. She now inserts the selecting plug into the selecting jack WK 1. Thereby the *b*-lead is earthed over the number dial and is disconnected from the answering cord.

44. Tens selection "1". At the break impulse, the relay I falls back and the relay U is operated over: earth, back contact 8 *i* 1, front contact 8 *v* 2/1, back contact 8 *st* 1, relay 8 U, battery, earth.

Its contact 8 *u* 5 opens the locking circuit of the relay K, which falls back, in order not to disturb the bridge located behind the contacts 2 *k* 2 and 2 *k* 3.

Over the contacts 2 *u* 2 and 2 *u* 3 the relays E 1 and IC are operated: earth, battery, resistance 2 *g*, front contact 2 *u* 3, relay 2 E 1 winding I, back contacts 2 *p* 1 and 7 *zh* 2, front contact 7 *v* 2/3, earth, and parallel thereto relay 2 IC, front contact 2 *u* 2, resistance 2 *g*, battery, earth.

The relay E 1 locks itself over: earth, front contact 7 *v* 2/3, back contact 7 *zh* 2, front contact 2 *e* 1/2, relay 2 E 1 winding II, back contact 6 *g* 3, relay 6 P, battery, earth.

The latter is operated.

At the succeeding circuit make at the number dial, the relay I is operated again. Relay



U falls back and the relay IC also falls back, because the circuit is closed for some time.

The tens relay Z is operated: earth, battery, relay 7 Z winding I, front contact 7 *e* 1/4, back contacts 7 *ww* 1 and 7 *ic* 2, front contacts 7 *p* 5 and 7 *v* 2/3, earth.

The relay Z locks itself over: earth, battery, resistance 7 *z*, front contact 7 *z* 3, relay 7 Z winding II, relay 7 ZH, front contact 7 2/3, earth.

The contact 7 *zh* 2 opens the locking circuit of the relays E 1 and P, which fall back. The relay WW is operated: earth, battery, relay 7 WW, front contact 7 *zh* 1, back contact 7 *p* 6, front contact 7 *v* 2/3, earth.

This locks itself over the front contact 7 WW 3. After the tens selection the following relays are energized: I, V 1, T 12, Ab, Z, ZH, WW.

45. Units selection. This condition is the same as at the beginning 28, except that the relays T 12 and Ab are energized. These relays have no effect on the succeeding units selection. The seventh circuit closure creates the condition (see end of 33 and 34).

46. Coupling up the line 17. After a little while the relay IC falls back. The relays K and T 7 are operated as described in 37. The release of the switch takes place as described under 37.

At the succeeding ringing, the two subscribers are called. When one of them answers, the operator asks for the number. If the calling party has answered, the operator asks him to hang up again and she continues to ring.

47. The release is initiated when both subscribers have hung up their receivers, because relay R then falls back.

#### IV. Revertive call to another group centre

The subscriber No. 10 wants the subscriber No. 23.

48. The subscriber No. 10 calls the exchange and hangs in the call; he is requested to hang up his receiver.

In the group centre 10-19 the following relays are energized: I, V 1, V 2, K, T 0, Ab (condition see 8).

In the group centre 20-29 the relays I, V 1, V 2 are energized (condition see 5).

49. The tens selection "2" in the calling group centre 10-19. The train of impulses "2" energizes the relay E 2 and P as several times previously described. At the first number impulse the relay U was operated and at its contact 8 *u* 5 it opened the locking circuit of the relay 8 K, which then fell back. After the numerical selection, the relay IC falls back and closes the following circuit: earth, battery, relay 7 Sp winding I, front contact 7 *e* 2/4, back contacts 7 *ww* 1, 7 *ic* 2, front contacts 7 *p* 5 and 7 *v* 2/3, earth.

The relay Sp locks itself over: earth, bat-

tery, relay 8 Sp winding II, resistance 8 *sp*, front contacts 8 *sp* 2 and 8 *v* 1/1, earth.

At contact 8 *sp* 3 was opened the locking circuit of the relay 8 V 2, which soon falls back and by opening its contact 7 *v* 2/3 effects the release of the relays E 2, IC and P.

After the tens selection the following relays are energized in the calling group centre: I, V 1, T 0, Ab, Sp.

50. Tens selection "2" in the wanted group centre 20-29.

At this group centre the contact 7' *e* 2/4 is connected to the relay 7' Z winding I instead of the contact 7 *e* 1/4 shown in the figure. Hence the tens selection takes place as described in 22 to 25. And there the following relays are energized: I, V 1, V 2, Z, ZH, WW.

51. Units selection "3".

At the group centre 10-19 the beating of the relay I causes no further circuit changes, because the relay V 2 is not energized and the contact 7 *v* 2/3 is therefore open, and over it the relays would have to be energized.

At the group centre 20-29 the units selection functions according to 28, to 34, and 36, to 37. Hence in the group centre after the selection, the following relays are energized: I, V 1, K, T 3, Ab, Sp. (Condition see end of 37.)

52. It should be noted that in the group centre 30-39 only the relays I, V 1 and Sp are energized and not the relays K and Ab. Therefore the following ringing current cannot energize the relay 2 W at the group centre 30-39.

53. Ringing the group centre 10-19.

The ringing current transmitted by the operator (see 38), flows over: the *a*-lead, front contact 2 *ab* 5, condenser C 4, relay 2 W, condenser C 2, bank contact 2 *f* 3, relay 2 R, battery, earth.

The relay W is operated, but not the relay R. The contact 2 *w* energizes the relay 2 F. The contacts 2 *f* 4 and 2 *f* 5 connect ringing current directly to the line of the calling subscriber 10. During the pause in the ringing, the relay A is energized over: earth, back contact 2 *p* 2, relay 2 A winding I, back contacts 2 *r* 2 and 2 *f* 2, front contact 2 *ab* 5, *a*-lead, cord, clearing signal, relay 1 AB winding I, battery, earth.

54. Ringing the wanted group centre 20-29.

In this group centre the relay K is energized (see end of 38). Ringing therefore takes place exactly as described in section 38.

55. The calling subscriber 10 answers first, therefore too soon.

On taking down the receiver, the relay R is operated. Its contact 4 *r* 4 removes the short circuit from the relay 4 D. The latter is operated and the contact 8 *d* 1 closes the following circuit: earth, battery, relay 8 K winding II, front contacts 8 *d* 1 and 8 *sp* 1,



back contact 8 *u* 5, front contact 8 *v* 1/1, earth.

The relay K is operated and locks itself over: earth, battery relay 8 K winding II, front contact 8 *k* 4, back contact 8 *u* 5, front contact 8 *v* 1/1, earth.

The contact 2 *r* 1 connects the relay A over the back contact 2 *k* 1 to the *a*-lead. The operator asks the party answering the call what his number is. If he is the calling party, she asks him to hang up again and she continues to ring. When the calling party hangs the receiver up again, the relays R and D fall back again. At the group centre 10-19 are energized the relays I, V 1, T 0, Ab, Sp, K (see end of 49).

56. When both subscribers have taken down their receivers, conversation can commence. In the calling group centre the following relays are energized: I, V 1, T 0, Ab, D, Sp, K, R, while at the wanted group centre the following relays are energized: I, V 1, K, T 3, Ab, D, Sp, R, (see 51).

At the group centres that are not used, the relays I, V 1 and Sp are energized.

At the main exchange the clearing signal appears when one of the subscribers hangs up. For the release, two conditions can occur:

(a) The operator withdraws the plug when only one subscriber hangs up.

Until the time when the relay AV 2 falls back in the main exchange, the group centre of the subscriber who has hung up is released in the usual manner.

But at the other group centre the relay R is still energized. Hence the relays T, D and Ab do not fall back, but all the others do so. For this reason, after the relay AV 2 has fallen back at the main exchange, the subscriber again takes into use the line and causes the calling signal ASZ to appear at the main exchange. The operator answers the call and requests the subscriber to hang up his receiver. After the clearing signal has appeared, she withdraws the plug again. In order to reduce the liability of making a double connection (because one subscriber is there already), the operator should not release a revertive call connection until she has cut in and found that both subscribers have hung up.

(b) Both subscribers have hung up. Release takes place in the usual manner.

#### V. The main exchange line is engaged

57. The relay V 1 is energized as soon as the main exchange line is taken into use for an incoming or outgoing call, and it then opens the starting circuit at contact 4 *v* 1/3. When during this time a subscriber, for example No. 10 takes down his receiver, the following circuit is closed: earth, back contact 4 *b*es, relay 4 Bes, back contact 4 *t* 0/1,

subscriber's loop, back contact 4 *t* 0/3, relay 4 T 0 windings II and I, battery, earth.

The relay Bes has so high a resistance that it only and not the relay T 0 is operated. At contact 4 *b*es the relay Bes opens its own circuit, thus causing it to buzz. This notifies the calling party that the line is engaged.

#### VI. Disconnecting a faulty line

A. The fault on the subscriber's line is such that a call to the main exchange is originated, hence the loop is closed, or there is an earth on the *b*-lead of the subscriber.

58. The closing of the loop or the earthing of the *b*-lead has the same effect as taking down the receiver. When the operator answers the call, the following relays are energized: I, V 1, V 2, T<sub>x</sub>, Ab, D, K, R (see 8).

The operator gets no reply and concludes that there is a fault. The following arrangements are made for disconnecting the faulty line:

Every subscriber's line extends over two back contacts (3, 4) *si* to the calling devices in the group centre. These back contacts *si* are so fitted on the known fuse strips, that the known alarm springs of the fuse open the contacts as soon as the fuse melts. The fuse 7 *Si* itself lies in a local circuit.

The operator inserts the selecting plug into the selecting jack WK 1 and transmits ten impulses. In the manner already several times described, the relay E 10 is energized at all the group centres and the relay P is then likewise operated. A circuit is closed over: earth, front contacts 7 *v* 2/3 and 7 *p* 5, back contacts 7 *ic* 2 and 7 *ww* 1, front contacts 7 *e* 10/3, 7 *tx*/4 of the faulty line, fuse 7 *Si* of the faulty line, resistance *tx*, battery, earth, irrespective of which group centre contains the fault. The operator withdraws the selecting plug and inserts the connecting plug into the jack VK 1. After a little while, the fuse melts and opens the contacts (3, 4) *si*. Thereby the faulty line is disconnected and the clearing signal appears in the main exchange owing to the falling back of the relay R.

On dialling the number "10", the first impulse (U is energized) the relay 8 K is released. As, however, the relay D is energized, the relay K would be again operated after the relay U has fallen back, if the relay A were not energized over: earth, front contact 2 *p* 3, relay 2 A winding II, battery, earth.

After the faulty line has been disconnected, it is necessary to ascertain in which group centre the fault is located (in order to avoid the fault searcher making unnecessary journeys). For that purpose a plug is inserted into the connecting jack VK 1, this plug contains an indicator for earth in the *a*-lead. Now the three tens digits of the three group centres are dialled in succession after each



time previously releasing. On dialling the group centre, in which the disconnection has taken place, the clearing signal will appear immediately after dialling, the circuit extending over: earth, indicator, plug, *a*-lead, front contact 6 *z* 1, of the selected group centre, alarm contact bus bar 7 AKS, released strip of the fuse strip 7 Si, resistance 7 *tx*, battery, earth. This circuit with battery on the *a*-lead can only occur in this case.

When the fault seeker has removed the fault, he must replace the fuse and again close the contacts *si*.

B. There is an earth on the *a*-lead of the subscriber's line.

60. This fault does not cause a main exchange call and does not disturb the setting up of connections. When the subscriber sets up a connection or receives a call, the line will be noisy, because an earth connection usually gives rise to false currents. Thereby the operator can recognize the fault and record the same.

61. However, the fault also becomes apparent owing to double connections. The earth on the subscriber's *a*-lead renders the blocking of the starting circuit (contacts 4 *d* 3, 4 *ab* 3, 4 *v* 1/3) inoperative. Hence when a conversation is taking place over the main exchange line and a call is originated by a subscriber of the group centre, to which the faulty line is connected, its starting circuit will be closed over the faulty earth instead of the busy relay being energized. The fault can be recognized by the double connection.

62. The first thing to be done is to find which line is faulty. The test clerk in the main exchange inserts an ordinary selecting plug into the selecting jack WK 1 and inserts a special plug into the connecting jack. The tip of this plug is connected over a head set receiver and a hand generator to earth. The test clerk dials the number 11, and then slowly rotates the hand generator. If the line 11 for example be not faulty, alternating current will flow over: earth, generator, receiver, *a*-lead, group centre 10-19, front contact 2 *k* 2, condenser C 1, subscriber's bell of the station 11, which is not to be operated, back contact 2 *f* 3, relay 2 R, battery, earth.

The sound audible in the receiver is weak. But if the *a*-lead of the line 11 be earthed, the generator current will flow back over this earth and not over the bell end the relay R. Hence the sound is very much stronger.

The test clerk thus calls one line after another until he has found the faulty line. It is unnecessary to disconnect this line, because the fault only affects a few connections.

63. If the *a*-lead of the main exchange line AL be earthed, the relay AR in the main exchange will be energized and it will give rise to a permanent call. While a faulty subscriber's line (earth on the *b*-lead) giving rise

to a permanent call causes the calling potential (earth) to disappear when the call is answered owing to the relay K being operated in the group centre, earth potential remains when the external line be earthed and it gives the clearing signal also after the operator has answered the call. Thereby the kind of fault can be recognized. Here of course it is unnecessary to dial the number "0". The line can be marked engaged (blocked) by leaving the plug in the jack. The disappearing of the clearing signal indicates that the fault has been cleared.

If the external main exchange line AL has the *b*-lead earthed, it is impossible for the line to be marked engaged either when an incoming or an outgoing call is made, because the relays I are short circuited. It is impossible to make a selection.

In this condition, when a group centre subscriber originates a call, it gives rise to a normal call. But the relays I, V 1 and V 2 cannot be operated owing to the relay I being short circuited. Therefore, after the call has been answered, the clearing signal does not disappear from the cord circuit, because the relay K cannot be operated. On the other hand it is just possible to communicate over relay V. This clearly indicates the kind of fault.

What is claimed is:

1. In a telephone system, an exchange, a trunk terminating in said exchange, a plurality of line groups in said exchange, a selecting device controlled over said trunk, means for operating said device to select a particular one of said line groups, means automatically responsive when the group is selected for restoring said device to normal, and means for re-operating said device to connect with a particular line of the selected group.

2. In a telephone system, a trunk line comprising two normally disconnected sections, a current feed bridge normally connected to the first section of said trunk, means for applying signalling current to the second section of said trunk, and means responsive to the application of said signalling current for disconnecting said bridge and for connecting the two sections of said trunk.

3. In a telephone system, a digit operated device, a plurality of groups of lines, a control relay and a cut-off relay in each of said groups, means controlled by said device for simultaneously operating the control relay of a wanted group and the cut-off relays of all other groups, and means responsive to the operation of said control relay for rendering said device effective to establish a connection with a particular line in the wanted group.

4. In a telephone system, an exchange, a plurality of groups of lines in said exchange of which any of said lines may be subject to abnormal conditions, a trunk terminating in



said exchange, a directively operated device controlled over one conductor of said trunk, means automatically responsive when an abnormal condition exists on a line for extending a connection over another conductor of said trunk, and means controlled by said device for determining the particular group in which said abnormal condition exists.

5. In combination, a line subject to abnormal conditions, fuse controlled contacts in the conductors of said line, and a remotely controlled device for blowing said fuses when an abnormal condition exists on said line.

6. In combination, a trunk, a line which may become defective due either to a grounded condition or to a short circuit on the line, means automatically responsive when said line becomes defective for connecting said line to said trunk, and means controlled over said trunk for disconnecting said line from said trunk and for preventing subsequent connection thereto.

7. In a telephone system, an operator's position, a signal at said position, a line subject to abnormal conditions, fuse controlled contacts in the conductors of said line, means automatically responsive when an abnormal condition exists on said line for operating said signal, and means controlled by the operator at said position for blowing said fuses to disable said line.

8. In combination, a line subject to abnormal conditions, fuse controlled contacts in the conductors of said line, a fuse blowing circuit, means automatically responsive when an abnormal condition exists on said line for connecting said fuses to said circuit, and a remotely controlled device for rendering said circuit effective to blow said fuses.

9. In a telephone system, a subscriber's line, normally-closed contacts in the conductors of said line, a fuse controlling said contacts, a trunk, means responsive to an abnormal condition on said line for connecting said line to said trunk, and means controlled over the trunk for blowing said fuses whereby said contacts are opened to disconnect the line from the trunk.

10. In a telephone system, a subscriber's line, normally-closed contacts in the conductors of said line, a fuse controlling said contacts, a trunk, means responsive to abnormal condition on said line for connecting the line to said trunk and for preparing a local circuit for said fuse, and means controlled over said trunk for completing said local circuit.

11. In a telephone system, a subscriber's line, normally-closed contacts in the conductors of said line, a fuse controlling said contacts, and a circuit for said fuse independent of the line conductors for blowing the fuse to disable said line when an abnormal condition exists thereon.

12. In a telephone system, a subscriber's

line, a disconnecting device in each conductor of said line, an operator's position, means responsive to an abnormal condition on said line for extending a connection from the line to said position, and means controlled from said position for operating said devices.

13. In a telephone system, a trunk extending from a sub-exchange to an operator's position at a main exchange, a subscriber's line terminating in the sub-exchange, means automatically responsive when an abnormal condition develops on said line for extending a connection from the line to said position via said trunk, and means at the sub-exchange controlled from said position over said trunk for opening points in the conductors of said lines.

14. In a telephone system, a plurality of groups of subscribers' lines, a trunk, means responsive to an abnormal condition on any one of said lines for connecting that line to said trunk, means controlled over the trunk for opening the conductors of the defective line, and means controlled over the trunk for determining the particular group in which the defective line is located.

15. In a telephone system, a main exchange, a plurality of sub-exchanges, subscribers' lines terminating in each sub-exchange, a trunk line extending through said sub-exchanges to said main exchange, a switch in each sub-exchange, means for transmitting a series of digit impulses over the trunk to operate said switches simultaneously, means for releasing only the switch in the exchange designated by said digit, and means for transmitting a second series of digit impulses over the trunk line to reoperate the released switch to extend a connection to a subscriber's line.

16. In a telephone system wherein connections between two local sub-exchange subscribers' lines are set up and controlled over the same two-conductor trunk extending to a main exchange, means for maintaining the calling subscriber's substation ringer in connection with said trunk during the establishment of a connection to the desired called subscriber's line, and means at the sub-exchange responsive to ringing current extending over said trunk from the main exchange for directly connecting the ringing current to the substation ringers of both the calling and called lines.

17. In a telephone system, a main exchange, a sub-exchange, a two-conductor trunk connecting said exchanges, a plurality of subscribers' lines terminating in said sub-exchange each adapted to be connected to said trunk, a local battery bridge across the conductors of said trunk at the sub-exchange, a condenser in each of said conductors separating the said battery bridge from the main exchange, and means responsive to ringing current extending over said trunk from the main



exchange for disconnecting said battery bridge and for shunting said condensers to directly connect ringing current to the called subscriber's line.

5 18. In a telephone system, a main exchange, a sub-exchange, a two-conductor trunk connecting said exchanges, a plurality of subscribers' lines terminating in said sub-exchange each adapted to be connected to said  
10 trunk, a local battery bridge across the conductors of said trunk at the sub-exchange, a condenser in each of said conductors separating the said battery bridge from the main exchange, means responsive to ringing current extending over said trunk from the main  
15 exchange for disconnecting said battery bridge and for shunting said condensers to directly connect ringing current to the called subscriber's line, a holding circuit including only one of said conductors for maintaining a  
20 connection between a calling and a called line, and means at the main exchange for interrupting said circuit to permit the release of the connection.

25 19. In a telephone system, a main exchange, a sub-exchange, a two-conductor trunk connecting said exchanges, a plurality of subscribers' lines terminating in said sub-exchange each adapted to be connected to said  
30 trunk, a local battery bridge across said conductors at the sub-exchange, an altering current relay and a condenser bridge across said conductors at the sub-exchange, another relay in the sub-exchange having contacts for  
35 disconnecting said battery bridge and for directly connecting said conductors to the substation ringer of the called subscriber's line, and contacts on said altering current relay for controlling said other relay.

40 20. In a telephone system wherein subscribers' lines terminating in a sub-exchange are arranged to be connected to a main exchange trunk line terminating in an operator's position at the main exchange and arranged to signal the operator thereat responsive to the initiation of a call, means for maintaining the calling subscriber's line in  
45 operative connection with said trunk line after the calling subscriber replaces his receiver in response to such request by the operator when  
50 calling a local subscriber, means in the sub-exchange controlled by impulses sent over said same trunk line from the operator's position for connecting a desired called subscriber's line to said trunk line, and means controlled by the operator for signalling both  
55 the calling and called subscriber over said trunk line.

60 In witness whereof, I hereunto subscribe my name this 15th day of December, A. D. 1927.

FRITZ APPELIUS.