Oct. 6, 1936. C. S. DEMAREST ET AL 2,056,347

SIGNALING SYSTEM

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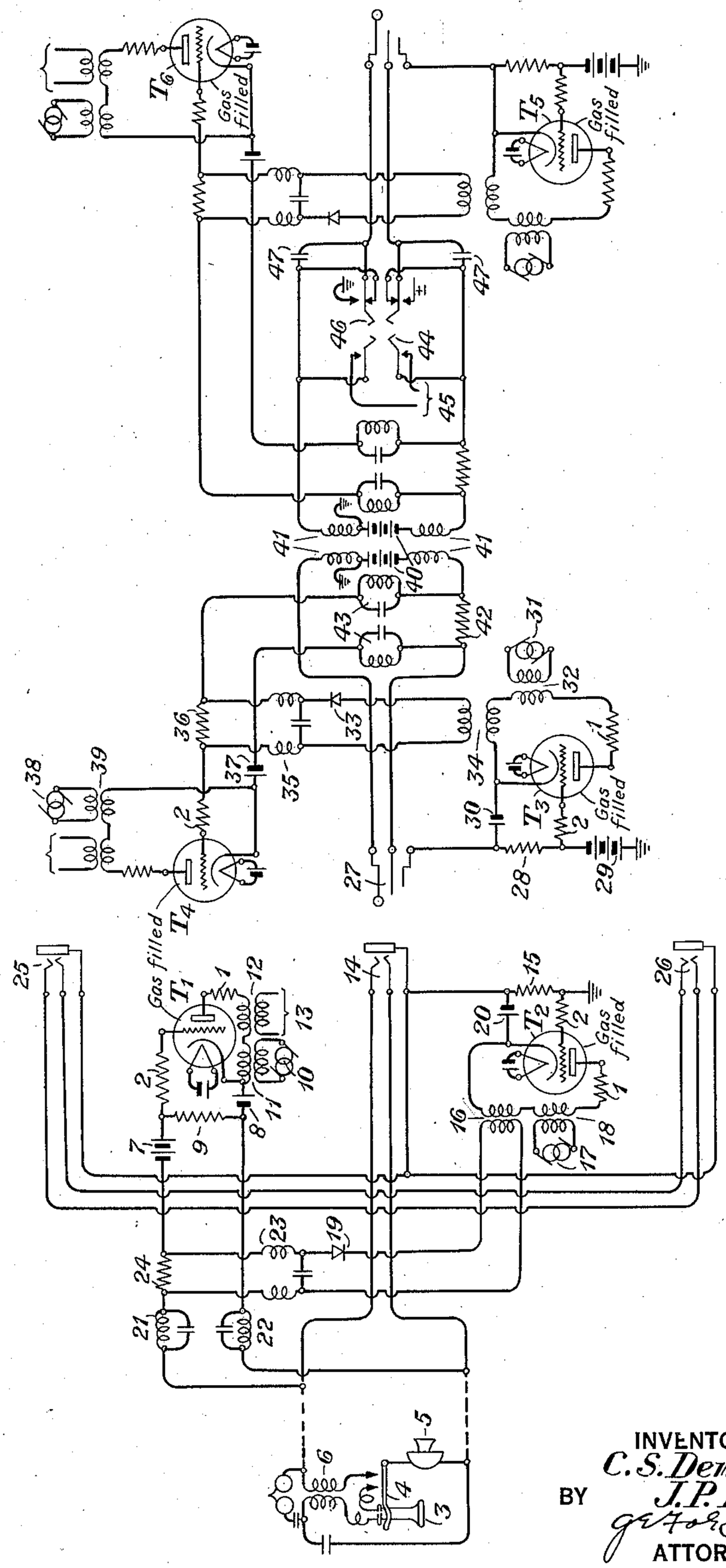

Fig. 1

Fig. 2

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SIGNALING SYSTEM

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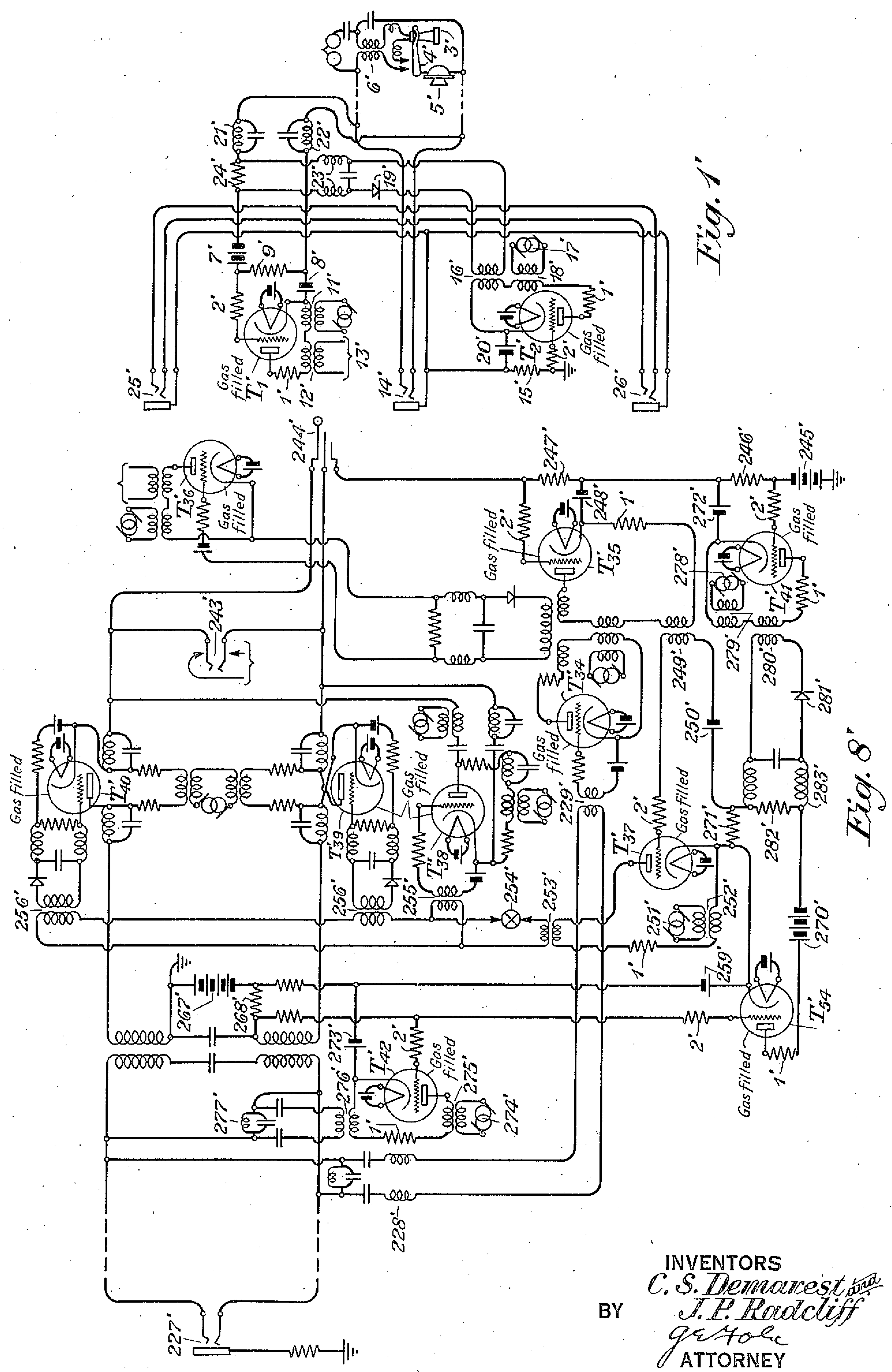

Fig. 1'

Fig. 8'

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SIGNALING SYSTEM

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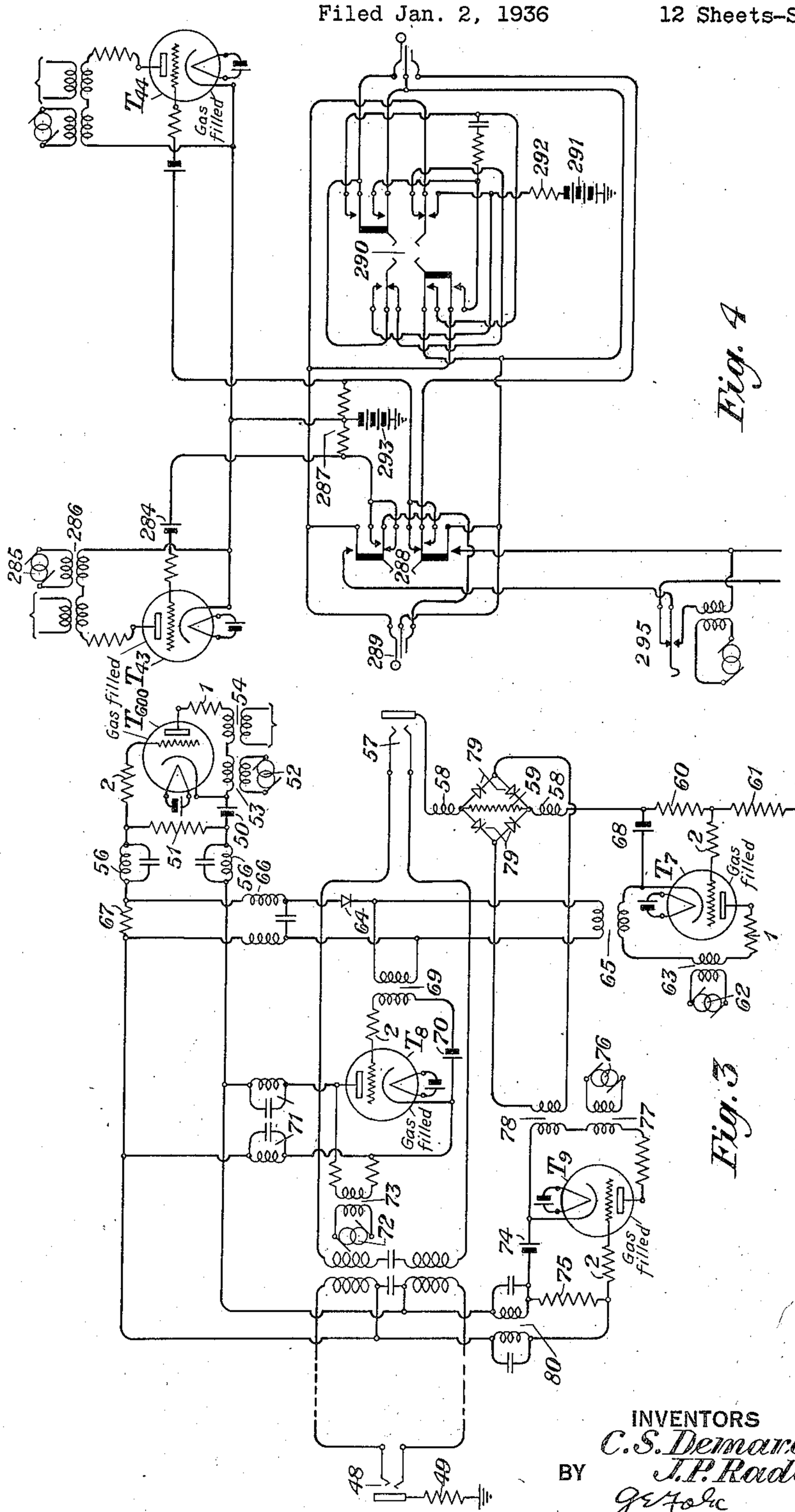

Fig. 4

Fig. 3

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SIGNALING SYSTEM

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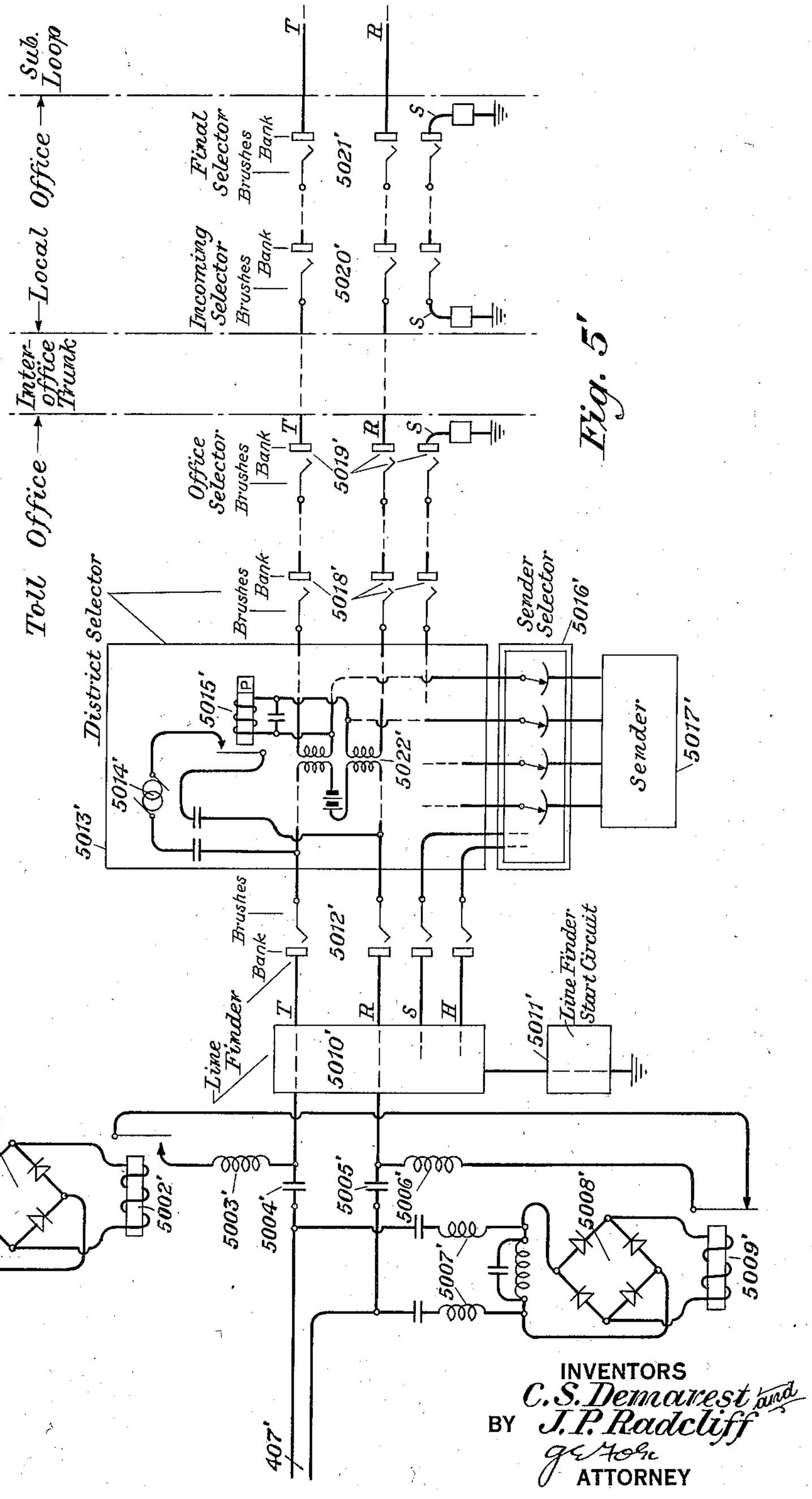

Fig. 5'

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SIGNALING SYSTEM

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Fig. 7

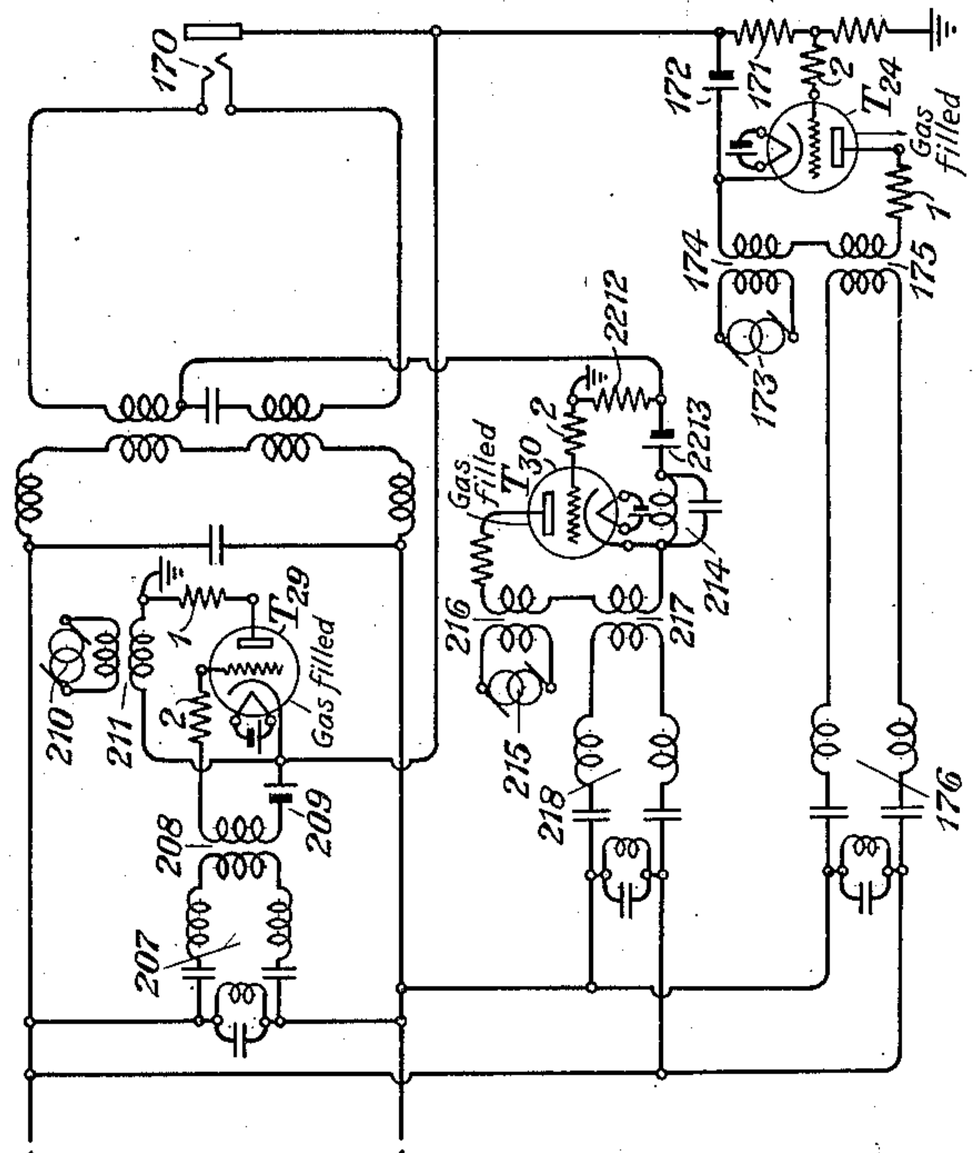

Fig. 6

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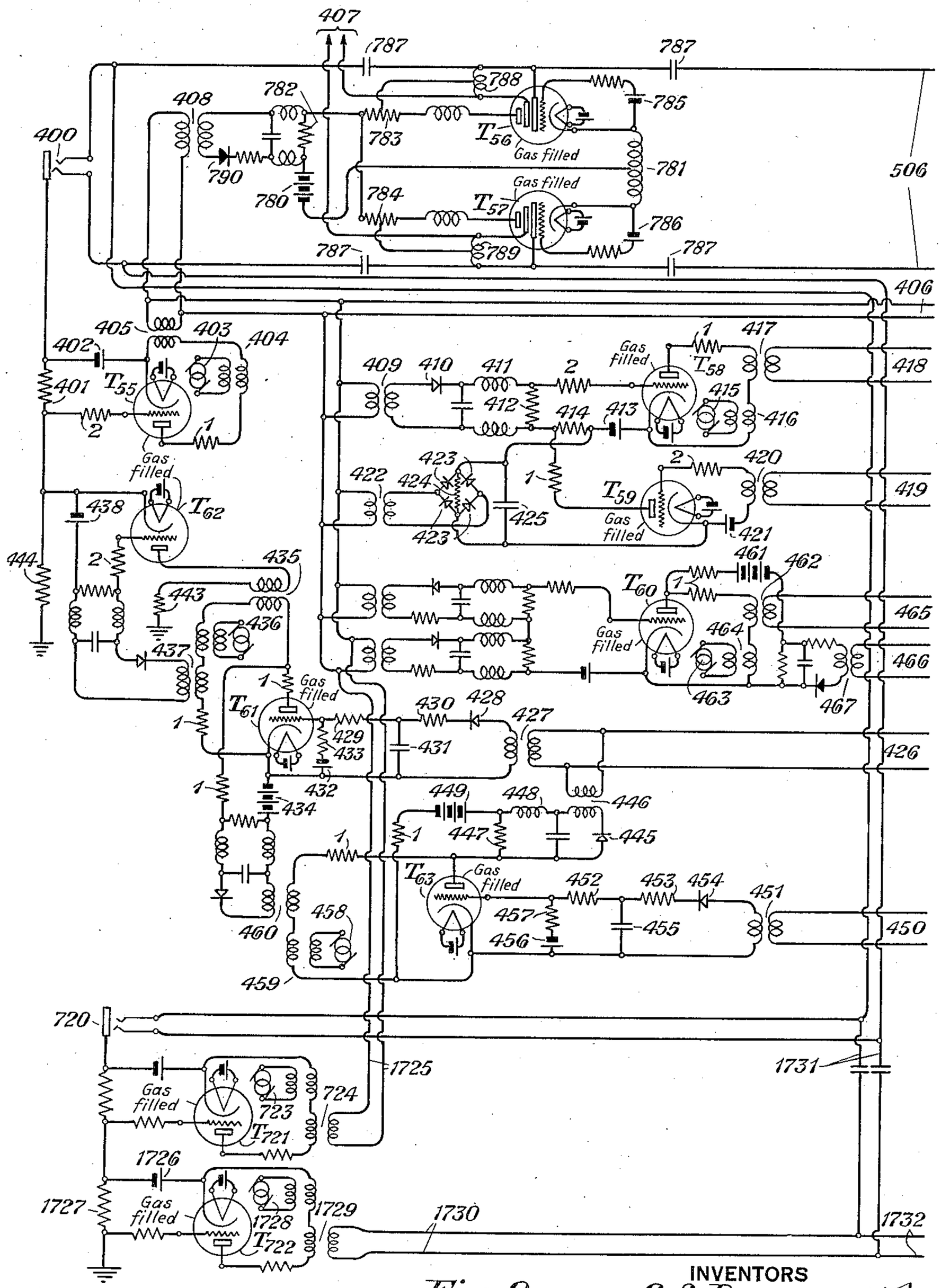

Fig. 9

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SIGNALING SYSTEM

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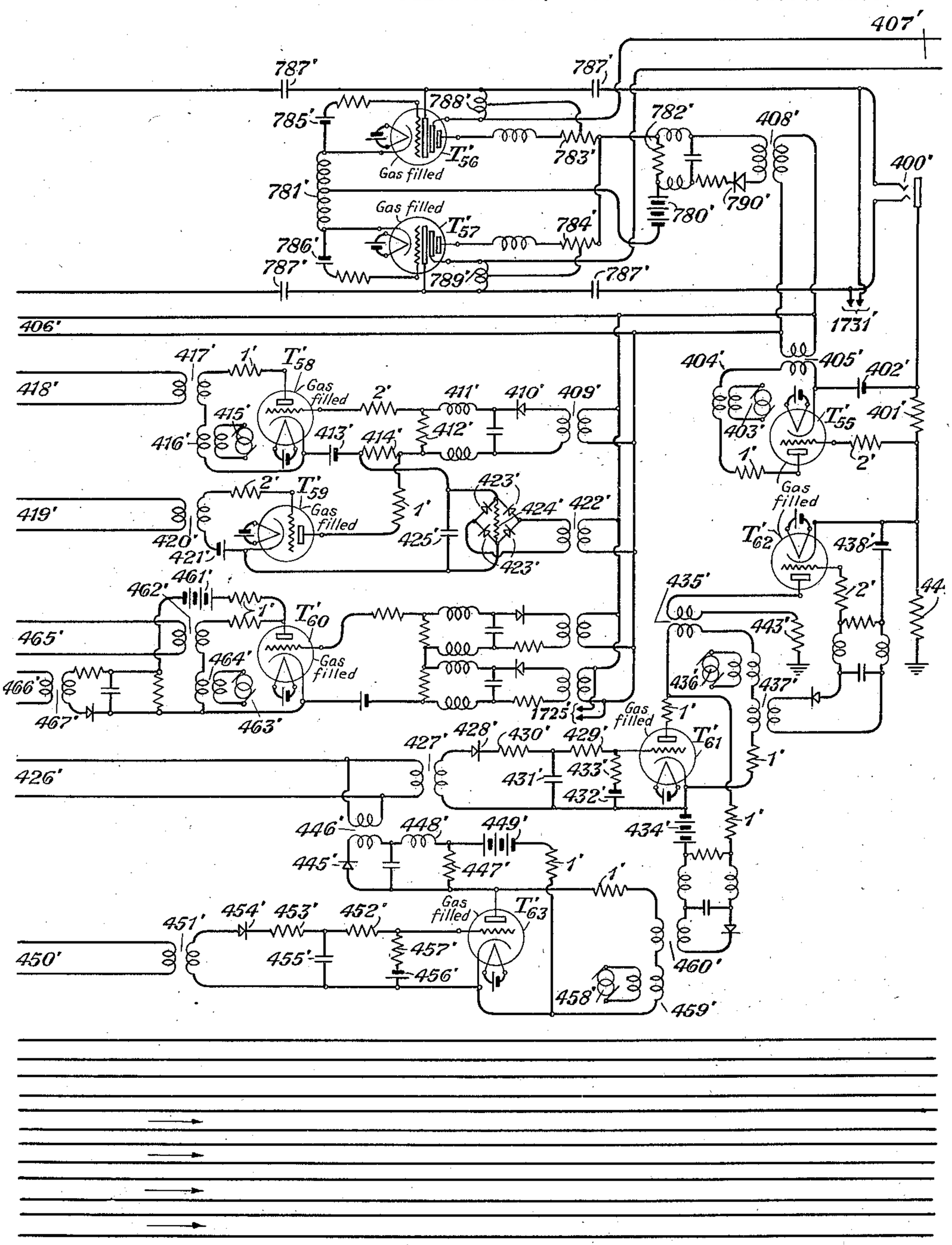

Fig. 9'

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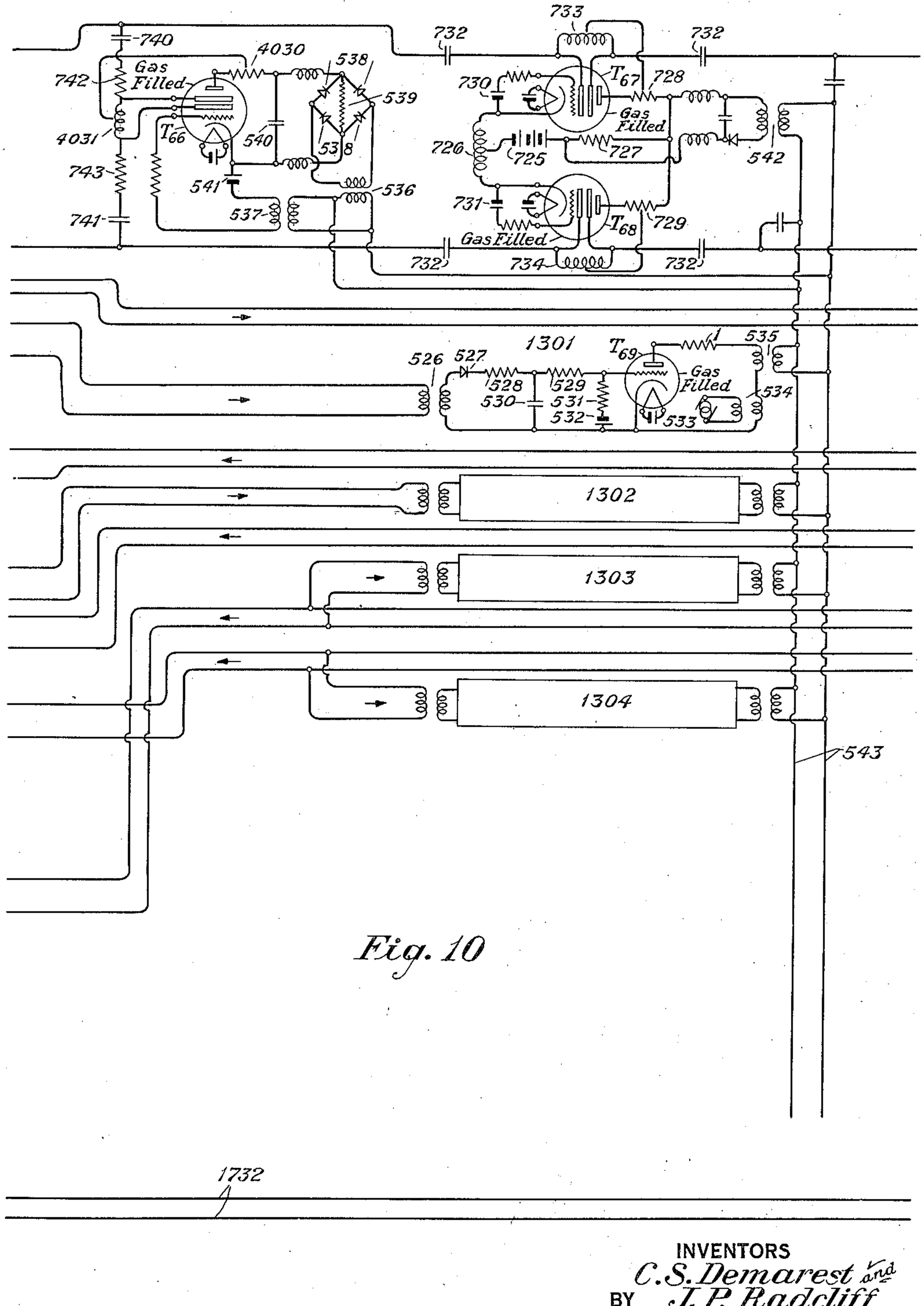

Fig. 10

1732

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SIGNALING SYSTEM

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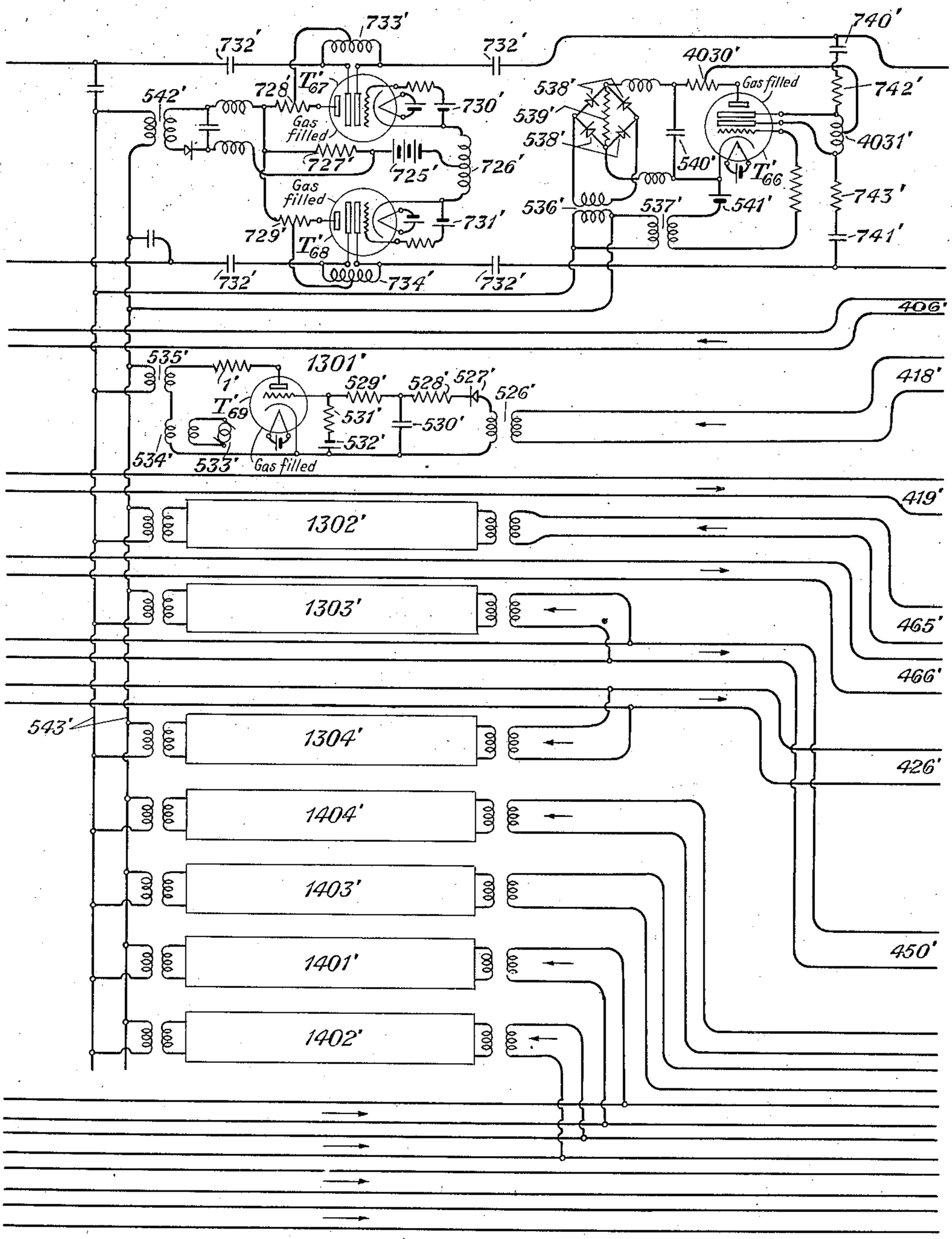

Fig. 10'

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SIGNALING SYSTEM

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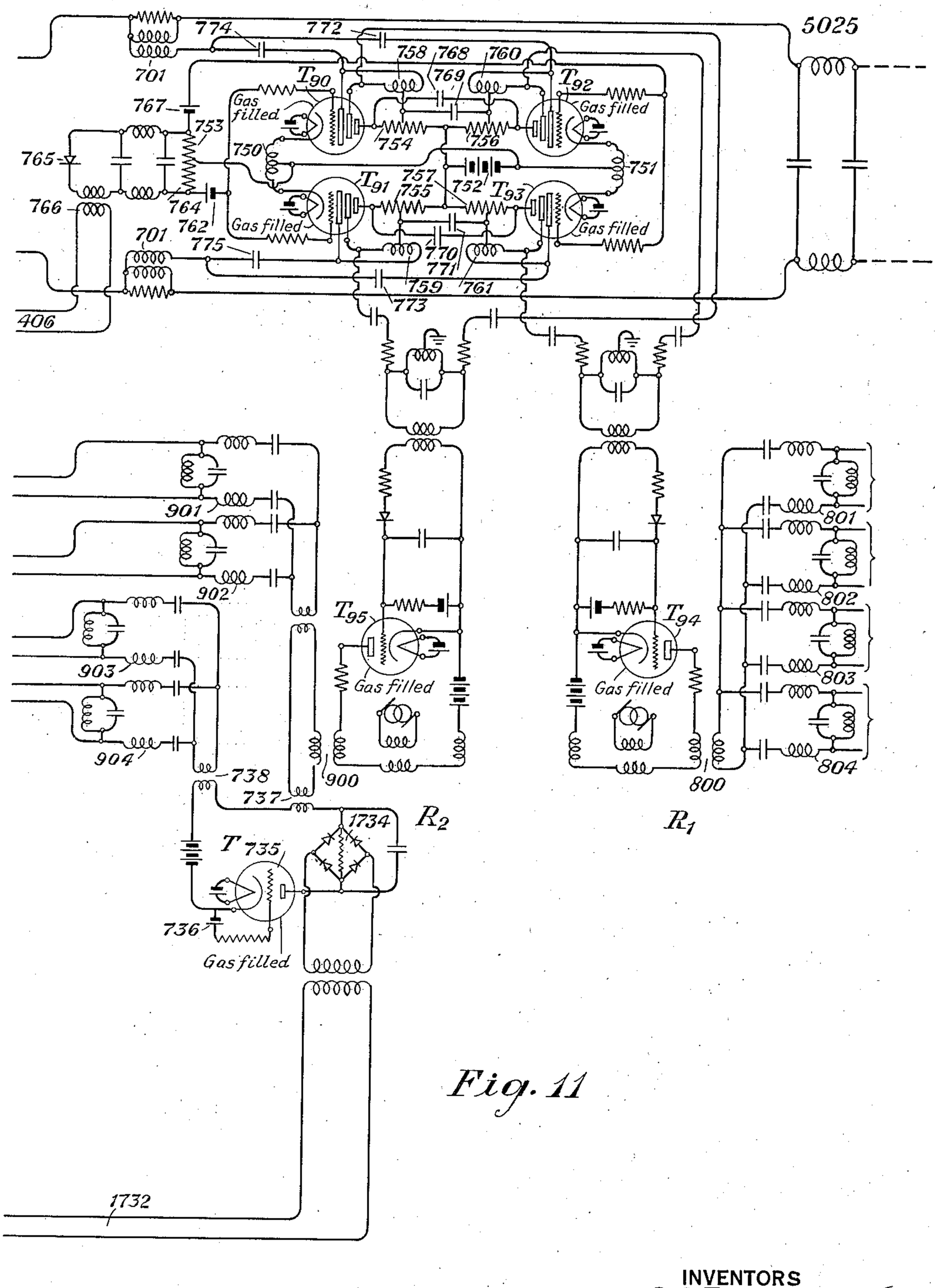

Fig. 11

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SIGNALING SYSTEM

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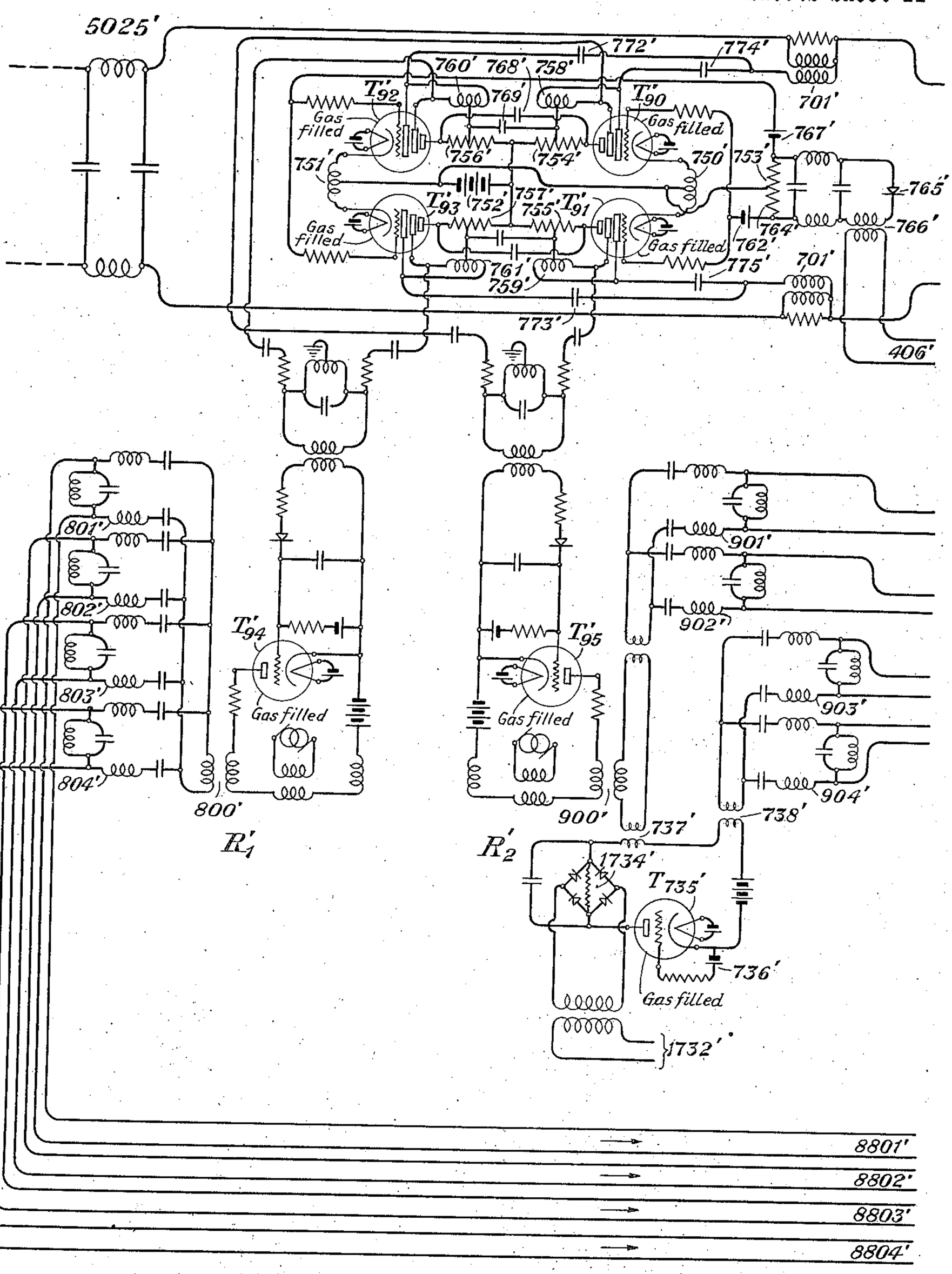

Fig. 11'

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SIGNALING SYSTEM

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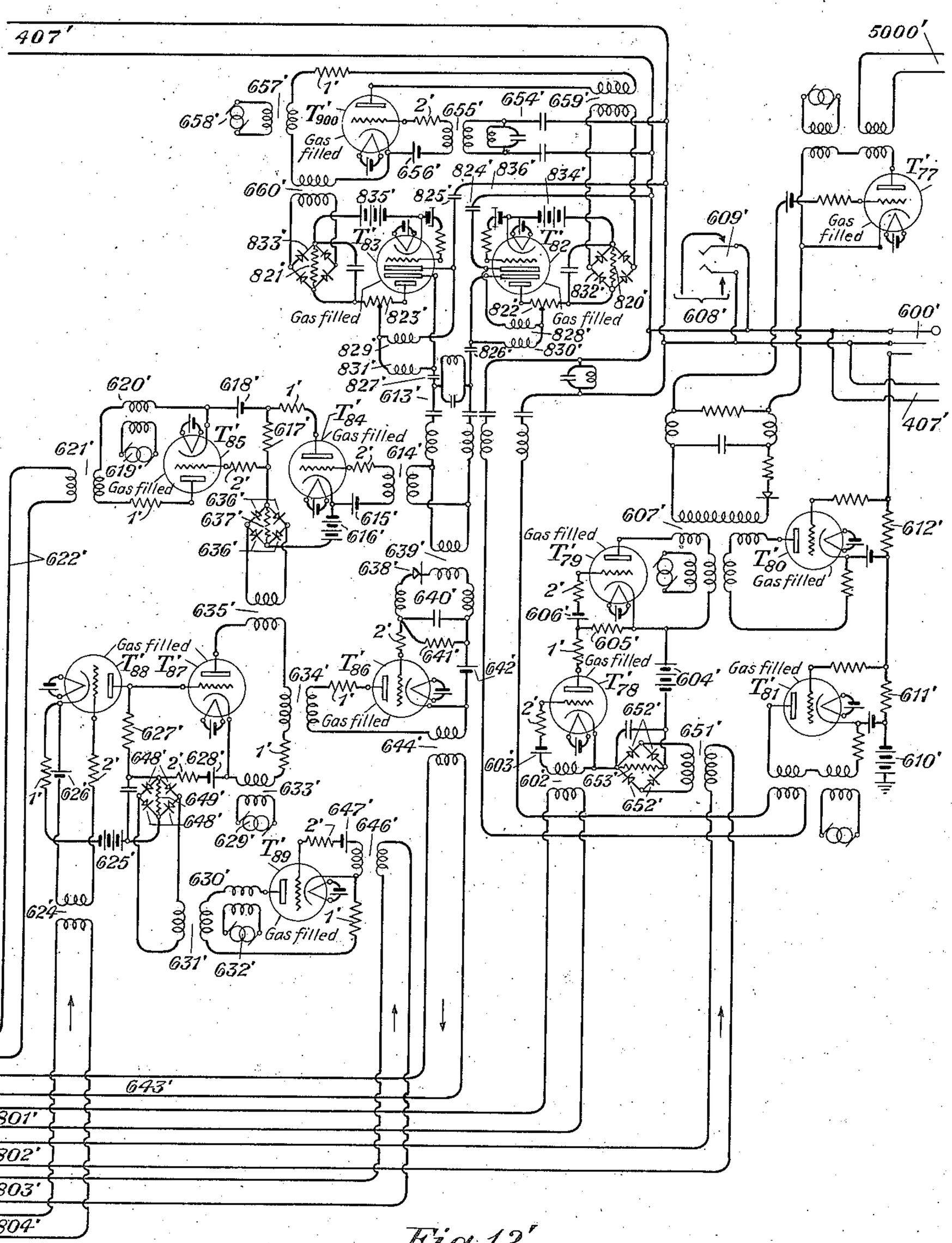

Fig. 12'

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Patented Oct. 6, 1936 2,056,347

UNITED STATES PATENT OFFICE

2,056,347

SIGNALING SYSTEM

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Application January 2, 1936, Serial No. 57,266

23 Claims. (Cl. 179—45)

This invention relates to transmission systems and more particularly to improved means for signaling over such systems and is a continuation in part of our application Serial No. 4583, filed February 1, 1935.

As the invention is particularly adapted for use in signaling over certain types of telephone circuits, it will be specifically described herein with respect to the type of circuit termed a "through two-way supervision toll circuit." In the through two-way supervision toll circuit, the outgoing toll operator has complete supervision of the whole circuit. All supervisory signals are transmitted from both the calling and the called party to the outward toll operator. In this type of circuit the supervisory signals are transmitted through an intermediate point of a built-up connection without the aid of an operator. While the invention is described with respect to this type of toll circuit, it is understood that it is for the purpose of illustration only and that the arrangements of the invention may be used with other types of transmission systems.

The signaling and control arrangements in toll circuits heretofore used employ direct current, low frequency alternating current, or voice frequency alternating current or any combination of these which may be necessary to operate electromagnetic relays and other devices requiring mechanically moving parts for contact-making and contact-breaking devices either directly or with the aid of associated apparatus. Such apparatus requires mechanical adjustment which sometimes necessitates considerable maintenance in practice. The speed of operation of mechanical devices is limited by the weight of the moving parts or by the time required to build up a magnetic field in the electromagnetic field. This may limit the application of such devices because of the slowness of operation. In some cases marginal operation is employed to perform certain operations. The number of margins which are permissible when electromagnetic devices are employed is limited. It is difficult to devise electromagnetic devices which will operate successfully at any but relatively low frequencies. This factor limits the possible use of various frequencies as means of signaling over telephone circuits. The signaling and control arrangements now available for telephone systems, therefore, are somewhat limited in the number of variables which may be employed to perform various necessary functions

In the arrangements of this invention, gas-filled discharge tubes together with circuits designed therefor are utilized to replace electromagnetic devices. Gas-filled discharge tubes are capable of response to currents of relatively high frequencies as well as low frequencies and direct current. Accordingly, the combination of gas-filled tubes and circuit arrangements therefor result in a signaling system applicable to transmission circuits which is superior to the relay arrangements of the prior art, since the number of frequencies which may be employed and, consequently, the variety of functions obtainable is greatly increased. Moreover, in accordance with this invention, the gas-filled tubes and circuit arrangements therefor are of such design that the tube can be caused to operate or release as the circuit may require by means of the application of carrier frequency, alternating current, alternating currents of lower frequency or direct currents of the proper polarity. The direct current may be supplied by either the primary or secondary cells through resistance units or alternating current which has been rectified by means of rectox units, vacuum tube or gas-filled rectifiers or by any other rectifying device, several of which are well known in the art. Furthermore, in accordance with the arrangements of this invention, more precise and constant specific time of operation is obtained through the use of gas-filled tubes and their associated circuits than can be obtained by using a system of electromagnetic relays. Also, the gas-filled tube circuits are capable of being faster acting than the electromagnetic equipment and the gas-filled tube, and circuit therefor, adapts itself readily to marginal operation.

The invention may be more fully understood from the following description together with the accompanying drawings, in the Figures 1, 2, 3, 4, 6, 7, 9, 10, 11, 1′, 5′, 8′, 9′, 10′, 11′ and 12′ of which are shown circuit diagrams embodying one form of the invention. Figure 1 is a circuit diagram showing a local subscriber's line connecting the subscriber to the local office. In the drawings Fig. 2 should be placed to the right of Fig. 1. Fig. 2 shows a cord circuit for the operator at the local office. In the drawings Fig. 3 is placed to the right of Fig. 2. Fig. 3 shows a recording trunk for interconnecting the local office with a toll office. In the drawings Fig. 4 is placed to the right of Fig. 3. Fig. 4 shows a cord circuit for the operator at the toll office. Figs. 6 and 7 show a toll switching trunk when Fig. 7 is placed to the right of Fig. 6. This toll switching trunk may be used to establish a connection between the local subscriber's line, such as shown

in Fig. 1, and a toll operator's cord circuit, such as shown in Fig. 4. Figs. 9, 10 and 11 should be placed in the drawings so that Fig. 9 is to the right of Fig. 4. Fig. 10 is to the right of Fig. 9, and Fig. 11 is to the right of Fig. 10. When so placed Figs. 9, 10 and 11 show certain details of the terminal equipment associated with a toll line of the through two-way supervision type. At the distant end of the toll line there would be the apparatus shown in Figs. 11', 10', 9' and 12', with Fig. 10' placed to the right of Fig. 11', with Fig. 9' placed to the right of Fig. 10' and with Fig. 12' placed to the right of Fig. 9'. As Figs. 9', 10' and 11' are in many respects identical with Figs. 9, 10 and 11, similar reference characters with the added designation prime have been used in Figs. 9, 10 and 11 to indicate like parts with respect to Figs. 9, 10 and 11. Fig. 8' in the drawings should be placed to the right of Fig. 12'. Fig. 8' shows the details of a toll switching trunk utilized to connect the toll line to the distant subscriber's line which is shown in Fig. 1'. If the toll call were initiated from the subscriber's line shown in Fig. 1', a local cord circuit, a recording trunk, a toll operator's cord circuit and a toll switching trunk, such as shown respectively, in Figs. 2, 3, 4, 6 and 7, would be provided at the distant end of the line. However, as these circuits would be identical with those shown at the other end of the line they have not been illustrated. If the call is to be completed through an automatic exchange the arrangements of Fig. 5' would be used in place of those of Figs. 8' and 1' and Fig. 5' would be placed to the right of Fig. 12'.

If a call is to be completed over a through two-way supervision toll circuit, the local "A" operator answers the call in a manner similar to that described above and reaches the toll operator over a two-wire recording trunk. After the toll operator learns the destination of the call she plugs into an outgoing through two-way supervision toll switching trunk interconnecting the outward toll operator to the "B" board at the local office of the calling subscriber. This lights a lamp in front of the "B" operator. The toll operator instructs the local "B" operator to go into the subscriber's line jack over the busy test. The subscriber is now connected to the toll operator by means of the outgoing through two-way supervision toll switching trunk. The toll operator then pulls down from the two-wire recording trunk, thus giving a disconnect signal to the local "A" operator who disconnects the subscriber's cord from both the subscriber's line and the two-wire recording trunk. The toll operator also selects the proper toll circuit and plugs into this circuit with the toll cord. When she plugs into the toll circuit, a lamp is lighted automatically before the incoming toll operator at the distant end. The distant toll operator determines the destination of the call and selects the proper incoming through two-way supervision toll switching trunk interconnecting the inward toll operator to the local office of the called subscriber. She then plugs into this trunk with the plug terminated end of the toll line instead of with her cord circuit. A lamp then appears in front of the local "B" operator who answers the call. Having received the called subscriber's number, she plugs into the proper subscriber's line jack. This operation automatically starts the subscriber's bell ringing. When the subscriber answers, the off-hook signal caused by lifting the receiver from the switch is sent back to the outgoing toll operator who controls the entire circuit. All switchhook signals are transmitted back to this outward toll operator. When either subscriber hangs up, a light appears before the outward toll operator. She then disconnects from the toll circuit which causes a light to appear before the inward toll operator, who disconnects the toll line from the incoming through two-way supervision toll switching trunk. This operation sends a disconnect signal to the local "B" operator's position and she disconnects from the called subscriber's line. When the outward toll operator disconnects from the outgoing through two-way supervision toll switching trunk, a light appears at the local "B" operator's position and she disconnects the subscriber from the circuit. In the through two-way supervision toll circuit it is necessary to select a special jack if the circuit is to be built up of more than one toll circuit. To function on a built-up connection, the equipment is so designed that only disconnect signals are received at the intermediate positions. Hence, it is not necessary for the outward toll operator to clear the circuit as in the previously described case.

In the following detailed description of the invention the word "operate" or derivatives thereof will be used hereafter to indicate the process which takes place within the gas-filled tube when the gas contained inside the bulb ionizes and an arc is established from the cathode to the anode. The word "release" or derivatives thereof will be used hereafter in the description of this invention to indicate the extinction of the arc and the return of the gas to a deionized condition. Each of the gas-filled tubes in this invention has a protective resistance 1 in the plate circuit of the tube. This protective resistance is used to limit the current in the plate circuit to a suitable or a safe value. Furthermore, each gas-filled tube has a protective resistance 2 in the grid circuit in order to prevent the grid current of the tube from becoming excessive. Since these resistances are to be found associated with every tube, no further mention will be made of their purpose.

The type of gas-filled tube illustrated herein is of the heater type and the heater power is shown supplied by means of direct current. It is understood in this invention that the cathode is not necessarily of the heater type and the power supply is not limited to direct current. Furthermore, the gas-filled tube may be of the cold cathode type, under which conditions no heater nor heater power would be required, and in which case a glow discharge rather than an arc discharge might be utilized.

The types and characteristics of the gas-filled tubes used in this invention will be varied and numerous and each gas-filled tube employed will be of the type and have the characteristics which are essential and necessary to perform the functions which are required of the tube by the use to which it is specifically put.

One type of tube may be of such physical dimensions that it is capable of being mounted in the switchboard in front of the operator. The gas content of this tube is of such a nature and pressure that a visual glow is present when the tube is operating. However, this type of tube may be used to give a visual indication or to perform some electrical function such as the completion of a circuit. This type of gas-filled tube will be

referred to in this description as a "combined lamp and relay".

Another type of tube has five electrodes contained within the envelope. The cathode, grid and anode perform the same functions as in the three-element tube. In addition to these elements are two probes or plates. When the tube is in the non-operate or release condition, the resistance between these two probes or plates is very high but when the tube operates and a bias slightly positive with respect to the anode is applied to the probes the resistance between these two probes and the cathode, or between the probes is relatively low. Hence, by properly connecting such a tube in a circuit, the circuit may be completed through these probes or plates. This type of tube will be referred to in this description as a "five-element tube".

The other types of tubes employed in this invention are of such physical characteristics and have such gas and gas pressure within the envelope as to meet the requirements which are set up by the circuit conditions.

In the embodiment of the invention described herein, certain gas-filled tubes are arranged for self-quenching by means of an alternating potential applied to the anode circuit from a separate source of alternating current. It is of course, within the scope of this invention to apply other quenching means to such tubes as may require the same in the practice of this invention. For example, one of the aforesaid tubes may be arranged in a self-oscillatory circuit in such a manner that the plate current is interrupted once for each cycle of the operation. It would also be possible to provide auxiliary quenching tubes in such a manner that the discharge would be transferred from one of the main tubes to the auxiliary tube when required, or where tubes are used alternately, from one tube to the other.

Certain gas-filled tubes described in this invention are so connected as to be associated with an auxiliary circuit. Connection is made to these auxiliary circuits through a transformer connected in the plate circuit of certain gas-filled tubes. The words "auxiliary circuit" are taken to mean such equipment as may not be required if the telephone circuit is to include the connections required for connecting together and giving service to only two subscribers, one at each end of the toll connection or local connection. This auxiliary circuit equipment would be necessary if more than the above mentioned subscribers were to be served. Certain of these auxiliary circuits may also be used in connection with dialing. It is proposed in this description to indicate a method or methods of connecting such auxiliary equipment to the herein described telephone circuit.

Figure 1 is the subscriber's line circuit. Gas-filled tube T_1 may be a combined lamp and relay. The operation of tube T_1 is under the control of the subscriber's switchhook and tube T_2 which is controlled by the sleeve circuit of jack **14**, **25** or **26**. When the subscriber lifts the receiver **3** from the switchhook **4**, the subscriber's line is short-circuited through one of the coils of the induction coil **6** and the telephone transmitter **5**. This short-circuit on the line applies the positive potential of battery **7** to the grid of tube T_1. The applied potential is of such a polarity as to cause the tube to operate. Tube T_1 is normally held released by the negative potential of battery **8** applied to the grid of tube T_1 through the resistance **9**. The plate of tube T_1 is supplied with an alternating potential by generator **10** through transformer **11**. The operation of the tube T_1 operates a visual signal to the operator and also allows plate current to flow in the plate circuit of the tube. This current induces a voltage in the secondary of transformer **12** which supplies an auxiliary circuit **13**, the purpose of which has been discussed previously. Anti-resonant circuits **21** and **22** consisting of suitable coils and condensers are placed in the input circuit of tube T_1 to prevent the alternating current which is supplied to the plate of the tube from being fed back into the telephone line. When the local "A" operator answers the call, she plugs into the subscriber's line jack **14**. This applies negative battery to the sleeve of the jack. The potential drop across resistance **15** in the sleeve circuit is such that tube T_2 operates. When tube T_2 operates, potential is supplied to rectifier **19** by transformer **16**. The plate supply of tube T_2 is supplied by alternator **17** through transformer **18**. Tube T_2 is held normally unoperated by a negative potential supplied by battery **20**. Unidirectional current supplied by rectifier **19** flows through filter **23** to resistance **24**. The potential drop across resistance **24** is in such a direction as to apply the proper polarity to the grid of tube T_1 to cause it to release, thus extinguishing the visible glow. Whenever a cord is plugged into any of the subscriber's line jacks, **14**, **25** or **26**, switchhook signals from the subscriber are transferred to the cord circuit and do not cause tube T_1 to operate. Jacks **25** and **26** are at inward positions or at the local "B" operator's position and the insertion of a plug in these jacks causes tube T_2 to operate and function in the circuit as described above. When the subscriber hangs the receiver **3** on hook **4**, the short-circuit is removed from the subscriber's line and the potential of battery **7** is removed from the grid of tube T_1. Hence, when the cord is pulled out of either jack, **14**, **25** or **26**, tube T_1 will not operate and no visible signal is given to the local "A" operator by tube T_1. Should a cord be pulled out of either jack **14**, **25** or **26**, before the subscriber has placed his receiver on the hook, tube T_1 would operate and a visual signal would appear before the local "A" operator.

Fig. 2 is the local operator's cord circuit which is available to the local "A" operator. The subscriber's cord circuit is used to answer calls from the calling subscriber and connect the subscriber to the toll operator if the call is to be a toll call. Incoming calls are answered by inserting plug **27** into the subscriber's line jack. This operation completes the sleeve circuit of the plug, thus allowing a current to flow from battery **29** through resistance **28**. The completion of the sleeve circuit applies a negative potential to the grid of tube T_3 of such a value that the tube is released. Tube T_3 is normally held operated by the positive potential of battery **30** being applied to the grid of the tube. Alternating potential from generator **31** is applied to the plate of tube T_3 through transformer **32**. When tube T_3 is operated, an alternating potential is applied to rectifier **33** through transformer **34**. The unidirectional voltage from rectifier **33** passes through filter **35** and is applied to resistance **36**. The potential applied across resistance **36** is in such a direction as to oppose the potential supplied by battery **37** to the grid of tube T_4. The potential supplied to the grid of tube T_4 from battery **37** is applied thereto through resistances **42** and **36**. Tube T_4 is accordingly normally released. When the subscriber's cord is plugged

into a line jack tube T_3 will release as heretofore pointed out and this will tend to cause tube T_4 to operate. However, this operation of tube T_4 at this time will be prevented if the subscriber's receiver is off the hook as will be pointed out hereinafter. The tube T_4 may be a combined lamp and relay and is so placed as to be visible to the operator. The alternating potential for tube T_4 is supplied by generator **38** through transformer **39**. A transformer is provided to connect the subscriber's cord circuit shown to auxiliary apparatus, the purpose of which has been discussed above. When the subscriber's receiver is off the hook, current from battery **40** is supplied to the subscriber's line through the repeating coil **41**. This current flows through resistance **42** in such a direction that potential drop across this resistance is in opposition to the potential applied to the grid by battery **37** and hence will cause a negative potential to be applied to the grid of tube T_4 thus releasing the tube. Anti-resonant circuits **43** are employed to prevent the alternating potential which is applied to the plate of tube T_4 from feeding back into the subscriber's line circuit. When the subscriber places the receiver on the hook, current ceases to flow through resistance **42** and tube T_4 will operate, thus operating a visual signal to the operator that the subscriber has completed the call. When the operator pulls plug **27** out of the line jack, tube T_3 operates due to the ceasing of the current flow through resistance **28**. When tube T_3 operates, a potential is applied across resistance **36** in such a direction as to cause tube T_4 to be released. The tubes T_5 and T_6 and the equipment associated with them perform in a manner substantially similar to that described immediately above for tubes T_3 and T_4. This will be pointed out in more detail hereinafter. Key **44** is the key by which the operator can connect her telephone to the line circuit. The operator's telephone set and associated equipment are connected at **45**. Key **46** is a ringing key to apply ringing current to the subscriber's line should the "A" operator desire to call a subscriber. Condensers **47** are used to send audible ringing current back to the calling subscriber.

Fig. 3 is the two-wire recording trunk which connects the local "A" operator to the toll operator. This is the trunk over which information is passed from the calling subscriber through the local operator to the toll operator. The trunk is not used to complete the call but the toll operator reaches the calling subscriber over a different type of trunk and the calling subscriber communicates with the called subscriber over the last mentioned trunk but not over a two-wire recording trunk. Signals are transmitted over this trunk only from the local "A" operator to the toll operator.

The local "A" operator reaches the toll operator by inserting the plug of the subscriber's cord circuit into jack **48**. Resistance **49** completes the sleeve circuit of this jack to ground. The plug of a subscriber's cord circuit is so wired that the tip has a positive and the ring a negative potential on it. The positive potential applied to the tip of the trunk places a positive potential on the grid of tube T_{600} causing it to operate. Tube T_{600} may be the type of combined lamp and relay which has been referred to previously. Tube T_{600} is normally held released by the potential of battery **50** applied to the grid of the tube through resistance **51**. The plate potential of tube T_{600} is supplied by generator **52** through transformer **53**. A transformer is used to connect this circuit with auxiliary apparatus. Anti-resonant circuits **56** prevent the alternating potential applied to the plate of the tube from going out to the line. When tube T_{600} operates, there is a visual indication to the toll operator that a call is waiting on that trunk. She inserts the plug of a toll cord into the jack **57**.

The sleeve circuit of jack **57** contains inductances **58** and resistances **59**, **60** and **61**. When the plug of the toll operator's cord circuit of Fig. 4 is inserted into the line jack **57**, current flows from battery **293** through resistance **60** in such a direction as to apply a positive potential to the grid of Tube T_7, causing it to operate. Tube T_7 is held normally released by the negative potential supplied to the grid of this tube by battery **68**. Generator **62** supplies the alternating plate potential of the tube through transformer **63**. When the tube operates, alternating current is applied to rectifier **64** through transformer **65**. The unidirectional current from rectifier **64** flows through the filter **66** into the resistance **67**. The resulting potential across resistance **67** is in such a direction as to oppose the potential applied to the tip and ring of the line circuit by the subscriber's cord. This releases tube T_{600}. When tube T_7 operates, alternating potential is applied to the grid of tube T_8 through transformers **65** and **69**. The tube T_8 is held normally released by the negative potential supplied by battery **70**. When tube T_8 operates, it applies a relatively low impedance across the tip and ring of the two-wire recording trunk through the anti-resonant circuits **71**. The placing of this low impedance across the tip and ring conductors of the recording trunk will allow current to flow from battery **40** through a resistance in the local "A" operator's cord circuit similar to resistance **42**, which in a manner similar to that described with respect to resistance **42** will apply a potential to tube T_6 so as to extinguish or release it. These anti-resonant circuits are placed in the leads to the trunk to prevent the alternating potential supplied to the tube by generator **72** through transformer **73** from being fed back into the trunk. When the toll operator has received the instructions concerning the call, she pulls down from the line jack **57**. This removes battery **293** from the sleeve of the jack and thus removes the potential drop across resistance **60**. Tube T_7 releases and removes the potential drop from across resistance **67** and also removes the voltage from the grid of tube T_8 causing it to release. The removal of the potential drop across resistance **67** will cause tube T_{600} to operate at this time and it will remain operated until the jack is removed from plug **48**. The release of tube T_8 removes the low impedance from across the two-wire recording trunk. This gives a visual indication to the local operator to remove her plug from the line jack of the recording trunk. When the local operator removes the subscriber's cord from the recording trunk, tube T_{600} is extinguished as referred to above.

The operation of tube T_9 will now be described. When the local operator inserted the subscriber's cord in the jack of the two-wire recording trunk, a positive potential was placed on the grid of tube T_9, causing it to operate. Tube T_9 is normally held released by the negative potential supplied by battery **74** through resistance **75**. The plate potential of tube T_9 is supplied by the generator **76** through transformer **77**. When an alternating current flows in the plate circuit of

tube T_9, an alternating potential is applied to rectifier unit **79** by transformer **78**. The unidirectional current from rectifier **79** flows through resistance **59** in such a direction as to oppose the flow of current caused by the battery **293** in the sleeve circuit. The value of this potential, however, is not sufficiently great to prevent the operation of tube T_7, but it is of a sufficient value to make the sleeve circuit appear as a very high impedance circuit to the toll cord. Should the local operator remove the plug from jack **48** before the toll operator removes the plug from jack **57**, tube T_9 would be released, the counter voltage set up by the rectifier unit **79** would be removed, and the sleeve circuit would appear as a low impedance circuit. This would cause a visual signal at the toll operator's position in the toll cord circuit due to the operation of tube T_{43} as hereinafter described. Anti-resonant circuits **80** are placed in the input circuit of tube T_9 to prevent the alternating potential supplied to the plate of that tube from feeding back into the two-wire recording trunk.

Figs. 6 and 7 illustrate the circuit of a toll switching trunk which may be used if the outgoing call is to be completed over a through two-way supervision toll line. When the toll operator plugs into line jack **170**, a potential drop of such a polarity is set up across resistance **171** that tube T_{24} operates. Tube T_{24} is held normally released by the potential of battery **172**. Alternating potential is applied to the plate of this tube by generator **173** through transformer **174**. The frequency of the alternating potential supplied by generator **173** is in the super-audible or carrier range. When tube T_{24} operates, a carrier frequency is sent out through transformer **175** and the carrier frequency filter **176** over the toll switching trunk to the terminal equipment at the local office shown in Fig. 6. The carrier frequency passes through the filters **177** and **178** and is applied to the grid of tube T_{25} through transformer **179**. Tube T_{25} is held normally unoperated by the potential of the battery **180**. When tube T_{25} operates, alternating current is caused to flow through primary **181** of a three-winding transformer **182**. Alternating potential from generator **183** is supplied to tube T_{25} through a three-winding transformer **184**. An alternating potential applied to transformer **182** from source **183** operates tube T_{26} in the following manner. Tube T_{26} is normally held released by the negative potential of the battery connected to its grid. The alternating potential applied to transformer **182** will because of rectifier **1800** cause a potential to be applied across resistance **1801** in such a direction to overcome the negative potential normally applied to the grid of tube T_{26} and will cause it to operate. Tube T_{26} is capable of giving a visual signal. When the local "B" operator sees the visual indication which results from the operation of tube T_{26}, she connects her headset to the toll switching trunk by means of key **192**. After ascertaining the proper destination of the call she inserts plug **193** into the proper line jack. This completes the sleeve circuit of plug **193**, and battery **194** causes the potential drop across resistance **195** to be in such a direction as to result in the operation of tube T_{27}. This tube is normally held released by the negative potential supplied by battery **196**. The operation of tube T_{27} results in the release of tube T_{26}. This is because the alternating current in the left hand primary winding of transformer **182** will oppose the aforementioned alternating current in the right hand winding of transformer **182** and the resulting potential across resistance **1801** will be zero thus permitting tube T_{26} to be released by the negative potential normally applied to its grid. When tube T_{27} operates, current flows through the primary of transformer **197**. This results in a potential being applied to rectifier **198**, which, in conjunction with filter **199**, applies a unidirectional potential across resistance **200**. This drop of potential is in such a direction as to cause the operation of tube T_{28} if the subscriber's receiver is on the switch-hook. Tube **28** is normally held released by the potential supplied by battery **201**. Generator **203** supplies alternating potential of carrier frequency to the plate of this tube through transformer **204**. Anti-resonant circuit **202** in the input circuit of tube T_{28} prevents the alternating current from source **203** from being transmitted into the talking circuit. When tube T_{28} operates, carrier frequency from generator **203** is sent through transformer **205** and filter **206** over the toll switching trunk to the toll end of the same.

This carrier frequency passes through filter **207** of Fig. 7 and causes the operation of tube T_{29} through transformer **208**. When tube T_{29} operates, the resistance of the sleeve circuit of jack **170** is changed from a high resistance to a low resistance thus causing a visual indication to be given to the toll operator by the operation of tube T_{43} in the toll cord circuit in a manner heretofore described. Tube T_{29} was normally held unoperated by the potential of battery **209**. Alternating potential from generator **210** is applied to the plate of the tube through transformer **211**.

Returning to Fig. 6, if the subscriber's receiver is off the switchhook which would be the normal condition at this time for an outgoing call, current from battery **212** flows over the line through resistance **213**. The current flows through resistance **213** in such a direction (namely in opposition to the current through resistance **200**) as to result in the release of tube T_{28}. When tube T_{28} releases, the carrier frequency is removed from the line and tube T_{29} of Fig. 7 is therefore also released. This restores the high resistance sleeve circuit and extinguishes the visual indication caused by tube T_{43} in the toll cord circuit. In other words if the subscriber's receiver is off the hook the tube T_{43} in the toll operator's cord will not be operated at all at this time.

In the event that the toll operator should not be able at the moment to find an idle toll line, she might tell the subscriber to hang up the receiver and await a call. When the toll operator desires to ring the subscriber, she can do so by pulling her ringing key in the cord circuit of Fig. 4. This applies a negative potential to the tip of the toll switching trunk, causing the operation of the tube T_{30} due to the drop in the resistance **2212**. Tube T_{30} is normally held released by the negative potential of battery **2213**. Generator **215** supplies alternating potential of carrier frequency to the plate of tube T_{30} through transformer **216**. Anti-resonant circuit **214** is inserted in the input circuit of the tube to prevent the alternating potential applied to the plate from being transmitted back into the toll switching trunk. When this tube operates, a carrier frequency is sent out through transformer **217** and filter **218** over the toll switching trunk.

This carrier frequency passes through filter **177** and filter **219** of Fig. 6. This carrier frequency is prevented from reaching the input circuit of tube T_{25} because of filter **178**. Filter **219** pre-

vents the carrier frequency heretofore referred to from generator **173** from reaching the input circuits of tubes T_{31}, T_{32} and T_{33}. The carrier frequency passes through transformers **220** and **221** and results in the release of tubes T_{32} and T_{33} and the operation of tube T_{31}. Tubes T_{32} and T_{33} are identical in operation.

The anode circuits of tubes T_{32} and T_{33} are supplied with high frequency alternating current from the generator common to both through anode circuits and with direct current from battery **212**. The frequency of this alternating current is above the range of speech frequencies used in telephony being, for example, 8,000 cycles if the transmission band for telephony ranges from 200 to 3,000 cycles. Anti-resonant circuits are provided to exclude this current from other portions of the trunk circuit. When arcs exist in each of these tubes T_{32} and T_{33}, which will be during those portions of a cycle when the anodes are positive with respect to their cathodes, if there is no input to transformers **220**, current will flow in the anode-cathode path and speech current superposed thereon may flow from anode to cathode or vice versa, provided the amplitude of the current from the high frequency source exceeds that of the speech currents. These speech currents will modulate the 8,000 cycle current but only the speech frequencies will pass through the anti-resonant circuits associated with the alternating current anode supply to tubes T_{32} and T_{33}. Thus a talking path is completed through the normally operated tubes T_{32} and T_{33}. Direct current from battery **212** also flows through the anode-cathode path of tube T_{32} and the subscriber's line when plug **193** is inserted in jack **14**, thence through the induction coil **6** and transmitter **5**, returning over the subscriber's line, and by way of jack **14** and plug **193** to the anode-cathode discharge path of tube T_{33}, and thence through the repeating coil and resistance **213** and the negative pole of battery **212**. Transmitter current modulated by the voice at transmitter **5** is thus supplied through the discharge paths of tubes T_{32} and T_{33}, which paths are in series for this direct current flow. Superposed on this and producing interruptions at a frequency above the band used for speech transmission is the alternating current supply to tubes T_{32} and T_{33}, which enables the grids thereof to regain control and suppress the flow of current during the ringing interval when ringing current is applied to transformer **220**. The heretofore referred to carrier frequency passing through the transformers **220** and **221** effects the release of tubes T_{32} and T_{33} and the operation of tube T_{31} in the following manner:

Rectifier **223** and filter **224** convert the alternating current voltage from transformer **220** into a direct current and thereby bias the grid of tube T_{32} to a negative value such that the arc will not restrike on the next positive half cycle of the high frequency alternating current anode supply. Thus the application of the carrier frequency to transformer **220** releases tube T_{32} and similarly tube T_{33}. At the same time the grid of tube T_{31} is made positive due to the positive half cycles. The release of tubes T_{32} and T_{33} will open the trunk circuit so as to prevent the transmission of ringing current back to the toll operator by the operation of tube T_{31} as will now be described.

Tube T_{31} and the circuit associated with it functions in the following manner: The tube T_{31} is normally held released by the negative potential of battery **2214**. The alternating potential applied through transformer **221** will cause the tube to operate. When the tube is operated ringing current from source **2215** will be applied to the line and to the subscriber's line.

A description will now be given of the circuits of the equipment included at the terminals of a through two-way supervision toll line. As stated above, all supervisory signals of this type of system are transferred directly to the outward toll operator. On-hook signals from either the calling or the called subscriber appear as visual signals in the outward toll operator's cord circuit. If the call is to be passed over more than one through two-way supervision toll line, the intermediate toll operator must select the through jack instead of the outward jack. When this jack is selected, all on and off-hook signals are transmitted through the intermediate position without giving any visual signal at this position. However, the disconnect signal does appear as a visual signal at the intermediate position. The distant toll operator is rung automatically in a through two-way supervision toll line.

Carrier frequencies are utilized for the control of supervisory signals, particularly in connection with on-hook and off-hook conditions and for other purposes, as has been heretofore described in connection with Figs. 6 and 7. These signals are transmitted continuously over the circuits while conversation is taking place, and so must lie outside, and preferably above, the audible range. These carrier frequencies are therefore of a different range from the voice frequency carrier currents used on the toll line for signaling purposes, as will be hereinafter described. The superaudible carrier currents are utilized in the transmission of supervisory signals from one portion of the circuit to another over relatively short distances and will ordinarily be confined to a single office, or at the most over an interoffice trunk extending from one office to another in the same service area. The voice frequency carrier currents used on the toll line for signaling purposes, as hereinafter described, are not applied during conversation, and currents lying in the voice frequency range may therefore be utilized for this purpose. In many cases the facilities used to interconnect the called and calling ends of the toll circuit would not transmit appreciably such superaudible frequencies. It is nevertheless desirable to prevent their transmission beyond the terminal equipment and low pass filters **5025** and **5025'** cutting off above the voice frequency range in Figs. 11 and 11', respectively, are provided for this purpose. Similar filters might, if required, be included in the cord circuits of Fig. 6 or Fig. 8' adjacent to and in the tip and ring conductors of plug **193** of Fig. 6 or plug **244'** of Fig. 8', or in the circuits to the right of the district selector **5013'** of Fig. 5'.

The through two-way supervision toll line equipment is so designed as to make use of a plurality of carrier frequencies in the voice frequency range each of which is modulated at various frequencies to carry supervisory signals from one toll terminal to the other. One carrier frequency may be used to transmit the signals from the outward to the inward end of the toll line while another carrier frequency may be used to transmit the signals from the inward to the outward end. Other such carrier frequencies might be utilized for other signals if desired. Each carrier that is used may be modulated at a plurality of frequencies for example, four. The

modulation frequencies are used to transmit the outward toll operator's connect and disconnect signals and the called subscriber's receiver on-hook and off-hook signals. The unmodulated carrier frequencies themselves may also be used for signaling purposes if desired. Each terminal is equipped with two ringers R_1 and R_2 shown in Fig. 11 and R'_1 and R'_2 shown in Fig. 11', which are tuned to the frequencies sent out by the outward and the inward terminals respectively. Ringer R_1 is normally connected to the toll line through the directional selection circuit 701. Ringer R_2 is connected to the toll line automatically when the terminal equipment is selected by an outward operator as will be pointed out hereinafter. Hereafter in the description of the through two-way supervision toll line circuit F_1, F_2, F_3, F_4 will be used to designate supervisory signals sent to indicate connect, disconnect, on-hook and off-hook conditions, respectively, from the outward position. G_1, G_2, G_3 and G_4 will be used to designate the same signals sent from the inward position. Every signal which is sent out must receive an acknowledgment signal from the distant end.

Figs. 9, 10 and 11 show certain details of the terminal circuit arrangements used by the outward toll operator to complete a toll call over the through two-way supervision toll line. Each end of a toll line of this type would terminate in an outward jack, a through jack, a plug and associated equipment. The jacks and associated equipment may be termed outward terminal equipment and the plug and associated equipment may be termed inward terminal equipment. At the outward toll office only the outward and through jacks and their associated equipment are illustrated. The plug and its associated equipment would be identical with the plug and equipment shown in Fig. 12' at the inward end of the line. It would be associated with the toll line at the outward position by being connected to conductors 407. It would also be connected to the circuits 801, 802, 803 and 804 of ringer R_1, shown in Fig. 11 in the same manner that the plug and its associated equipment, shown in Fig. 12' is connected to the circuits of ringer R'_1 of Fig. 11'. With respect to the outward jack 400 and the through jack 720 shown in Fig. 9, it is pointed out that the outward jack 400 would always be utilized at the originating end of the toll connection. However, if the call is to be completed over a second toll line the plug at the end of the first toll line would be connected into the through jack of the second toll line. Such a through jack and its equipment is shown as jack 720 in Fig. 9. The through jack and its associated equipment in the second toll line used in a through connection would be similar to this jack. At the distant end of the toll line shown in Fig. 9' the outward jack 400' only has been shown. However, in practice, a through jack would be provided and would have its equipment connected to the leads 1725' and 1731' in Fig. 9' in a manner similar to that shown in Fig. 9. A more detailed description of the through jack apparatus will be given hereinafter.

In initiating a call the outward toll operator will insert the plug of a toll cord in the line jack 400 of the toll line. As will be pointed out in detail hereinafter this operation sends a signal to the distant toll operator at the inward position. It also disconnects the plug and its associated equipment from the toll line at the outward position. It disconnects the ringer R_1 from the line and connects the ringer R_2 to the line. It also prepares the sleeve circuit of the toll operator's cord to receive supervisory signals from the called subscriber. A detailed description of these operations will now be given.

When the plug of the toll cord is inserted in jack 400 of Fig. 9 potential from battery 291 is supplied to the sleeve circuit and the resulting potential drop across resistance 401 is of such a value and polarity as to cause tube T_{55} to operate. This tube is normally held released by the negative potential of battery 402 applied to the grid. Generator 403 supplies the plate potential through transformer 404. When tube T_{55} operates, alternating current is supplied through transformer 405 to circuit 406 which is connected to the ringer circuits shown on Fig. 11 and to the circuits of tubes T_{56}, T_{57}, T_{58}, T_{59} and T_{60}, shown in Fig. 9.

Tubes T_{56} and T_{57} are normally operated and connect the plug and its associated equipment heretofore refered to, to the toll line. As pointed out this plug and its associated equipment is connected to circuit 407. When alternating current is supplied to the circuit of these tubes by transformer 405 through transformers 408, the tubes release thus removing the plug and its associated equipment from the toll line. Normally there is an arc between the anode and cathode of tubes T_{56} and T_{57}, the current being supplied from the battery 780, the negative pole of which is connected to the center tap of the inductance 781 interconnecting the cathodes of the tubes, and the positive pole of which is connected to the anodes of these tubes through resistance 782 in the common path, and resistances 783 and 784 in the individual anode circuits of each of these tubes. The grids of each of these tubes are held at a positive potential with respect to the cathodes, by the biasing batteries 785 and 786.

Blocking condensers 787 are introduced into the transmission circuit, and inductances 788 and 789 interconnect the collectors of the tubes T_{56} and T_{57}. The center tap of each of these inductances is connected to a tap on the resistance 783 or 784 in the individual anode circuit of each of these tubes, whereby the collectors are held at a potential slightly positive with respect to the anode of each tube. This results in a low impedance in the circuit collector-cathode-collector of each of these tubes. When alternating potential is supplied through transformers 405 and 408 it is rectified by rectifiers 790 and after passing through a filter is applied to resistance 782 in the common portion of the anode circuit of tubes T_{56} and T_{57}, and produces a voltage drop therein which is opposite to the polarity of battery 780, so that the anodes and collectors of the tubes T_{56} and T_{57} are made negative with respect to the cathodes thereof, extinguishing the arc and creating a substantially open circuit condition between the collectors of each tube. The inductances 788 and 789 between the collectors of tubes T_{56} and T_{57} are of such a value that their inductive reactance at voice frequency is very high so that the circuit is effectively open for such frequencies. It may also be noted that the inductance 781 between the cathodes of the tubes T_{56} and T_{57} is of such a value that its inductive reactance, which is in shunt to the transmission circuit when these tubes are in the conducting condition, is so high as to occasion but a negligible transmission loss.

Tube T_{58} of Fig. 9 is the tube which causes the

signal to be sent to the distant end of the toll line indicating to the toll operator that a call is waiting on that toll line. When alternating current is applied to the grid circuit of tube T_{58} by transformer **405** through transformer **409**, a unidirectional potential of the proper value and polarity is applied to the grid of the tube to cause it to operate. The operating potential of tube T_{58} is supplied across resistance **412** by the rectifier **410** working through filter **411**. This tube is normally held released by the negative potential of battery **413** applied to the grid. Generator **415** supplies the plate potential of the tube through transformer **416**. When tube T_{58} operates alternating current is supplied to circuit **418** by transformer **417**. The alternating current in circuit **418** causes a signal voltage F_1 to be sent out over the toll line. This is accomplished by the equipment **1301** shown in detail in Fig. 10 which will be described at a later time.

When signal F_1 arrives at the distant toll terminal, it produces a visual indication in front of the inward toll operator and also sends back to the outward end an acknowledgment signal G_1. The details of these operations will be described hereinafter. This signal G_1 is received and detected by ringer R_2 of Fig. 11. It will be the type of signal which will be selected by circuit **901**. An alternating current is thus produced in circuit **419** of Fig. 9. This alternating current is applied to the grid of tube T_{59} through transformer **420**. This tube is held released normally by the negative potential of battery **421** applied to the grid. The plate potential of the tube is obtained by the resistance drop across resistance **424**. This unidirectional potential across resistance **424** is supplied by rectifier **423** which obtains an alternating potential from transformer **422**. Condenser **425** is of such a value as to prevent the release of the tube T_{59} during the short interval when the toll operator is throwing her talking key from the normal to the talking position.

The operation of tube T_{59} of Fig. 9 causes a flow of current through resistance **414** of such a value and polarity as to result in the release of tube T_{58}. This removes signal voltage F_1 from the line. The removal of signal voltage F_1 from the line in turn removes the signal voltage G_1 from the line, as will be explained hereinafter.

When the distant called subscriber's line is reached in a manner to be pointed out hereinafter and the subscriber removes the receiver from the switchhook a signal of frequency G_4 is received by ringer R_2 of Fig. 11. The manner in which this operation is accomplished will be explained hereinafter. This signal G_4 would be the type selected by circuit **904** of ringer R_2. This causes an alternating current to be set up in circuit **426** of Fig. 9 and causes a signal F_4 to be returned to the inward end where it removes signal G_4. The manner in which the signal F_4 is returned to the inward end of the line in order to remove the signal G_4 is as follows: Connected in parallel with circuit **426** is a circuit, shown in Fig. 10, leading to the input of signaling equipment **1304**. The received signal G_4 will traverse this path and in a manner to be pointed out later will cause the signaling equipment **1304** to transmit back over the signal F_4. This in a manner to be described later will remove signal G_4 from the line. The removal of signal G_4 automatically removes the signal F_4 from the line. This alternating current of signal G_4 is applied through transformer **427** to the slow-release and slow-operate circuit of tube T_{61} of Fig. 9. The slow-operate and release circuit of the tube is comprised of resistances **429** and **430**, rectifier **428** and condenser **431**. This tube is normally held released by the negative potential of battery **432** applied to the grid through resistance **433**. The plate potential of the tube T_{61} is supplied by battery **434**. The operation of tube T_{61} from the pulse of signaling current G_4 results in the flow of alternating current through the primary winding of transformer **435**. The source of the alternating current is generator **436** which is supplied to the plate circuit through transformer **437**. The tube T_{61} will not release at this time when G_4 ceases because the normal potential of battery **434** is sufficient to maintain it operated once it has been operated.

The operation of tube T_{61} causes tube T_{62} to release. Tube T_{62} is held normally operated by the positive potential of battery **438**.

Battery **293** on Fig. 4 is connected with its positive pole grounded and its negative pole is connected through resistance **287** and the contacts of key **283** to the sleeve circuit of jack **400** when plug of the toll cord is inserted therein. In this manner the positive grounded battery **293** supplies voltage to the anode circuit of tube T_{62}, which is shown grounded through resistance **443**. Thus, as tube T_{62} is normally operated, the sleeve circuit is completed to ground through the high resistance **444** and in parallel therewith through the anode-cathode discharge path of tube T_{62}, and through the winding of transformer **435** and the low resistance **443**. The resulting effective resistance therefore of the sleeve circuit will be approximately that of resistance **443**, and so relatively low.

When alternating current flows through transformers **435** and **437** due to the operation of tube T_{61} the rectifier and filter circuit associated with transformer **437** change the bias of the grid of tube T_{62} to a negative value, so that when the alternating voltage appearing across the secondary of transformer **435** reduces the anode current in T_{62} to zero, the grid thereof regains control and T_{62} is released. When this tube is released resistance **443** is effectively replaced by resistance **444** in the sleeve circuit jack **400**. Resistance **444** is a high resistance and therefore extinguishes the lamp in the toll operator's cord circuit. This indicates to the tool operator that the subscriber has answered the call. Tube T_{44} in the toll operator's cord circuit was originally operated when a connection was made with jack **400** because the sleeve circuit of the toll cord was completed through the low resistance **443** and tube T_{62}.

When the subscriber has completed the call and replaces the receiver on the switchhook a signal G_3 is sent over the toll line and received by ringer R_2 of Fig. 11. This applies an alternating current to circuit **450** and sends back a signal F_3 to the inward end where G_3 is then removed. The manner in which signal G_3 causes a signal F_3 to be sent back over the line is similar to that described respecting G_4 and F_4. Signal G_3 causes the operation of apparatus **1303** and this sends signal F_3 back over the line. Signal F_3 will then remove signal G_3 as pointed out hereinafter. Tube T_{63} of Fig. 9 is caused to operate by the application of this alternating current through transformer **451** to the slow-operate, slow-release circuit in the grid of the tube. This circuit is comprised of resistances

452 and 453, rectifier 454 and condenser 455. The negative potential of battery 456 applied to the grid of the tube through resistance 457 keeps the tube T_{63} normally released. When tube T_{63} operates alternating current supplied by generator 458 through transformer 459 is supplied to transformer 460. The application of an alternating current to transformer 460 results in the release of tube T_{61} in a manner similar to that which caused the release of tube T_{62}. The release of tube T_{61} results in the operation of tube T_{62}. This causes the resistance of the sleeve circuit of jack 400 to be decreased and results in a visual indication in the cord circuit by the operation of tube T_{44}.

It is pointed out that in the foregoing the first signals described were the connect signal F_1 and the acknowledgment signal therefor, G_1, the next were the off-hook signal of the called subscriber G_4 and the acknowledgment signal therefor F_4, and then followed the on-hook signal of the called subscriber G_3 on the acknowledgment signal therefor F_3. It happens that there will be a short interval between the transmission of the connect signal and before the called subscriber answered and sent the off-hook signal during which the on-hook signal G_3 would be sent over the line to the outward position. As heretofore pointed out signal G_3 operates tube T_{63}. This causes alternating potential to be applied through transformers 459 and 460 to the plate circuit of tube T_{61} which will so reduce the potential of plate battery 434 as to release tube T_{61}. When tube T_{63} is operated by signal G_3 it locks up or remains operated because its plate potential is supplied by battery 449, the voltage of which is sufficient for this purpose. This will cause tube T_{61} to remain in a condition so that it cannot be operated by the incoming off-hook signal G_4 unless tube T_{63} is first released. Accordingly, signal G_4 coming in over circuit 426 in addition to being transmitted to the input of tube T_{61} also supplies an alternating potential to rectifier 445 through transformer 446. This rectifier applies a unidirectional potential across resistance 447 through filter 448. The potential drop across resistance 447 is in such a direction as to lower the anode potential of tube T_{63} below the operating point. The anode potential for tube T_{63} is normally supplied by battery 449. This will cause the tube T_{63} to be released if it had previously been operated by an on-hook signal. As heretofore pointed out the input circuit of tube T_{61} is a slow operate or delay circuit. Accordingly, the pulse of signal current G_4 will have time to release tube T_{63} before it reaches the grid of tube T_{61}. By the time it reaches the grid of tube T_{61} the plate voltage of the tube has been restored to normal by the release of tube T_{63} and the signal G_4 will operate tube T_{61}.

After the receipt of this on-hook signal signifying that the toll conversation has ended, it is time for the outward toll operator to transmit a disconnect signal F_2 to the inward toll operator. This is accomplished in the following manner. Tube T_{60} of Fig. 9 has been held normally released during the time that the plug of the toll cord has been inserted in jack 400. There are two slow-operate, slow-release circuits included in the grid circuit of this tube. These two circuits are so arranged as to operate during the same time and to cause no change in the potential applied to the grid of tube T_{60}. However, one of the circuits is arranged to release in a much quicker time than the other circuit. The resulting polarity of the slow-release circuits is such as to cause the operation of tube T_{60}. Tube T_{60} is supplied with plate potential from battery 461. When this tube operates current is caused to flow through transformer 462 by generator 463 and transformer 464. This applies an alternating current to circuit 465 which results in a signal F_2 being sent over the toll line by equipment 1302 shown in Fig. 10 and described later. When this signal F_2 has reached the distant end an acknowledgment signal of frequency G_2 is returned to the outward position in a manner to be described hereinafter. This is detected by ringer R_2 of Fig. 11 and an alternating potential is applied to circuit 466 because the type of signal G_2 is selected by apparatus 902. Alternating current flowing through the transformer 467 results in the releasing of tube T_{60} by a reduction in the plate potential of the tube in a manner similar to that described for tube T_{61}. This removes the signal F_2 from the toll line. This in turn removes signal G_2 in a manner to be described later.

Fig. 10 is a circuit diagram of the equipment necessary to send the supervisory signals out over the toll line when a connection is established at the outward office with the jack 400. This equipment would consist of four separate signaling devices, 1301, 1302, 1303 and 1304. These devices are used to apply ringing current of various carrier frequencies modulated at different frequencies to the toll line. For example, signaling device 1301 would supply to the toll line the signal of the type F_1 heretofore referred to. Devices 1302, 1303 and 1304 would supply signals of the types F_2, F_3 and F_4 respectively. Only the signaling device 1301 is shown in detail. The others would be substantially similar thereto except for the difference in the signaling sources included therein. A tube T_{66} is provided in Fig. 10 and is used to terminate the office equipment in a network during the time that ringing current is applied to the toll line. Tubes 67 and 68 are provided and used to cut the office equipment from the toll line during the application of ringing current to the toll line. There would also be connected to the conductors 543, signaling devices similar to devices 1404', 1403', 1402' and 1401', shown in Fig. 10'. These signaling devices would be connected to the plug and its associated equipment heretofore referred to and connected to conductors 407 of Fig. 9. As this equipment is not necessary in the description of the transmission of signals when a connection is established with the jack 400, these devices and their connection with the plug and its associated equipment heretofore referred to as connected to conductors 407 have been omitted.

When an alternating current is set up in circuit 418 it flows through the primary of transformer 526 thus causing the operation of tube T_{69} of Fig. 10. This tube circuit is of the slow-operate, slow-release type. Resistances 528 and 529, condenser 530 and rectifier 527 are used to produce the slow-operate, slow-release feature. Tube T_{69} is normally held released by the negative potential of battery 532 supplied to the grid of the tube through resistance 531. Generator 533 supplies the plate potential to the tube through transformer 534. This generator supplies a carrier frequency voltage modulated at the proper frequency to the toll line through transformer 535 whenever the tube is operated. This voltage which is supplied through transformer 535 to the toll line will be hereafter referred to as the signal voltage F_1. The above is

a detailed description of the signal transmitting device **1301**. The devices **1302**, **1303**, **1304** are identical with **1301** except that their generators will supply to the toll line carrier frequency voltages modulated at other frequencies to produce other signals, such as F_2, F_3 and F_4.

The signal voltage flows through transformers **536** and **537** causing the operation of tube T_{66}. Tube T_{66} is of the five-electrode type heretofore referred to and serves to connect a terminating resistance across the transmission circuit during the ringing interval. There is provided a shunt path across the transmission circuit, consisting of condensers **740** and **741**, resistances **742** and **743**, and inductance **4031**. When there is no arc in T_{66}, the reactance of **4031** is such that this shunt is of very high impedance and has a negligible effect on transmission. Connected across the terminals of this inductance **4031** are the probe or collector electrodes of the 5-element tube T_{66}. The anode of this tube is supplied with direct current from the rectifier **538**, through a low pass filter. The grid is excited from a transformer **537**, connected to the same circuit as that supplying alternating current to the anode rectifier of T_{66}.

Upon the application of alternating current to these transformers, an arc will strike from anode to cathode of T_{66}. The center of inductance **4031** is connected to a tap on resistance **4030**, which limits the anode current in T_{66}, whereby the collector electrodes are maintained at an average D. C. potential slightly higher than that of the anode. Under this condition the A. C. impedance from collector to cathode will be very low, so that the inductance **4031** is substantially short-circuited through the collector-cathode-collector circuit of T_{66}, and the impedance bridged across the transmission path is effectively that of the resistances **742** and **743** in series, if the blocking condensers are sufficiently large so that their reactance may be neglected for currents of the frequencies used on the transmission circuit.

Upon deenergizing the transformers **536**, **537**, the arc in tube T_{66} will go out, and the bridged impedance will revert to the large inductive reactance offered by coil **4031** when T_{66} is in the non-conducting condition.

The signal voltage also flows through transformers **542** and causes the release of tubes T_{67} and T_{68}. The 5-element tubes T_{67} and T_{68} are provided to open the transmission path during the ringing interval. Normally there is an arc between anode and cathode of these tubes, current being supplied from the battery **725**, the negative pole of which is connected to the center tap of the inductance **726** interconnecting the cathodes of the tubes T_{67} and T_{68}, and the positive pole of which is connected to the anodes of these tubes through resistance **727** in the common path, and resistances **728** and **729** in the individual anode circuits of each of these tubes. The grids of each of these tubes are held at a positive potential with respect to the cathodes by the biasing batteries **730** and **731**.

Blocking condensers **732** are introduced into the transmission circuit, and inductances **733** and **734** interconnect the collectors of the tubes T_{67} and T_{68}. The center tap of each of these inductances is connected to a tap on the resistance **728** or **729** in the individual anode circuit of each of these tubes, whereby the collectors are held at a potential slightly positive with respect to the anode of each tube. This results in a low impedance in the circuit collector-cathode-collector of each of the tubes T_{67} and T_{68}. When ringing current is applied through transformer **542**, it is rectified and the rectified current applied to the resistance **727** in the common portion of the anode circuit of the tubes T_{67} and T_{68}, and produces a voltage drop therein which is opposite to the polarity of the battery **725**, so that the anodes and collectors of the tubes T_{67} and T_{68} are made negative with respect to the cathodes thereof, extinguishing the arc and creating a substantially open circuit condition between the collectors of each tube. The inductances **733**, **734** between the collectors of T_{67} and T_{68} are of such value that their inductive reactance at signaling frequency is very high, so that the circuit is effectively open for such frequencies. It may also be noted that the inductance **726** between the cathodes of the tubes T_{67} and T_{68} is of such value that its inductive reactance, which is in shunt to the transmission circuit when these tubes are in the conducting condition, is so high as to occasion but a negligible transmission loss.

The five-electrode type tubes T_{90}, T_{91}, T_{92} and T_{93} are provided to connect the signalling path which branches from the transmission path through the directional selection circuit **701**, alternatively to either of the two ringer circuits R_1 or R_2, only one of which is connected to the toll line at any one time.

The signaling circuits are completed through the low impedance of the collector-cathode-collector circuit of the 5-element tubes T_{90} and T_{91} or T_{92} and T_{93}. Normally there is an arc between anode and cathode in T_{92} and T_{93}. The cathodes of T_{90}, T_{91} and of T_{92}, T_{93}, are connected in pairs through inductances **750**, **751**, whose value is so large that they form negligible shunts on the signaling circuit, and the negative pole of the battery **752** is connected to the center tap of these inductances. The grids of T_{92} and T_{93} are connected together through individual grid resistances to a positive bias battery **767** and thence through resistance **753** to the center tap of the inductance **750**.

The anodes of each of the tubes T_{90}, T_{91}, T_{92} and T_{93} are connected to the positive pole of battery **752** through resistances **754**, **755**, **756** and **757** individual to each anode circuit. Taps from these resistances go to the center taps of inductances **758**, **759**, **760**, **761** each of which interconnect the collectors of the tube associated with the resistance. These inductances **758**, **759**, **760**, **761** are of such large value that their reactance is very high at signaling frequencies, so that when these inductances are not shunted by the collector-cathode-collector path existing when there is an anode cathode arc, they present substantially an open circuit to signaling currents.

The grids of the tubes T_{90} and T_{91} are connected through individual grid resistances to the negative bias battery **762**, and thence through resistance **764** and the lead interconnecting the negative pole of the battery **752**, and the center taps of the inductances **750**, **751**, interconnecting the cathodes of tubes T_{90}, T_{91}, T_{92} and T_{93}. A rectifier **765** is provided which when energized from transformer **766**, connected to leads **406** will cause direct current to flow through resistances **753** and **764** in such a direction as to oppose the polarity of the grid bias batteries **762** and **767**. As a result, if A. C. be applied to leads **406** which results when a connection is made to jack **400**, the girds of tubes T_{92} and T_{93} which are normally positive, are made negative, and the

grids of tubes T_{90} and T_{91}, normally negative, are then made positive. It will be understood that these grid voltages are measured with respect to the cathode.

The anodes and collector circuits of tubes T_{90} and T_{92} are connected through commutating condensers **768** and **769**. Similarly, the anodes and collectors of tubes T_{91} and T_{93} are also connected through commutating condensers **770** and **771**.

If there is no alternating current applied to leads **406**, there will be arcs in tubes T_{92} and T_{93} and the directional selection circuit will be connected through the blocking condensers **772**, **773** and the collector-cathode-collector path of tubes T_{92} and T_{93} to the input circuit of tube T_{94}. If, however, alternating current is applied to the leads **406**, the grid polarities are changed as has been explained, and arcs will strike in tubes T_{90} and T_{91}. The striking of the arc in tube T_{90} will transmit a negative surge in the well known manner through the commutating condensers **768** and **769** to the anode and collectors of T_{92}, momentarily interrupting the arc therein and allowing the now negative grid to regain control and prevent the restriking of the arc in T_{92} so long as this grid remains negative with respect to the cathode, which will be the case as long as A. C. is applied to leads **406**. Similarly, an arc will strike in T_{91} and by the action of the negative surge through the commutating condensers **770** and **771** extinguish the arc in T_{93}. The directional selection circuit **701** will thus be connected through the blocking condensers **774** and **775**, and the collector-cathode-collector paths of tubes T_{90} and T_{91} to the input circuit of tube T_{95}, and will remain so connected as long as there is an A. C. of suitable magnitude applied to leads **406**.

Upon removal of this A. C. the normal values of grid bias will be restored and arcs will strike in tubes T_{92} and T_{93}, and negative surges transmitted therefrom through the commutating condensers **768**, **769**, **770** and **771** will extinguish the arcs in T_{90} and T_{91}, and reconnect the directional selection circuit to the input of tube T_{94}, as originally was the case.

The rectifier **765**, which applies operating potential to the grids of the tubes T_{90}, T_{91}, and serves also to apply potential to hold the tubes T_{92} and T_{93} released, operates through a resistance capacity filter providing a slow release feature, whereby the release of tubes T_{90} and T_{91} is delayed, to give time for the return of the acknowledgment signal. This is done by making the shunt condensers of the filter circuit between rectifier **765** and resistances **753–764** of large values, and making resistances **753** and **764** also large. Furthermore the voltage applied by rectifier **765** produces a drop in the resistance **753** which biases the grids of tubes T_{92} and T_{93} quite negative, so that in the removal of input to transformer **766** an appreciable time must elapse before the filter condensers can discharge to the point where the arc will strike in tubes T_{92} and T_{93}, extinguishing those in T_{90} and T_{91}, as has been explained. These condensers discharge through resistances **753** and **764** in series, in parallel with the resistance of rectifier **765** in the non-conducting direction. This circuit will operate rapidly in the operate case, as there is no resistance to limit the output of rectifier **765** so that the filter condenser will charge rapidly.

The ringer circuits R_1 and R_2 operate in the following manner. As heretofore pointed out the signals utilized over the toll line are carrier frequencies modulated by different lower frequencies. Tubes T_{94} and T_{95} are operated by these incoming carrier frequency signals and when operated serve as detectors and cause to be set up in their plate circuits currents varying with the frequency of the modulated component of the carrier signal. The modulated component would be transmitted through transformers **800** and **900** and would be selected by the tuned circuits **801**, **802**, **803**, **804** and **901**, **902**, **903**, **904**. These circuits are so tuned as to respond to the modulation frequencies of the signal voltages G_1, G_2, G_3, G_4 and F_1, F_2, F_3, F_4 respectively. The tuned circuits of these ringers are connected to points on Fig. 9 as described above. In Fig. 11′ are shown the ringers R'_1 and R'_2 which are identical with R_1 and R_2. Their connections are shown in detail and a description of the details thereof will not be given.

Fig. 12′ is the inward end of a through two-way supervision toll line. When a call is received over such a toll tube T'_{77} operates a visual indication to the inward toll operator. The details of these operations are pointed out hereinafter. She then connects her telephone set to the toll line by operating her key **609′** and ascertains the destination of the call. After she has chosen the proper toll switching trunk such as the trunk shown in Fig. 8′ which will reach the required local office, she plugs into the same with plug **600′**. This brings in the local "B" operator who then completes the call from there on by connecting to the subscriber's circuit shown in Fig. 1′. After this neither the inward toll operator or the local "B" operator has anything to do with the call until they receive a disconnect signal initiated by the outward toll operator.

When a signal F_1 is transmitted over the toll line it operates ringer R'_1 of Fig. 11′. This incoming signal F_1 is selected by device **801′** and applies an alternating current to circuit **8301′** of Fig. 12′. Connected to circuit **8301′** in Fig. 10′ is a branch circuit leading to the signaling device **1401′**. The application of signal F_1 to device **1401′** will result in there being transmitted back over the toll line an acknowledgment signal G_1. In a manner heretofore described the signal G_1 will remove signal F_1 from the line and this in turn will remove G_1 from the toll line. An alternating potential is thus applied to the grid of tube T'_{78} by transformer **602′**. This tube is held normally released by the negative potential of battery **603′** applied to the grid. Battery **604′** supplies the normal plate potential to the tube. When tube T'_{78} operates, current flows through resistance **605′** in such a direction as to cause the operation of tube T'_{79}. This tube is held normally unoperated by the negative potential of battery **606′** applied to the grid of the tube. When tube T'_{79} operates, the plate current flows through one of the primary windings of transformer **607′** and causes the operation of tube T'_{77}. The operation of the circuit including transformer **607′**, tube T'_{77} and tube T'_{79} has been completely described above and will not be repeated at this point. Transformer **607′** of Fig. 12′ is similar to transformer **182** of Fig. 6. Tube T'_{77} is similar to tube T_{26} of Fig. 6.

Tube T'_{77} of Fig. 12′ may be a combined lamp and relay and when it operates, it gives a visual signal to the toll operator. She then operates the key **609′** which connects her telephone set to the toll line through circuit **608′**. Having ascertained the destination of the call, she in-

serts plug 600' into the jack of the proper incoming toll switching trunk, the circuit of which is shown on Fig. 8'. When the plug 600' is inserted in a jack battery 610' causes current to flow through resistances 611' and 612'. This current flow through the resistances causes the operation of tubes T'80 and T'81. Tube T'80 functions to extinguish tube T'77. This is accomplished in a manner similar to that describing the operation of tube T26 of Fig. 6. Tube T'81 causes a signal of carrier frequency to be sent over the toll switching trunk shown in Fig. 8'. This signal results in a visual indication before the local "B" operator in a manner to be described hereinafter. Tube T'81 operates in a manner similar to that of tube T24 of Fig. 7 which has been described in detail above.

When the subscriber's line has been reached and the subscriber has answered the call, a carrier frequency indicating an off-hook condition is sent back over the toll switching trunk in a manner to be pointed out hereinafter. This carrier frequency passes through tubes T'82 and T'83 and through filter 613' and transformer 614' and causes tube T'84 to operate. This tube is held normally released by the negative potential of battery 615' applied to the grid. The plate potential of tube T'84 is supplied by battery 616'.

When tube T'84 operates, the potential drop across resistance 617' results in the operation of tube T'85. Battery 618' supplies a negative potential to the grid of tube T'85 to keep it normally released. Generator 619' supplies the plate potential to the tube through transformer 620'. When alternating current flows in circuit 622' the device 1404' of Fig. 10', which is similar to device 1301 of Fig. 10, operates and sends a signaling voltage G_4 out over the toll line. As heretofore pointed out G_4 is the off-hook signal.

This reaches the other end of the toll line and in a manner heretofore described causes a signal F_4 to be returned over the toll line. This signal is received and detected by ringer R'1 of Fig. 11' and results in an alternating current being applied to circuit 8804'. An alternating potential is thus applied to the grid of tube T'88 by transformer 624'. Battery 625' supplies the plate potential and battery 626' supplies a negative potential to the grid of the tube T'88 to keep it normally released. This applied signal F_4 causes tube T'88 to operate.

Where tube T'88 operates, the potential drop across resistance 627' causes tube T'87 to operate. This tube T'87 supplies plate potential to tube T'86 to condition it for later operation. It also causes tube T'84 and T'85 to release. Tube T'87 is held normally released by the negative potential of battery 628' applied to the grid. Generator 629' supplies the plate potential through transformer 633'. Plate potential is supplied to tube T'86 by transformer 634'. Transformer 635' supplies an alternating potential to rectifier 636'. A unidirectional potential is applied across resistance 637' by rectifier 636'. The potential drop across resistance 637' is in such a direction as to lower the voltage applied to the plate of tube T'84 to a value below that voltage necessary to maintain the tube in an operating condition. Thus tube T'84 is released and this in turn releases tube T'85. The signal voltage G_4 is thus removed from the toll line and this in turn removes signal voltage F_4 from the distant end as heretofore pointed out. Tube T'88 and tube T'87 remain operated at this time.

When the called subscriber's receiver is off the hook, the tube T'86 is held unoperated. The carrier frequency which is sent over the toll switching trunk continuously when the subscriber receiver is off the hook is applied to rectifier 638' by transformer 639'. A unidirectional potential is applied to resistance 641'. Filter 640' is between the rectifier and the resistance. Battery 642' supplies a positive potential to the grid of the tube. The unidirectional potential applied by rectifier 638' to resistance 641' is of such a value and in such a direction that it will oppose the positive potential normally applied to the grid and the tube T'86 is held released.

When the subscriber hangs up the carrier frequency is removed from the toll switching trunk and hence tube T'86 of Fig. 12' is allowed to operate. This is because the normal positive potential applied to the grid now becomes effective and because it had previously been conditioned for operation by the operation of tube T'87, as heretofore pointed out. When tube T'86 operates an alternating current is applied to circuit 643' by transformer 644'. Alternating current in this circuit results in the operation of device 1403' and a signal frequency G_3 is sent out over the toll line.

The signal voltage G_3 is transmitted to the distant outward end where it is detected and performs the necessary operations as heretofore pointed out. Signal voltage F_3 is returned to the inward toll position where it is detected by ringer R'1 shown on Fig. 11'. The ringer circuit 803' of Fig. 11' applies alternating current to circuit 8803' and applies an alternating potential to the grid of the tube T'89 through transformer 646'. Negative potential of battery 647' is applied to the grid of tube T'89 and holds this tube released normally. Alternating potential is applied to the plate of the tube T'89 by generator 632' through transformer 630'.

When tube T'89 operates, an alternating potential is supplied by transformer 631' to rectifier 648'. This rectifier applies a unidirectional potential across resistance 649' of such a value and in such a direction as to reduce the plate voltage of tube T'88 below that value necessary to maintain the operation of the tube. Hence tube T'88 is released. This causes the release of tube T'87 which removes the plate potential from tube T'86 and causes it to release. When tube T'26 releases, signal frequency G_3 is removed from the line. This in turn removes the signal frequency F_3 from the line which releases tube T'89 and returns the circuit to its normal condition.

When the distant outward toll operator pulls down from the toll circuit a signal voltage F_2 is detected by ringer R'1 of Fig. 11'. This applies an alternating current to circuit 8802' and thence to rectifier 652' by transformer 651'. It also operates device 1402' and sends signal G_2 back over the line to cut off F_2 in a manner heretofore described. This in turn removes G_2 from the line. This rectifier applies a unidirectional potential to resistance 653' of such a value and in such a direction as to make the total plate voltage of tube T'78 lower than that necessary to maintain the tube in an operated condition. When tube T'78 releases tube T'79 releases and tube T'77 will operate due to the fact that a potential will be applied to transformer 607' solely through the primary winding in the plate circuit of tube T'80 which has remained operated. This gives a visual indication to the inward toll operator and she pulls the plug out of the jack of the toll switching trunk of Fig. 8' causing the re-

lease of tubes T'80, T'81 and hence T'77. When tube T'81 releases, the carrier frequency is removed from the toll switching trunk and that part of the circuit is returned to normal.

Fig. 8' is a circuit drawing of the toll switching trunk which is employed to complete an incoming call which has been transmitted over a two-way through supervision toll line. The toll operator as heretofore pointed out inserts the plug **600'** of the toll cord into jack **227'**. When the toll operator plugs into the line jack **227'**, a carrier frequency from the plug circuit of the toll line is sent over the toll switching trunk by the heretofore referred to operation of tube T'81 and this carrier frequency passes through filter **228'** and transformer **229'**, causing tube T'34 to operate. This tube causes tube T'36 to operate and give a visual signal to the local "B" operator that an incoming call is waiting on that toll switching trunk. A detailed description of the operation of tubes T'34 and T'36 will be omitted here as these tubes function in a similar manner to that of tubes T25 and T26 of Fig. 6 respectively, the operation of which has been given in detail in a preceding part of this description.

When the local "B" operator receives a visual indication due to the operation of tube T'36, she connects her operator's set to the toll switching trunk by means of key **243'**. Having ascertained the destination of the call, she inserts the plug **244'** into the proper line jack such as **25'** of Fig. 1'. This operation starts the automatic ringing of the subscriber's bell as pointed out hereinafter. When plug **244'** is inserted in the line jack **25'** the sleeve circuit of the plug is completed and battery **245'** causes a potential drop across resistances **246'** and **247'**. The resistance drop across resistance **247'** is in such a direction as to cause the operation of tube T'35. This tube is held normally unoperated by the negative potential of battery **248'** applied to the grid of the tube. The operation of tube T'35 causes the release of tube T'36 in the same manner that tube T27 of Fig. 6 causes the release of tube T26 of Fig. 6 as previously described.

The operation of the tube T'35 also causes an alternating potential to be applied to the grid of tube T'37 through transformer **249'**. This tube T'37 is held normally unoperated by the negative potential of battery **250'** which is applied to the grid of the tube. Generator **251'** supplies the plate potential for tube T'37 through transformer **252'**. The application of this alternating potential to the grid of tube T'37 causes it to operate. The operation of this tube results in the building up of an alternating potential across the secondary of transformer **253'**. This alternating potential causes a device **254'** to operate. This device is an interrupter of any well known type. The output of this interrupter is fed through transformers **255'** and **256'** to the circuits of tubes T'38, T'39 and T'40 causing T'38 to operate and T'39 and T'40 to release intermittently. Tube T'38 supplies ringing potential to the subscriber's line and tubes T'39 and T'40 are used to cut the toll switching trunk off from the subscriber's line during the time that ringing current is applied to the subscriber's line. Due to the interrupter **254'** the subscriber will be rung intermittently. Tubes T'39 and T'40 function similarly to tubes T32 and T33 of Fig. 6 a detailed description of which was given above. Tube T'38 functions in a manner similar to that of tube T31 of Fig. 6 which was described above.

During an interval when ringing is not applied to the subscriber's line and the subscriber's receiver is removed from the switchhook, current is allowed to flow through resistance **268'** from battery **267'**. This is because the circuit for battery **267'** and resistance **268'** is completed over the subscriber's line and can only be so completed when tubes T'39 and T'40 are operated. The potential drop across resistance **268'** is in such a direction as to cause the operation of tube T'54. The plate of tube T'54 is supplied with a direct potential from battery **270'**. Battery **259'** supplies a negative potential to the grid of the tube. When tube T'54 operates, the potential drop across resistance **271'** is in such a direction as to cause the release of tube T'37. This will release tube T'38 and stop the transmission of ringing current to the subscriber.

Tube T'41 is held normally operated by the positive potential of battery **272'** applied to the grid. However, when the sleeve circuit of plug **244'** is completed a potential drop across resistance **246'** results in the release of tube T'41.

The potential drop across resistance **268'** is in such a direction as to cause the operation of tube T'42. T'42 is held normally released by the negative potential of battery **273'** applied to the grid. Generator **274'** supplies an alternating potential to the plate of the tube through transformer **275'**. The frequency of this alternating potential is in the carrier frequency range and is different from that selected by filter **228'**. A carrier frequency signal is sent out over the toll switching trunk through transformer **276'** and filter **277'** when tube T'42 is operated. When the subscriber has completed his call and replaced the receiver on the switchhook, the carrier frequency supplied by tube T'42 is removed from the line. This is because the potential drop across resistance **268'** is removed and tube T'42 is thereby released. When the inward toll operator receives a signal from the distant outward operator that the called subscriber has completed his call, she pulls down from jack **227'**. This removes the carrier signal from transformer **229'** and results in the release of tube T'34. When tube T'34 releases, the local "B" operator receives a visual signal due to the operation of tube T'36. The exact details of how this is accomplished has been described above in the case of the toll switching trunk illustrated in Figs. 6 and 7.

When the local "B" operator pulls down from the subscriber's line the sleeve circuit of plug **244'** is broken, causing the potential drop across resistance **246'**, caused by battery **245'**, to fall to zero. This results in the operation of tube T'41. Alternating potential is supplied to the plate of tube T'41 by generator **278'** through transformer **279'**. When tube T'41 operates, current flows through the primary of transformer **280'** and the alternating potential supplied by the transformer to rectifier **281'** is applied across resistance **282'** through filter **283'**. The potential drop across resistance **282'** is in such a direction as to cause the release of tube T'54 due to the reduction of the plate voltage. The circuit is now returned to its normal condition.

The foregoing description has shown in detail how a connection is established from the two-way supervision toll line through a toll switching trunk such as that shown in Fig. 8' to a subscriber's line. However, under certain conditions it might be desirable to extend the connection from the two-way through-supervision toll line shown terminating in plug **600'** in Fig. 12'

through another two-way supervision toll line and thence through the toll switching trunk to the subscriber's line. Under such conditions it is desirable that the off-hook and on-hook signals given by the called subscriber should not affect the signaling apparatus located at the called end of the first two-way supervision toll line and the signaling apparatus at the calling end of the second toll line. In other words, the apparatus for transmitting these off-hook and on-hook signals which is located at the end of the first two-way supervision toll line ending in plug **600'**, should be disabled and the signaling apparatus at the calling end of the second toll line capable of receiving the off-hook and on-hook signals and sending acknowledgment signals therefor should also be disabled. With respect to the first toll line, this apparatus comprises the tubes T'_{85} and T'_{86} and other associated tubes. Accordingly, when this type of connection is set up, the jack **600'** of the first through two-way supervision toll line is connected to a through jack of the second two-way supervision toll line. Such a through jack would be one similar to the jack **720** shown connected, for purposes of illustration, at the calling end of the first through two-way supervision toll line in Fig. 9. This through jack **720** is so arranged that when the first toll line is connected thereto by the insertion of plug **600'** therein, the tubes similar to T_{721} and T_{722} of Fig. 9 will be operated. The operation of tube T_{721} will allow current from the generator **723** to be applied through transformer **724** and over conductors **1725**. This tube T_{721} accordingly will perform the same functions that were accomplished by the tube T_{55}. In other words, with respect to the calling end of the second toll line, it will operate tubes similar to tubes T_{56} and T_{57} and disconnect the plug and associated equipment (not shown) from the line. It will also cause the operation of a tube similar to tube T_{58} and will condition for operation tubes similar to T_{59} and T_{60} in a manner similar to that heretofore described. The tube similar to T_{58} will cause the transmission over the second toll line of a connect signal in a manner similar to that heretofore described and will cause the operation at the called end of the second toll line of a tube similar to tube T'_{77} shown in Fig. 12'. In a manner similar to that heretofore described an acknowledgment signal will be sent back to the calling end of the second toll line to automatically remove this connect signal from the line. A tube similar to the tube T_{60} would function in a manner similar to that heretofore described to send disconnect signals and receive acknowledgment signals therefor over the second toll line. The application of current from a source similar to **723** to conductors similar to **1725** will also condition ringers similar to R_2 and R_1 for operation in a manner similar to that heretofore described with respect to the first toll line. When the jack **600'** of the first toll line is inserted into a through jack similar to jack **720** in the second toll line, a tube similar to T_{722} will also be operated. This will allow a carrier frequency from a source similar to **1728** to be applied through transformer **1729** and over conductors **1730** and **1731** to the tip and ring conductors of a jack similar to the aforementioned jack **720**. Conductors **1731** are shown extended to the tip and ring conductors of the second toll line to complete the talking connection thereover. The current from a source similar to **1728** applied to the tip and ring conductors of the jack similar to the aforementioned jack **720** will perform a function to be described hereinafter. This current will also be applied from conductors **1731** over conductors **1732** to the rectifier circuit **1734** shown in Fig. 11. The resulting rectified current in the plate current of tube T_{735} will cause said tube to release. Accordingly, off-and-on-hook signals transmitted from the subscriber over the second toll line and received by a ringer similar to R_2 will not be transmitted to the selective circuits similar to **903** and **904**, and hence will not cause the operation of a tube similar to T_{62} at the calling end of the second toll line. Furthermore, means for transmitting back to the called end of the second toll line of acknowledgment signals for the off-hook and on-hook signals will be disabled. The carrier frequency which was applied to the tip and ring conductors of the jack of the second toll line similar to **720** will be applied to the tip and ring of plug **600'** and will be passed through the filter **654'** and transformer **655'** and applied to the grid of tube T'_{900}. Tube T'_{900} is held normally unoperated by the negative potential of battery **656'** applied to the grid. Alternating potential is applied to the plate of this tube by generator **658'** through transformer **657'**. The above described application of this carrier frequency to the input circuit of tube T'_{900} will cause it to operate. When tube T'_{900} operates, alternating current is supplied to the plate circuits of tubes T'_{82} and T'_{83} by transformers **659'** and **660'**. These tubes T'_{82} and T'_{83} are of the 5-electrode type and are normally held operated for the following reasons:

The cathode of tube T'_{83} is connected to the negative pole of the battery **835**, the positive pole of which is connected to the anode of T'_{83} through the resistances **821'** and **823'**. Blocking condensers **825'** and **827'** in the leads **836'**, which are bridged across conductors **407'**, prevent any flow of direct current out into leads **407'** or through the windings of transformers **614'** and **639'**. Inductances **829'** and **831'** are connected in series between the collector electrodes of tube T'_{83}. These inductances present a very high inductive reactance to the signaling frequencies flowing into the branch circuit **836** from conductors **407'**. The common point of these inductances is connected to a tap on resistance **823**, so that the collectors of tube T'_{83} will be slightly positive with respect to the anode. The grid potential and the anode potential are so adjusted that normally there will be an arc established. The circuit of tube T'_{82} is identical with that of T'_{83}, and the foregoing description may be read upon it also, utilizing reference characters less by unity than those used in describing the circuit of T'_{83}.

Resistances **820'** and **821'** are connected to the D. C. side of rectifiers **832'** and **833'**, supplied from transformers **659'** and **660'**. The primaries of these transformers receive alternating current from generator **658'**, through transformers **657'** and the anode circuit of T'_{90}, when this tube is operated, as has been previously explained. This alternating current is rectified in the rectifiers **832'** and **833'**, and the resulting direct voltage across resistances **820'** and **821** is in opposition to the anode batteries **834'** and **835'** which lowers the anode and collector voltages to such an extent that an arc discharge cannot be maintained and these tubes therefore release. When there was an arc in tubes T'_{82} and T'_{83} there was a low impedance through the collector-

cathode-collector path thereof, connecting conductors 836′ to the filter 613′ and thence to transformers 614′ and 639′. But when the tubes T′82 and T′83 are released, the impedance of the inductances 828′, 830′ and 829′, 831′ is such that the input to the filter 613′ is substantially open for signaling frequencies. As heretofore pointed out in the description of a connection of the first toll line terminating in plug 600′ directly with a toll switching trunk, it was pointed out how the off-hook and on-hook signals from the subscriber were transmitted over the talking conductors of the toll switching trunk and thence through the normally closed tubes T′82 and T′83 and serve to control the functioning of tubes T′85 and T′86 to transmit off- and on-hook signals to the calling end of the first line. However, the release of tubes T′82 and T′83 by the connection of the plug 600′ of the first toll line with a through jack of the second toll line will prevent the off-hook and on-hook signals transmitted from the called end of the second toll line from affecting tubes T′85 and T′86 and their associated tubes. These off-hook and on-hook signals will then be transmitted over the talking conductors of the first toll line and will actuate the ringer apparatus R_2 of Fig. 11 and control the functioning of tube T_{62} of Fig. 9 to indicate the off-hook and on-hook signaling conditions to the calling toll operator. Thus on a built-up connection involving two toll lines, the off-hook and on-hook signals are not received at the through operator's position.

It is understood that the scope of this invention does not preclude the use of electromagnetic relays or other mechanical switching devices as aids in the transmission of signals if such electromagnetic relays or other mechanical switching devices may be used advantageously to perform certain necessary and essential functions. Furthermore, such aforementioned devices may be used either alone or in combination with gas-filled tubes of such a type and design as may be essential for the proper performance of the required operation or operations.

Although there are numerous applications of combinations of gas-filled tubes and electromagnetic devices which might be employed only one illustration of such combinations will be herein contained. This will be the case where the gas-filled tubes cooperate with dialing equipment. It is understood that the scope of this invention is not limited to this one particular circuit but that this circuit has been chosen only for the purpose of illustrating such combinations of gas-filled tubes and electromagnetic devices.

The gas-filled tube signaling arrangements heretofore described may be utilized in connection with the transmission of dial signaling impulses over the long distance system, whereby the completion of the connections at the called office between the toll line and the called subscriber may be effected by the calling toll-operator with the aid of the dialing equipment at the distant office. In other words, the calling toll operator may complete the call merely by the operation of a dialing key 295 shown connected with her toll cord in Fig. 4. As heretofore pointed out, when the toll operator's cord circuit of Fig. 4 is connected to the jack 400 of the toll line, the gas-filled tube arrangements of the invention and their associated apparatus will function to cause the operation of tube T′77 of Fig. 12′ at the distant end of the toll line. Instead of utilizing tube T′77 to give a visual signal, use may be made of the property of this tube of closing its plate circuit, whereby alternating current from the generator associated therewith is applied through the closed plate circuit and thence through the transformer shown associated therewith, and over conductors 5000′ to a copper-oxide rectifier 5001′ operating in connection with the relay 5002′ to operate the dial equipment shown in Fig. 5′. Fig. 5′ is placed to the right of Fig. 12′ in the drawings when the long distance call is completed through dial controlled automatic switching equipment instead of through the manually operated toll board heretofore described. As dial telephone systems are well known in the art, the greater portion of these circuits has been indicated in purely schematic form without any attempt to show the actual circuit details. Only such features of the dial system as are required to cooperate with the gas-filled tube circuits of this invention have been shown. For detailed descriptions of dial telephone systems, reference may be had to a volume entitled, "Telephone Theory and Practice—Automatic Switching and Auxiliary Equipment" by Kempster B. Miller. When an outward operator completes a circuit to jack 400 of Fig. 9 by connecting the plug of her toll cord thereto, the tube T′77 of Fig. 12′ will be operated as has been described, and alternating current will pass therefrom over the conductors 5000′ to the rectifier 5001′, and this rectified current will operate the relay 5002′. This completes a direct current path across the tip and ring conductors 407′, the make contacts of relay 5002′, through the inductance 5003′, the break contacts of relay 5009′, and inductance 5006′. The inductances are provided to prevent the alternating currents of speech and signaling frequencies from being unduly attenuated while providing a low resistance direct current path from the tip to the ring conductor of the circuit 407′. The completion of this direct current path will cause direct current to flow from a battery (not shown) associated with the line finder equipment 5010′, and will also start the line finder into operation by means of the line finder start circuit 5011′. The line finder may be a selector of the panel type, and the terminals in the bank thereof will be associated with the circuit 407′ in the manner shown. In addition to the tip and ring conductors there are provided two additional conductors, the sleeve marked "S" and the hold marked "H", which are used for control purposes in a manner well known in the art. The brushes associated with the bank contacts will traverse the various contacts in the bank until they engage the conductors connected to line 407′ at which point they will come to rest and connect the line to the district selector 5013′ and to the sender selector 5016′. The sender selector 5016′ will then hunt and connect an idle sender 5017′ to this link circuit in a well known manner. Upon completion of the connection between the sender and the line, dial tone from the normal contacts of the sender will be transmitted to pair 407′ and thence back over the talking conductors of the toll line to the calling operator's cord circuit. The sleeve circuit shown in Fig. 12′, which would normally extinguish tube T′77 upon the completion of the connection of the jack 600′, would be omitted in the case of a toll line terminating in a dial office. Also, in such a line, the tubes T′80 and T′81, and certain of the apparatus associated therewith, would be omitted. The tube T′77 remains operated so long as a plug is inserted in the jack 400 of Fig. 9. The dial tone is the signal

to the outward operator at the distant end of the circuit that the toll line is connected to a sender and is in a position to receive coded dial impulses indicating the subscriber's line desired. Upon the receipt of this information from the dial tone, the calling operator will dial the desired number by means of the dial key **295** of Fig. 4. This key is arranged to apply alternating current to the transmission circuit extending from the outward operator to the conductors **407'** at the input to the line finder. This dialing frequency will be so chosen as not to interfere with the operation of other selective signaling devices normally associated with the toll line. The dial key **295** of Fig. 4 is so arranged that, corresponding to the break impulses of the dials ordinarily used in connection with dial switching systems, it applies pulses of this dialing frequency. This frequency transmitted over conductors **407'** is selected by the network **5007'** and thence transmitted to the rectifier **5008'** where the rectified output operates the relay **5009'**. The operation of relay **5009'** opens the heretofore described direct current path across the conductors **407'** in accordance with the coded dial impulses so that this circuit is broken once for each of the previously mentioned dial impulses which corresponds exactly to the operation of the direct current dialing circuit associated with the ordinary dial telephone. Blocking condensers **5004'** and **5005'** are provided to segregate the A. C. impulse circuit from the D. C. impulse circuit controlled by relay **5009'**. These dial impulses are then transmitted to the sender **5017'** in the normal manner over the left-hand pair of contacts in the sender selector **5016'** and operate the registers of the sender to record the coded dial impulses transmitted. Upon receipt of the first dial impulse, the sender interrupts the supply of dial tone which had previously been sent over the conductors **407'** to the outward operator. The operation of registration will cause the sender **5017'** to control the operation of the district selector **5013'** so that its brushes **5018'** will stop on the appropriate bank terminals to extend the call to the proper office selector **5019'**. Upon accomplishing the office selection the call is extended over a two-wire interoffice trunk to the desired local office at which point an incoming selector and final selector are operated under control of sender **5017'** to extend the call to the terminals of the desired subscriber's line. Upon reaching this line, sender **5017'** is disconnected from the circuit by the release of the sender selector **5016'**. Should the called line be busy the final train of relays in the final selector will send a busy signal back over the transmission path to the outward operator and this distinctive tone will advise her that the called line is busy. If the line is not busy ringing current is automatically applied until the called subscriber answers. An audible ring-back signal is also transmitted during the ringing interval so that the calling operator may know that ringing is taking place. The subscriber's line circuit is of the type well known in the art, and has not been illustrated. When the called subscriber answers, a circuit is established from a repeating coil battery supply in the incoming selector **5020'** which circuit is well known in the art, and has, accordingly, not been illustrated. There is also a repeating coil associated with the district selector **5013'** which supplies battery normally to the calling subscriber, but in this case, supplies battery for the operation of the dialing circuits and the dialing start and hold circuits controlled by the relays **5002'** and **5009'**. The side of this repeating coil **5022'** toward the called line, has inserted at its midpoint a polar relay **5015'** bridged by a condenser to avoid the introduction of a transmission loss. This polar relay is adapted to connect the output of a source of alternating current **5014'** to the transmission circuit **407'** as extended through the line finder. When the called subscriber answers and removes his receiver from the hook, this relay operates so that the output of the generator **5014'** is applied to the conductors **407'** throughout the duration of the call. The frequency of this generator would be the same as that utilized in connection with the initiation of the off-hook signal heretofore described, namely, the frequency of the generator associated with tube T'_{42} of Fig. 8'. This frequency when applied to conductors **407'** would be transmitted through the circuits of the normally operated tubes T'_{82} and T'_{83} and cause the operation of the tube T'_{85} which would send back an off-hook signal to the calling operator in a manner identical with that heretofore described. When the called subscriber hangs up the breaking of the direct current circuit established through his instrument in a well known manner will result in the release of relay **5015'** and will remove the supersonic frequency of the generator **5014'** from the conductors **407'**. The removal of this frequency from conductors **407'** will result in the operation of tube T'_{86} of Fig. 12' which will, in a manner identical with that heretofore described, result in the transmission to the calling operator of an on-hook signal. Upon this notification to the outward operator that the conversation has been completed, she will remove the plug from the jack **400** of Fig. 9. This will result in the sending out of a disconnect signal from the outgoing end of the toll line which will be received by R'_1 of Fig. 11' and selected by circuit **802'**. This received pulse will operate ringer **1402'** of Fig. 10' and will also result in the release of tubes T'_{78} and T'_{79} as described heretofore. Now since tube T'_{80} has been omitted at the point where dial equipment is used, tube T'_{77} will remain operated until tubes T'_{78} and T'_{79} have been released as described above. This release of tube T'_{77} will remove the alternating current from the leads **5000'** of Fig. 5 and result in the release of the relay **5002'**, and will restore the automatic switching apparatus to normal in the same manner as when a calling subscriber hangs up his receiver. All the apparatus involved in the dial system shown in Fig. 5' is of the type well known to the art as the panel type dial telephone system. It has been slightly modified, however, by the introduction of the supersonic alternating current source **5014'** controlled by a relay so that supervision is extended back toward the calling circuit side of the district selector **5013'**. This is not ordinarily the practice in dialing systems, as the supervision of the called circuit normally terminated at that point. While this embodiment of the invention has been described with respect to the connection to a panel type telephone system, it will be obvious to one skilled in the art that by suitable modifications the toll line can be connected to dial apparatus of the step-by-step type, equipped with a director, to the rotary automatic system, to the all-relay automatic system, or to the cross-bar system.

While the invention has been disclosed in certain embodiments which are deemed desirable, it is to be understood that it is capable of many and other widely varied forms without departing from

the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a telephone system including a subscriber's circuit, a toll switching trunk and a toll operator's cord circuit, the combination of a supervisory gas-filled discharge tube (T_{26}—Fig. 6) capable of operating a visual signal and located in said toll switching trunk at the subscriber's end thereof, a first gas-filled discharge tube (T_{24}—Fig. 7) in said trunk operative when said trunk is connected to said toll cord for transmitting current of a definite carrier frequency over said trunk, a second gas-filled discharge tube (T_{25}—Fig. 6) in said trunk selectively controlled by said carrier frequency currents transmitted thereover, and means controlled by said second tube for controlling said supervisory tube.

2. In a telephone system including a subscriber's circuit, a toll switching trunk and a toll operator's cord circuit, the combination of a supervisory gas-filled discharge tube (T_{26}—Fig. 6) capable of operating a visual signal and located in said toll switching trunk at the subscriber's end thereof, a plurality of gas-filled discharge tubes in said trunk started in operation when said trunk is connected to said toll cord for transmitting over said trunk current of a definite carrier frequency and another plurality of gas-filled discharge tubes for responding to said transmitted carrier current for controlling said supervisory tube.

3. In a telephone system including a subscriber's circuit, a toll switching trunk and a toll operator's cord circuit, the combination of supervisory signaling means located in said toll switching trunk at the subscriber's end thereof, a first gas-filled discharge tube (T_{24}—Fig. 7) in said trunk operative when said trunk is connected to said toll cord for transmitting currents of a definite carrier frequency over said trunk, a second gas-filled discharge tube (T_{25}—Fig. 6) in said trunk controlled by said carrier frequency currents transmitted thereover, means controlled by the operation of said second tube for causing the initial operation of said supervisory signaling means, a third gas-filled discharge tube (T_{27}—Fig. 6) normally unoperated connected in said trunk at the subscriber's end thereof and operated when said trunk is connected to said subscriber's line, and means controlled by the operation of said third tube for causing the subsequent release of said supervisory signaling means.

4. In a telephone system including a subscriber's circuit, a toll switching trunk and a toll operator's cord circuit, the combination of a supervisory gas-filled discharge tube (T_{43}—Fig. 4) capable of giving a visual signal located in said toll operator's cord circuit, a plurality of gas-filled discharge tubes in said trunk at the subscriber's end thereof controlled when said trunk is connected to said subscriber's line by the condition of the subscriber's switchhook for transmitting over said trunk a carrier current of a definite frequency for controlling said supervisory tube.

5. In a telephone system including a subscriber's circuit, a toll switching trunk and a toll operator's cord circuit, the combination of a supervisory gas-filled discharge tube (T_{43}—Fig. 9) capable of giving a visual signal located in said toll operator's cord circuit, a plurality of gas-filled discharge tubes in said trunk at the subscriber's end thereof controlled when said trunk is connected to said subscriber's line by the condition of the subscriber's switchhook for transmitting over said trunk a carrier current of a definite frequency, a gas-filled discharge tube (T_{29}—Fig. 7) in said trunk at the toll end thereof responsive to said transmitted carrier current, and means controlled by said last mentioned tube when said trunk is connected to said toll cord for controlling said supervisory signal.

6. In a telephone system including a subscriber's circuit, a toll switching trunk, and a toll operator's cord circuit, the combination of supervisory signaling means located in said toll operator's cord circuit, a first gas-filled discharge tube (T_{27}—Fig. 6) connected in said trunk at the subscriber's end thereof, said first tube being normally unoperated and operated when said trunk is connected to said subscriber's line, a second gas-filled discharge tube (T_{28}—Fig. 6) located in said trunk at the subscriber's end thereof normally unoperated and adapted to be conditioned for operation by the operation of said first tube, means controlled by the operation of the subscriber's switchhook for operating said second tube when previously conditioned for operation, means controlled by said second tube for transmitting over said trunk carrier current of a definite frequency, means at the toll end of said trunk responsive to said transmitted carrier frequency for controlling said supervisory signaling means.

7. In a telephone system including a subscriber's line, a toll switching trunk, and a toll operator's cord circuit, the combination of means in said toll cord for applying a potential to the tip conductor thereof, a first gas-filled discharge tube (T_{30}—Fig. 7) in said trunk at the toll end thereof operated by the potential applied to the tip of said trunk when it is connected to said toll cord, means controlled by said tube for applying carrier current of a definite frequency over said trunk, a second gas-filled discharge tube (T_{31}—Fig. 6) located in said trunk at the subscriber's end thereof, means controlled by said second tube for applying ringing current to said trunk, third and fourth gas-filled discharge tubes (T_{32}—T_{33}—Fig. 6) normally operated and connected serially in the talking conductors of said trunk between the point of application thereto of said ringing current and the toll end thereof, and means controlled by the operation of said second tube for releasing said third and fourth tube.

8. In a telephone system including a toll operator's cord circuit, a toll line, and a toll switching trunk, the combination of a supervisory signaling means located in said toll line at the called end thereof, a first gas-filled discharge tube (T_{55}—Fig. 9) in said toll line at the calling end thereof operated when said toll line is connected to said cord, a second gas-filled discharge tube (T_{59}—Fig. 9) in said toll line at the calling end thereof operated by the operation of said first tube, means controlled by the operation of said second tube for applying to said line signaling current of a predetermined type as a connect signal, signal transmitting apparatus (1401') associated with said toll line at the called end thereof and operated only when said connect signal is being transmitted over said line for transmitting back over said line current of a predetermined type as an acknowledgment signal of said connect signal, means at the calling end of said line responsive to said acknowledgment signal for releasing said second tube whereby the transmission of both of said signals over said line will be stopped, and a plurality of gas-filled discharge tubes in said toll line at the called end thereof controlled by the connect signal trans-

mitted thereover for controlling said supervisory signaling means.

9. In a telephone system including a toll operator's cord circuit, a toll line, and a toll switching trunk, the combination of supervisory signaling means located in said toll line at the called end thereof, a first signal receiving device at the calling end of the toll line normally disconnected therefrom and arranged for the selective reception of acknowledgment signals of signals originating at the calling end of the line, a second signal receiving device at the calling end of the toll line normally connected thereto and arranged for the selective reception of other types of signals transmitted over said line, a first gas-filled discharge tube (T_{55}—Fig. 12) in said toll line at the calling end thereof adapted to be operated when said toll line is connected to said cord, means controlled by the operation of said first tube for reversing the normal connections of said signaling devices to said line, a second gas-filled discharge tube (T_{58}—Fig. 12) in said toll line at the calling end thereof operated by the operation of said first tube, means controlled by the operation of said second tube for applying to said line signaling current of a predetermined type as a connect signal, a plurality of gas-filled discharge tubes in said toll line at the called end thereof controlled by the connect signal transmitted over said line for controlling said supervisory signaling means, signal transmitting apparatus (**1401'**) associated with said toll line at the called end thereof and operated by the connect signal transmitted thereover for transmitting back over said line to said first mentioned signaling device signaling current of a predetermined type as an acknowledgment signal of said connect signal, and means controlled by said first signaling device for releasing said second tube whereby said connect signal and the acknowledgment signal thereof will be removed from said toll line.

10. In a telephone system including a toll operator's cord circuit, a toll line, and a toll switching trunk, the combination of a supervisory gas-filled discharge tube ($T_{77'}$—Fig. 12') capable of operating a visual signal and located in said toll line at the called end thereof, a first gas-filled discharge tube (T_{55}—Fig. 9) in said toll line at the calling end thereof operated when said toll line is connected to said cord, a second gas-filled discharge tube (T_{58}—Fig. 9) in said toll line at the calling end thereof operated by the operation of said first tube, means controlled by the operation of said second tube for applying to said line signaling current of a predetermined type as a connect signal, signal transmitting apparatus associated with said toll line at the called end thereof and operative only when said connect signal is being transmitted over said line for transmitting back over said line current of a predetermined type as an acknowledgment signal of said connect signal, means at the calling end of said line responsive to said acknowledgment signal for releasing said second tube whereby the transmission of both of said signals over said line will be stopped, a chain of gas-filled discharge tubes ($T_{78'}$—$T_{79'}$—Fig. 12') located in said toll line at the called end thereof and adapted to be operated and locked up by said connect signal, means controlled by the operation of said chain of tubes for causing the initial operation of said supervisory tube, and a third gas-filled discharge tube ($T_{80'}$—Fig. 12') connected in the sleeve circuit of said toll line at the called end thereof and operated when said toll line is connected to said trunk for causing the subsequent release of said supervisory tube.

11. In a telephone system including a toll operator's cord circuit, a toll line and a toll switching trunk, the combination of a supervisory gas-filled discharge tube ($T_{77'}$—Fig. 12') capable of operating a visual signal and located in said toll line at the called end thereof, a first gas-filled discharge tube (T_{55}—Fig. 9) in said toll line at the calling end thereof operated when said toll line is connected to said cord, a second gas-filled discharge tube (T_{58}—Fig. 9) in said toll line at the calling end thereof operated by said first tube, means controlled by the operation of said second tube for applying to said line signaling current of a predetermined type as a connect signal, signal transmitting apparatus associated with said toll line at the called end thereof and operated only when said connect signal is being transmitted over said line for transmitting back over said line current of a predetermined type as an acknowledgment signal of said connect signal, means at the calling end of said line responsive to said acknowledgment signal for releasing said second tube whereby the transmission of both of said signals over said line will be stopped, a chain of gas-filled discharge tubes (T'_{78}—$T_{79'}$—Fig. 12') located in said toll line at the called end thereof and adapted to be operated and locked up by said connect signal, means controlled by the operation of said chain of tubes for causing the initial operation of said supervisory tube, a third gas-filled discharge tube ($T_{80'}$—Fig. 12') connected in the sleeve circuit of said toll line at the called end thereof and operated when said toll line is connected to said trunk for causing the subsequent release of said supervisory tube, a fourth gas-filled discharge tube ($T_{81'}$—Fig. 12') located in the sleeve circuit of said toll line at the called end thereof and operated when said toll line is connected to said trunk, and means controlled by the operation of said fourth tube for transmitting over said trunk signaling current of a predetermined frequency.

12. In a telephone system including a toll operator's cord circuit, a toll line and a toll switching trunk, the combination of a supervisory gas-filled discharge tube ($T_{77'}$—Fig. 12') capable of operating a visual signal and located in said toll line at the called end thereof, a first gas-filled discharge tube (T_{55}—Fig. 9) in said toll line at the calling end thereof adapted to be operated when said toll line is connected to said cord and to be released when said toll line is disconnected from said cord, a second gas-filled discharge tube (T_{60}—Fig. 9) in said toll line at the calling end thereof, circuit arrangements associated with said second tube and said first tube and so arranged that said second tube will not be operated by the operation of the first tube but will be operated after said first tube is operated and released, means controlled by the operation of said second tube for applying to said line signaling current of a predetermined type as a disconnect signal, signal transmitting apparatus (**1402'**) associated with said toll line at the called end thereof and operated only when said disconnect signal is being transmitted over said line for transmitting back over said line current of a predetermined type as an acknowledgment signal of said disconnect signal, means at the calling end of the line responsive to said acknowledgment signal for releasing said second tube whereby the transmission of both of said signals over

said line will be stopped, and a plurality of gas-filled discharge tubes in said toll line at the called end thereof controlled by the disconnect signal transmitted thereover for controlling said supervisory tube.

13. In a telephone system including a toll operator's cord circuit, a toll line, and a toll switching trunk, the combination of supervisory signaling means located in said toll line at the called end thereof, a chain of gas-filled discharge tubes ($T_{78'}$—$T_{79'}$—Fig. 12') located in said toll line at the called end thereof and adapted to be operated and locked up when a connect signal is transmitted over said line, means controlled by said chain of tubes when operated for causing the initial operation of said supervisory signaling means, a gas-filled discharge tube ($T_{80'}$—Fig. 12') in the sleeve circuit of said toll line at the called end thereof adapted to be operated when said toll line is connected to said switching trunk, means controlled by said last mentioned tube when operated for causing the subsequent release of said supervisory signaling means, a first gas-filled discharge tube (T_{55}—Fig. 9) in said toll line at the calling end thereof adapted to be operated when said toll line is connected to said cord and to be released when said toll line is disconnected from said cord, a second gas-filled discharge tube (T_{60}—Fig. 9) in said toll line at the calling end thereof, circuit arrangements associated with said second tube and said first tube and so arranged that said second tube will not be operated by the operation of the first tube but will be operated after said first tube is operated and released, means controlled by the operation of said second tube for applying to said line signaling current of a predetermined type as a disconnect signal, signal transmitting apparatus (**1402'**) associated with said toll line at the called end thereof operated only when said disconnect signal is being transmitted over said line for transmitting back over said line current of a predetermined type as an acknowledgment signal of said disconnect signal, means at the calling end of the line responsive to said acknowledgment signal for releasing said second tube whereby the transmission of the disconnect signal and the acknowledgment signal therefor over said line will be stopped, and means controlled by the transmission over said line of said disconnect signal for releasing the locking arrangements of said previously mentioned chain of gas-filled tubes whereby the operation of said tube in the sleeve circuit of said toll line at the called end thereof will cause the second operation of said supervisory signaling means.

14. In a telephone system including a toll operator's cord circuit, a toll line, a toll switching trunk and a subscriber's circuit, the combination of supervisory signaling means in said toll cord, a first gas-filled discharge tube (T_{62}—Fig. 9) connected in the sleeve circuit of said toll line at the calling end thereof, said first tube being normally operated and adapted when operated and when said toll line is connected to said cord to reduce the impedance of the sleeve circuit of said toll line and cord sufficiently to cause the operation of said supervisory signaling means, a plurality of gas-filled discharge tubes ($T_{84'}$—$T_{85'}$—Fig. 12') located in said toll line at the called end thereof and operated when a connection is established between said toll line, said switching trunk and said subscriber's line, and when the subscriber's receiver is removed from the hook, means controlled by said chain of tubes for transmitting over said toll line signaling current of a predetermined type as an off-hook signal, means associated with said toll line at the calling end thereof and controlled by the off-hook signal transmitted over said line for releasing said first tube whereby the impedance of the sleeve circuit of said toll line and said toll cord will be sufficiently increased to cause the release of said supervisory signaling means, and signal transmitting apparatus (**1304**) associated with said toll line at the calling end thereof and operated only when said off-hook signal is being transmitted over said line for transmitting back over said line current of a predetermined type as an acknowledgment signal of said off-hook signal whereby said off-hook signal will be removed from said line.

15. In a telephone system including a toll operator's cord circuit, a toll line, a toll switching trunk and a subscriber's circuit, the combination of supervisory signaling means located in said toll cord, a first gas-filled discharge tube (T_{62}—Fig. 9) connected in the sleeve circuit of said toll line at the calling end thereof, said first tube being normally operated and adapted when operated and when said toll line is connected to said cord to reduce the impedance of the sleeve circuit of said toll line and cord sufficiently to cause the operation of said supervisory signaling means, means in said toll line at the calling end thereof operative when an off-hook signal is transmitted over said line for releasing said first tube and thereby causing the release of said supervisory signaling means, a second gas-filled discharge tube ($T_{86'}$—Fig. 12') located in said toll line at the called end thereof, said tube being held released when said toll line is connected to said trunk and said trunk is connected to said subscriber's line and said subscriber's receiver is off the switchhook and said tube being operated when the subscriber restores the receiver to the switchhook, means controlled by said second tube for transmitting over said toll line signaling current of a predetermined type as an on-hook signal, a chain of gas-filled discharge tubes (T_{61}—T_{63}—Fig. 9) in said line at the calling end thereof controlled by the transmission thereover of said on-hook signal, means controlled by said last mentioned chain of gas-filled tubes for causing said first gas-filled tube to be operated again whereby said supervisory signaling means will be operated again, and signal transmitting apparatus (**1303**) associated with said toll line at the calling end thereof and operated only when said on-hook signal is being transmitted over said line for transmitting back over said line current of a predetermined type as an acknowledgment signal of said on-hook signal whereby said on-hook signal will be removed from said line.

16. In a telephone system including a toll line, a toll switching trunk, and a subscriber's circuit, the combination of a first gas-filled discharge tube ($T_{37'}$—Fig. 8') in said trunk at the called subscriber's end thereof adapted to be operated when said trunk is connected to said subscriber's line, means controlled by said first tube when operated for transmitting signaling current from said trunk over said subscriber's line, a second gas-filled discharge tube ($T_{54'}$—Fig. 8') in said trunk at the subscriber's end thereof conditioned for operation by the connection of said trunk to said line, means controlled by the condition of said subscriber's switchhook for operating said second tube, means controlled by the operation of said second tube for releasing said first tube,

a third gas-filled discharge tube (T_{42}'—Fig. 8') in said trunk at the subscriber's end thereof, means controlled by the condition of said subscriber's switchhook for operating said third tube, and means controlled by said third tube for transmitting signaling current over said trunk to initiate the transmission of off-hook and on-hook signals over said toll line.

17. In a telephone system including a toll operator's cord circuit and a toll line, the combination of supervisory signaling means located in said toll line at the called end thereof, a first gas-filled discharge tube (T_{55}—Fig. 9) in said toll line at the calling end thereof controlled by the type of connection established between said toll line and said cord, a second gas-filled discharge tube (either T_{58} or T_{60}—Fig. 9) in said toll line at the calling end thereof controlled by said first tube, means controlled by said second tube for applying to said line signaling current of a predetermined type as a signal of predetermined significance, signal transmitting apparatus (either **1401'** or **1402'**—Fig. 10') associated with said toll line at the called end thereof and operated only when said signal of predetermined significance is being transmitted over said line for transmitting back over said line current of a predetermined type as an acknowledgment of said signal of predetermined significance, means at the calling end of said line responsive to said acknowledgment signal for controlling said second tube whereby the transmission of both of said signals over said line will be stopped, and a plurality of gas-filled discharge tubes in said toll line at the called end thereof controlled by said signal of predetermined significance transmitted thereover for controlling said supervisory signaling means.

18. In a telephone system including a toll operator's cord circuit and a toll line, the combination of supervisory signaling means located in said toll line at the called end thereof, a group of gas-filled discharge tubes (T_{58}, T_{60} and others—Fig. 9) located at the calling end of said toll line and controlled by the type of connection established between said toll line and said toll card, a first group of signal transmitting devices (**1301**, **1302** and others—Fig. 10) located at the calling end of said toll line and each controlled by one tube of said first-mentioned group of tubes for transmitting over said toll line signaling currents of predetermined types as signals of predetermined significance, a second group of signal transmitting devices (**1401'**, **1402'** and others—Fig. 10') located in said toll line at the called end thereof and each being adapted to be controlled by one of the different types of signals transmitted over said line from said first group of signal transmitting devices, each of the signal transmitting devices of said second group being adapted to transmit back over said line an acknowledgment signal for the signal transmitted by its corresponding signal-transmitting device in said first group, means at the calling end of said line controlled by said acknowledgment signals for controlling said first group of tubes, and a plurality of gas-filled discharge tubes in said toll line at the called end thereof controlled by said signals of predetermined significance for controlling said supervisory signaling means.

19. In a telephone system including a toll operator's cord circuit, a first toll line, and a second toll line, the combination of a first group of gas-filled discharge tubes (T'_{84}—T'_{85}—T'_{86}—Fig. 12') located at the called end of the first toll line and adapted to retransmit over said toll line to the calling end thereof the subscriber's off-hook and on-hook signals when said first toll line is connected directly through a toll switching trunk to said subscriber's line, a second group of gas-filled discharge tubes (T'_{82}—T'_{83}—T'_{900}—Fig. 12') located at the called end of said first toll line and adapted to control the operation of said first group of tubes, through switching means associated with the calling end of said second toll line arranged to be utilized when the call is to be completed from said first toll line through said second toll line to the subscriber, a first gas-filled discharge tube (T_{722}—Fig. 9) associated with said through switching means in said second toll line and adapted to be operated when said first and second toll lines are connected by said through switching means, and means controlled by the operation of said first gas-filled tube for releasing said second group of gas-filled tubes whereby said first group of gas-filled tubes will be disabled and the subscriber's off-hook and on-hook signals transmitted over said second toll line will not be retransmitted by said first group of gas-filled tubes over said first toll line.

20. In a telephone system including a toll operator's cord circuit, a first toll line, and a second toll line, the combination of a first group of gas-filled discharge tubes (T'_{84}—T'_{85}—T'_{86}—T'_{82}—T'_{83}—T'_{900}—Fig. 12') located at the called end of the first toll line and adapted to retransmit over said toll line to the calling end thereof the subscriber's off-hook and on-hook signals when said first toll line is connected directly through a toll switching trunk to said subscriber's line, outward switching means and through switching means associated with the calling end of said second toll line, a first gas-filled discharge tube (T_{55}—Fig. 9) associated with said outward switching means and adapted to be operated when a connection is established therewith, a second gas-filled discharge tube (T_{723}—Fig. 9) associated with said through switching means and adapted to be operated when a connection is established therewith, a second group of gas-filled discharge tubes (T_{58}—T_{60}—Fig. 9) associated with the calling end of said second toll line and adapted to transmit over said line distinctive signals to control supervisory signaling means at the called end of said second toll line, means controlled by said first gas-filled discharge tube or by said second gas-filled discharge tube for controlling said second group of gas-filled discharge tubes, a third group of gas-filled discharge tubes (T_{61}—T_{62}—T_{63}—Fig. 9) associated with the calling end of said second toll line and adapted when a connection is established with said outward switching means to receive off-hook and on-hook signals transmitted over said second toll line, a third gas-filled discharge tube (T_{722}—Fig. 9) associated with said through switching means, and means controlled by said third gas-filled discharge tube for disabling said third group of gas-filled discharge tubes and for disabling said first group of gas-filled discharge tubes.

21. In a telephone system including a toll operator's cord circuit and a toll line terminating at the called end thereof in an exchange of the automatic type, the combination of a first gas-filled discharge tube ($T_{77'}$—Fig. 12') located at the called end of said line, a second gas-filled discharge tube (T_{55}—Fig. 9) located at the calling end of said toll line and operated when said toll line is connected to said cord, a third gas-filled

discharge tube (T_{58}—Fig. 9) in said toll line at the calling end thereof operated by the operation of said second tube, means controlled by the operation of said third tube for applying to said line signaling current of a predetermined type as a connect signal, signal transmitting apparatus (1401') associated with said toll line at the called end thereof and operated only when said connect signal is being transmitted over said line for transmitting back over said line current of a predetermined type as an acknowledgment signal of said connect signal, means at the calling end of said line responsive to said acknowledgment signal for releasing said third tube whereby the transmission of both of said signals over said line will be stopped, a plurality of gas-filled discharge tubes in said toll line at the called end thereof controlled by the connect signal transmitted thereover for operating and holding operated said first gas-filled tube, means controlled by the operation of said first gas-filled tube for preparing automatic switching apparatus in said automatic exchange for the reception of dial impulses transmitted over said toll line whereby the connection from said toll line may be automatically extended.

22. In a telephone system including a toll operator's cord circuit and a toll line terminating at the called end thereof in an exchange of the automatic type, the combination of means at the called end of said toll line responsive to the transmission over said toll line of a connect signal for preparing automatic switching apparatus in said automatic exchange for the reception of dial impulses transmitted over said toll line whereby the connection from said toll line may be automatically extended to a subscriber's station, a group of gas-filled discharge tubes ($T_{84'}$—$T_{85'}$—$T_{86'}$—Fig. 12') located at the called end of said toll line and adapted to transmit over said toll line subscriber's off-hook and on-hook signals, means (5015') in said automatic switching apparatus in said automatic exchange controlled by the operation of the subscriber's switchhook, and means controlled by said last-mentioned means for transmitting to said group of gas-filled discharge tubes a carrier frequency adapted to control their operation.

23. A telephone circuit having at each end thereof inward, outward and through switching means at each end of said line being permanently connected thereto, a group of gas-filled discharge tubes (T_{56}—T_{57}—Fig. 9) at each end of said line normally operated and arranged when operated to connect to said line said inward switching means, gas-filled discharge tubes associated with each of said outward and through switching means and arranged to be operated when connections are established therewith, and means controlled by each of said last-mentioned gas-filled discharge tubes for releasing said first-mentioned groups of tubes whereby said inward switching means may be disconnected from said line.

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