Oct. 25, 1949. C. W. JOHNSTONE ET AL 2,485,886

TRIPLE GATE

Filed Feb. 21, 1946 3 Sheets-Sheet 1

FIG. 1

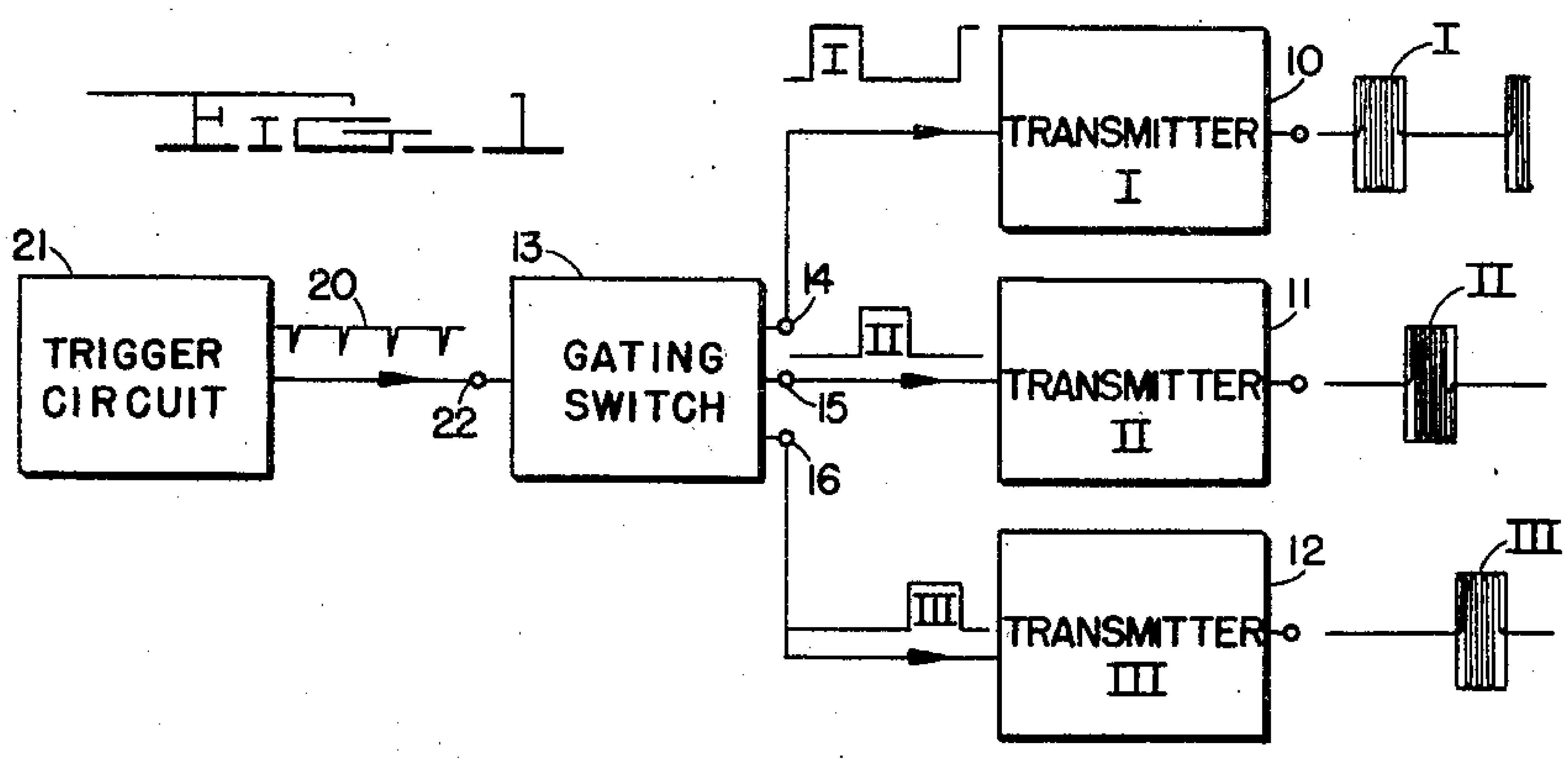
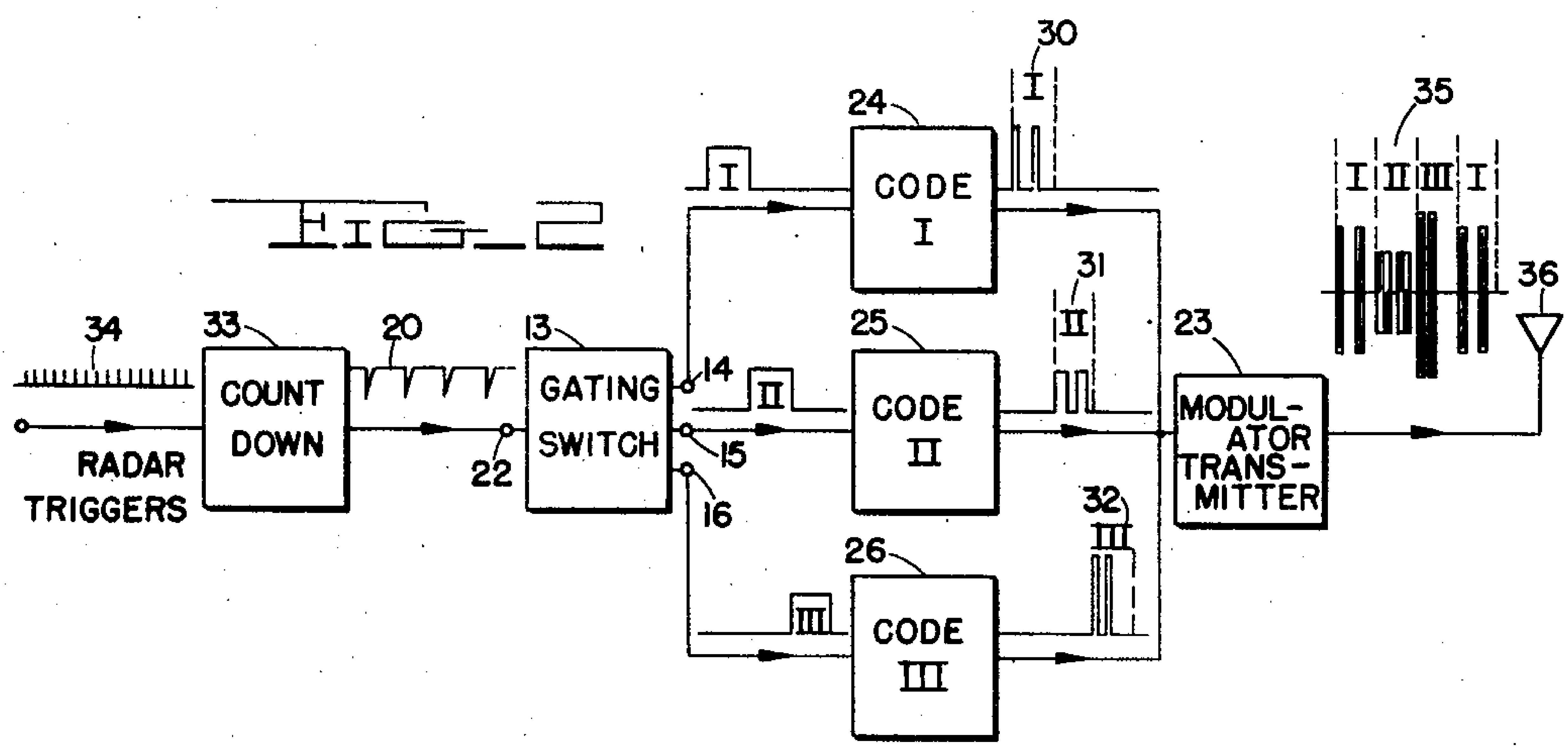


FIG. 2



Inventors
CHARLES W. JOHNSTONE
LEONARD P. MAUTNER

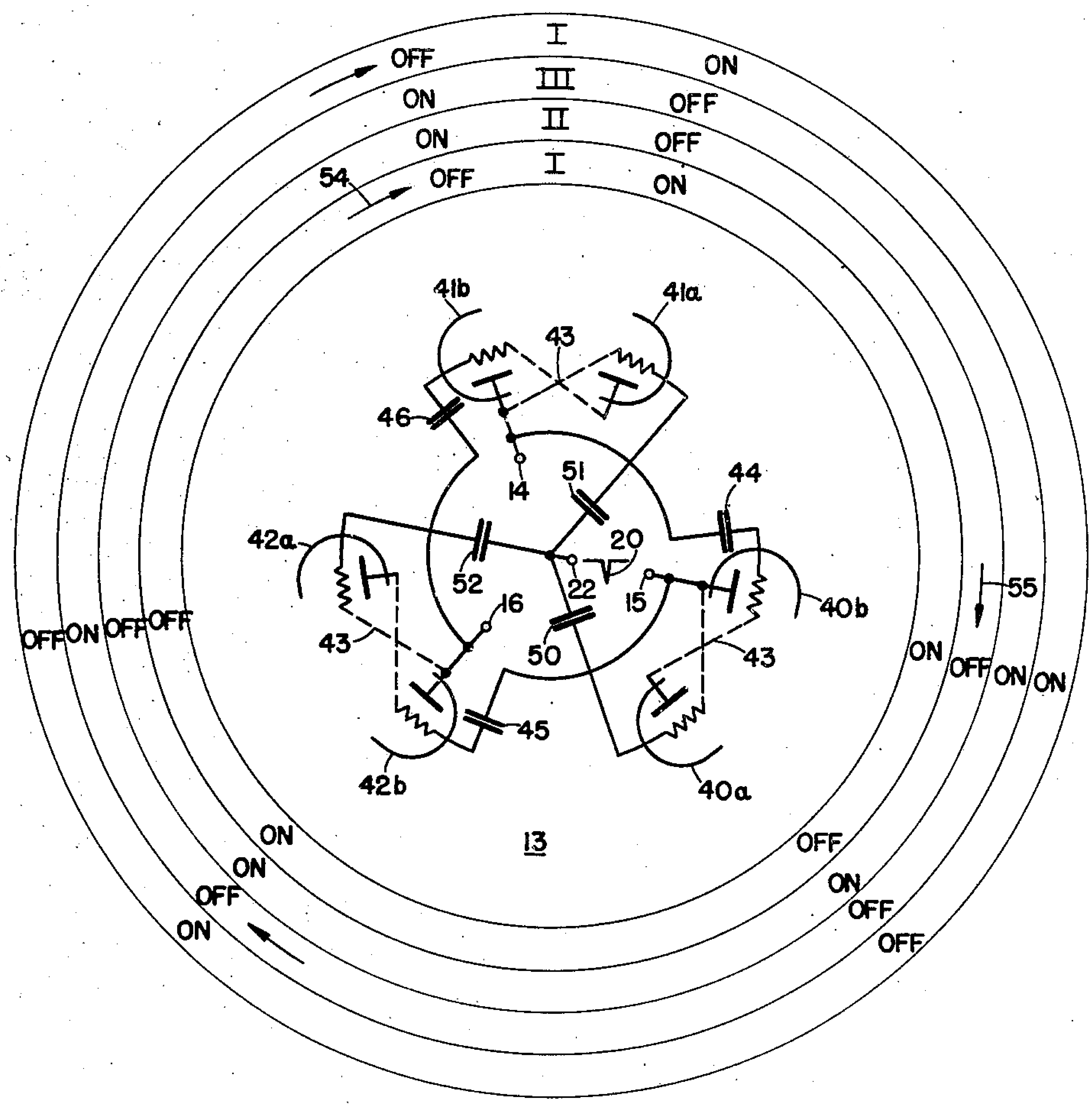
By M. C. Hayes

Attorney

TRIPLE GATE

Filed Feb. 21, 1946 3 Sheets-Sheet 2

FIG. 3



Inventors
CHARLES W. JOHNSTONE
LEONARD P. MAUTNER

By M. O. Hayes
Attorney

Oct. 25, 1949. C. W. JOHNSTONE ET AL 2,485,886

TRIPLE GATE

Filed Feb. 21, 1946 3 Sheets-Sheet 3

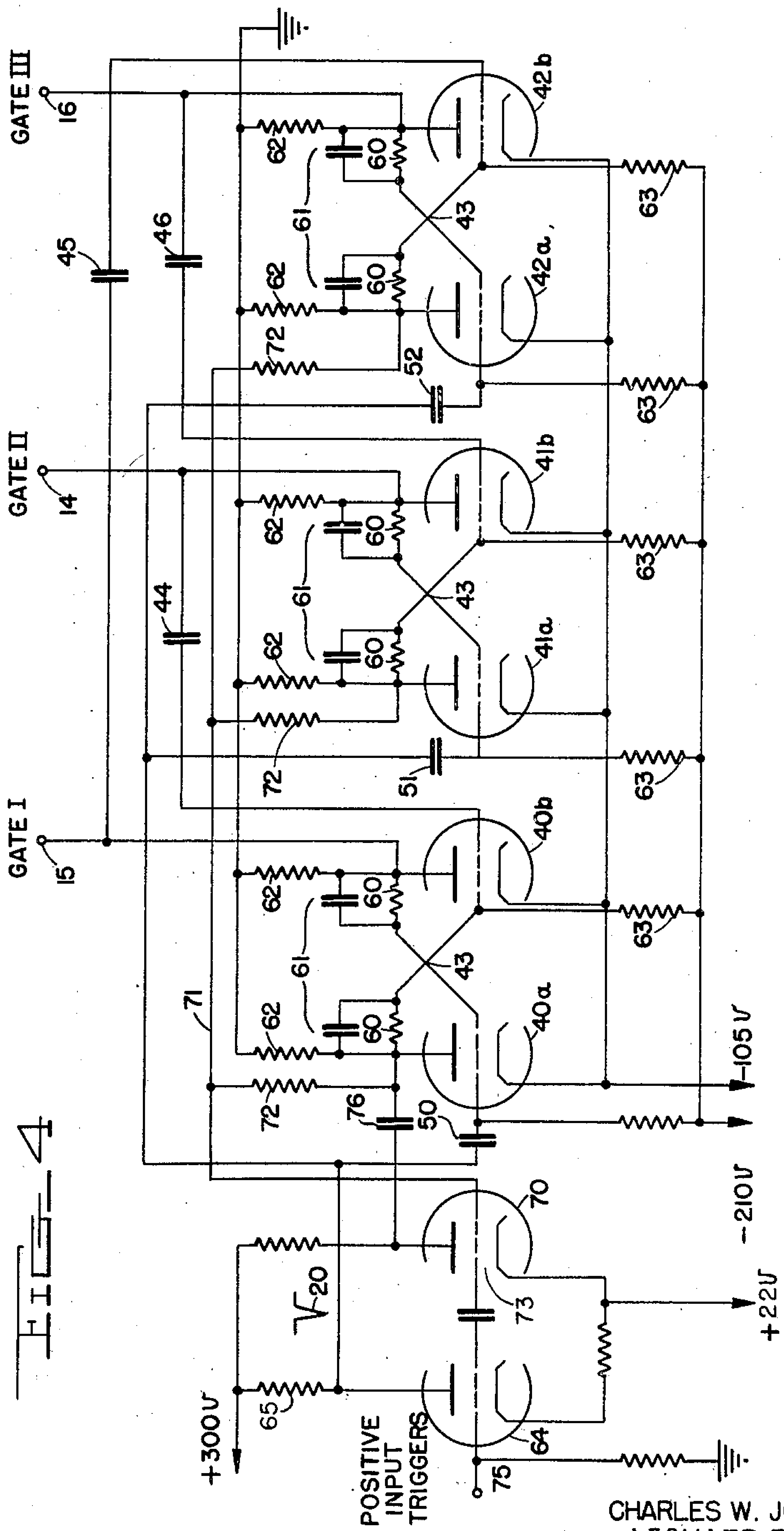


FIG. 4

Inventors
CHARLES W. JOHNSTONE
LEONARD P. MAUTNER

By M. C. Hayes

Attorney

Patented Oct. 25, 1949 2,485,886

UNITED STATES PATENT OFFICE

2,485,886

TRIPLE GATE

Charles W. Johnstone, Garden City, and Leonard P. Mautner, Bronx, N. Y., assignors, by direct and mesne assignments, to the United States of America as represented by the Secretary of the Navy

Application February 21, 1946, Serial No. 649,417

3 Claims. (Cl. 250—27)

1

This invention relates to a transmission system in which a plurality, greater than two, of different kinds of transmission means are caused to emit their individually distinctive signals in time sharing fashion.

It is an object of this invention to produce a time shared transmission system in which at least three transmission means are caused to send out their individually distinctive signals in time sharing fashion, the operation being controlled by a novel gating switch having a number of output terminals equal to the number of transmission means to be controlled. On each terminal appears, in rotative time sequence, a gating signal which permits operation of the associated transmitting means for a predetermined time interval, following which the gating signal is transferred to an adjacent terminal. Transferring of the signal is repeated in rotative succession.

It is another object of this invention to produce a time shared transmission system in which at least three transmission means are caused to operate intermittently in rotative succession, by the operation of an electronic gating switch having a number of switching means corresponding to the number of transmission means. Each switching means comprises a stable electronic multivibrator operable, upon reception of a proper triggering signal, between two discrete conditions.

It is a further object of this invention to produce a gating switch comprised of at least three switching means, each operable between two discrete conditions, and so arranged that upon operation of one of the switching means, an adjacent switching means automatically operates to its other discrete position, the operations being initiated by a switch triggering signal applied indiscriminately to each of the switching means.

In accordance with these objects and with other objects which will become apparent in the specification, the time shared transmission system and gating switch of this invention will be described with reference to the accompanying drawings in which,

Fig. 1 shows in block diagram form a first embodiment of the transmission system of this invention;

Fig. 2 shows a more detailed and complicated embodiment, also in block diagram form;

Fig. 3 shows schematically an electronic gating switch forming part of this invention and constituting one of the elements of the time shared transmission system of this invention; and

2

Fig. 4 shows a complete circuit diagram of the gating switch shown schematically in Fig. 3.

Referring to Fig. 1, there is shown a block diagram of a time shared transmission system comprising, in this embodiment, three transmission means **10**, **11** and **12**, each effective, when properly gated, to produce a distinctive and characteristic signal, shown by the numerals I, II and III. It is desired that the distinctive signal producers share transmission time in rotative succession, so that during an extended interval of time each of the three signals may be sent over a single transmission channel.

In order to permit time sharing among three or more individually distinctive transmission means, a novel gating switch **13** has been devised having a number of output terminals equal to the number of transmission means to be controlled, in this case three, as shown at **14**, **15**, and **16**. In the operation of gating switch **13**, a number of periodically repeated switch triggering signals **20**, derived from a trigger circuit **21**, are applied at the single input terminal **22** of the gating switch **13**, and at terminals **14**, **15**, and **16** appear gating signals I, II, and III, respectively. The gating signals, it will be noted, share time; so that with termination of gating signal I, initiated by one of the signals **20**, gate II appears on terminal **15**; and with its termination, also initiated by a signal **20**, gate III appears on terminal **16**. With the termination of gate III, gate I reappears and the cycle is reinitiated in rotative succession.

Gating switch **13** consists essentially of three switching means connected, respectively, to terminals **14**, **15** and **16**, and operating between two discrete conditions, one of said conditions producing the gating signal necessary to permit signal production by the associated transmission means **10**, **11**, or **12**. As will be explained more fully hereinafter, each of the switching means comprising the gating switch **13** is interconnected to an adjacent switching means; so that when the first mentioned switching means terminates its gating signal, the next adjacent switching means starts its gating signal, and so on in rotative succession. As mentioned hereinbefore, the particular moment when one gate terminates and the adjacent gate begins is determined by the switching impetuses or switch triggering signals **20**.

The time shared transmission system described broadly above and illustrated in Fig. 1 is particularly adaptable to an identification system associated with a radar, or ranging and direction finding system. In identification systems associated with radar search systems, it may be desirable to interrogate all craft with three or more different types of interrogation. In order to maintain continuity of control of interrogation and reply, it is necessary that the different types of interrogations be sent forth substantially simultaneously. However, if a plurality of different transmission channels is unavailable or infeasible, a time sharing system is necessary in which the first interrogating transmission, with its particular coding, is sent out for a first interval, followed successively by the second and third interrogating transmissions, the process being repeated in rotative succession. The gating signals must be of short duration, in order that substantially continual interrogation may be maintained at all times.

A system for attaining this object is shown in Fig. 2, wherein **23** designates a modulator-transmitter, which emits signals on a single carrier frequency, the characteristic of the envelope of transmission being determined by the nature of the modulating code I, II, or III, applied to modulator-transmitter **23**. Modulating code generators **24**, **25**, and **26** are capable of generating modulating pulses for transmitter **23**, each code being individually distinct from the others, as shown at **30**, **31**, and **32**. In order to accomplish the hereinbefore described time sharing, it is necessary that each of the code generators **24**, **25**, and **26** send forth modulating pulses only during its preassigned portion of the cycle. To this end, the gating switch **13** described above in connection with Fig. 1 is employed to apply at each of its terminals **14**, **15**, and **16** a gating signal permitting time sharing operation of the three code generators **24**, **25**, and **26**. The switch triggering signals **20** are obtained in this case, from a counting down circuit **33**, which selects every Nth trigger in a series of input radar triggers **34**, and derives therefrom the switch triggering signals **20**.

The operation of the system of Fig. 2 is as follows. Periodically repeated radar triggers **34**, synchronized with the search radar pulses, are counted down in circuit **33**. Every Nth radar trigger (illustrated in this case as every fourth trigger) emerges as a switch triggering signal **20**. Signals **20** are applied simultaneously to each of the switching means comprising gating switch **13** and produce in rotative succession the output gates I, II, and III on terminals **14**, **15**, and **16**, respectively. These gates permit operation of the code generators **24**, **25**, and **26**, so that the modulating codes **30**, **31**, and **32** are emitted during the respective "on" periods of code generators **24**, **25**, and **26**. The three codes **30**, **31**, and **32** modulate the modulator-transmitter **23** and emerge as the envelopes of the pulsed transmissions shown at **35**; they may be applied to an antenna **30** or to any suitable transmission channel.

Gating switch **13** is shown more particularly in the schematic diagram of Fig. 3, wherein three pairs of tubes, **40***a*—**40***b*, **41***a*—**41***b*, and **42***a*—**42***b* are illustrated schematically in a ring form of diagram. Each of the pairs of tubes **40***a*—**40***b*, **41***a*—**41***b*, and **42***a*—**42***b* is connected as a stable multivibrator, shown symbolically by the crossed dotted lines **43**. Multivibrators **40***a*—**40***b*, **41***a*—**41***b*, and **42***a*—**42***b* operate in the conventional manner of a stable multivibrator, or flip flop circuit. That is, one of the tubes of the pair is conducting, thereby holding the other tube non-conducting. A triggering signal applied to the multivibrator initiates a change in the condition of the multivibrator either by turning on the non-conducting tube or by turning off the conducting tube. The action started by the trigger is rapidly intensified by operation of the cross connection between the tubes; and the tube which was previously non-conducting goes into conduction, holding the other tube in a non-conductive condition. The multivibrator is then quiescent until another triggering signal is applied.

Each of the switching means, or multivibrators, shown consists of an *a* tube and a *b* tube. It will be noted that the output from each of the *b* tubes, **40***b*, **41***b* and **42***b* is applied to the input of the *b* tube next adjacent in rotative succession. Specifically, the anode of tube **41***b* is connected to the grid of tube **40***b* by capacitor **44**; the anode of tube **40***b* is connected to the grid of tube **42***b* by capacitor **45**; and the anode of tube **42***b* is connected to the grid of tube **41***b* by capacitor **46**, thus completing the cycle of connections. It will be understood that any suitable form of circuit means may be employed to connect the output of a given *b* tube to the input of the next succeeding *b* tube. From the anodes of the respective *b* tubes, **40***b*, **41***b*, and **42***b*, the gating switch output is taken, at terminals **15**, **14**, and **16**, respectively. The input to the gating switch is in the form of a negative trigger signal **20**, applied at terminal **22** connected to the grid of each of the *a* tubes, **40***a*, **41***a*, and **42***a*, through capacitors **50**, **51**, and **52**, respectively.

It will be seen that the gating switch above described consists of three switching means, each in the form of a stable multivibrator operating between two discrete conditions. Each multivibrator is comprised of an *a* tube and a *b* tube, with circuit means connecting the output of each *b* tube to the input of an adjacent succeeding *b* tube, and with an input circuit which applies negative trigger signals indiscriminately to the input of each of the *a* tubes.

The operation of the gating switch of Fig. 3 will now be described. With the application of anode voltages and grid biases to the circuit, one of the tubes of each pair will tend to assume conduction, producing a voltage holding the other tube in a non-conductive state. Although each of the six tubes is of the same type, assume that manufacturing discrepancies in the circuit cause tube **42***b* to start conduction a moment before the other tubes start conduction. Conduction in **42***b* will cause its anode to assume the lower voltage of its two discrete conditions, and will place a negative going signal on the grid of **41***b* through capacitor **46**. This will block conduction in **41***b*. Tube **41***b* going off will cause its anode to assume its positive condition, transferring a positive going voltage through capacitor **44** to the grid of **40***b*. This will drive **40***b* into conduction and will place a negative going signal on its anode, which will be translated through capacitor **45** to the grid of **42***b*. Since it has been assumed that **42***b* initiated the cycle of conduction, it will continue to conduct in spite of the negative signal. The above initial operation will thus place the six tubes in one of the two conditions, "off" or "on," as shown in the explanatory circles surrounding the circuit diagram of Fig. 3. Thus, step I finds **41***b* off, with **40***b* and **42***b* on; and the *a* tubes in a condition opposite to that of their associated *b* tubes. It is possible that the initial condition might be otherwise, in which case the circuit would not be prepared to commence its normal cyclic operation. This contingency will be provided for by the inclusion of a self starter tube, to be described in connection with the complete circuit shown in Fig. 4.

With the tubes in the conditions shown in ring I, a negative switching impetus or switch triggering signal **20** is applied through terminal **22** to the grid of each of the *a* tubes, **40***a*, **41***a*, and **42***a*. Inasmuch as both **42***a* and **40***a* are off, the only tube which will be affected by the negative trigger is **41***a*, which will begin to stop its conduction. The conventional multivibrator action, represented by the cross connecting circuits **43**, will intensify the blocking of **41***a*, so that **41***b* will come on while **41***a* will go completely off. Turning on, i. e., starting conduction, of **41***b* will place a negative going signal on the input of **40***b*, through the circuit means (in the form of capacitor **44**) connecting the output of **41***b* with the input of **40***b*. Tube **40***b*, which in step I was on, will be turned off, and multivibrator action will turn **40***a* on. Turning off of **40***b* will place a positive going voltage on its anode, but this will not affect **42***b* inasmuch as it is already in a conducting, or on, condition. It will thus be seen that the high voltage condition existing at the anode of an off tube has been transferred from **41***b* in step I, as denoted by arrow **54**, to the anode of **40***b* in step II, as denoted by arrow **55**. In the meantime, the multivibrator **42***a*—**42***b* has been unaffected by the change from step I to step II.

The succeeding negative trigger **20** will act in a similar manner on the *a* tube which is on, in this case **40***a*; and the high voltage condition represented by an off *b* tube will be transferred from **40***b* to **42***b*, while multivibrator **41***a*—**41***b* will be unaffected. In this manner, the off condition for the *b* tube is transferred in rotative succession around the ring by each negative trigger **20** applied to the grid, or input circuit, of each *a* tube.

It will be readily apparent that any number of pairs of tubes connected in multivibrator fashion may be utilized in such a ring circuit as shown in Fig. 3. Furthermore, if desired, triggers **20** may be positive instead of negative, in which case the non-conducting *a* tube will be the one affected.

Summarizing, it will be seen that the circuit of Fig. 3 comprises a plurality of switching means, to each of which is applied indiscriminately a switch triggering signal, but only one of which is in a condition at any one time to respond to the signal. Response of the conditioned switching means, causing it to operate to the second of its discrete conditions, causes operation of the next succeeding switching means in cyclic succession; but operation of the last mentioned switching means is not transmitted further to the succeeding switching means in the ring. The last mentioned switching means then becomes conditioned to be responsive to the next succeeding switch triggering signal, and so on around the ring as long as switch triggering signals are received.

From the above described operation of the circuit of Fig. 3, it is apparent how the gating signals appear on the terminals **14**, **15**, and **16** of Figs. 1, 2, and 3. These gating signals, represented by the positive blocks I, II, and III, correspond with the off condition of the several *b* tubes, which condition is shifted in rotative succession around the ring.

The circuit shown schematically in Fig. 3 is shown in detail in Fig. 4 and includes, in addition, a pair of trigger tubes, one being the normal trigger tube, and the other being the self-starting trigger tube, mentioned hereinbefore, which is needed if the initial conditions, when the circuit is first energized, are not such as to make an *a* tube receptive to the negative triggers **20**.

Referring to Fig. 4, the circuit has been shown with the three multivibrators **40***a*—**40***b*, **41***a*—**41***b*, and **42***a*—**42***b*, designated with the same reference numerals as in Fig. 3. The stable multivibrator cross connection **43** has been shown in the form of D. C. coupling resistors **60** in parallel with capacitors **61**. The anodes of each of the tubes are taken to ground through conventional load resistors **62**, while the cathodes have been connected to a source of —105 volts. The grids are returned to —210 volts through resistors **63**. The grids of each of the *a* tubes are triggered through a normal trigger tube **64** having plate load resistor **65**. Normal, steady-state operation of the circuit of Fig. 4 is as described for the circuit of Fig. 3, with positive input triggers being applied to tube **64**, in which they are amplified and inverted to form the negative triggers **20** applied to the grids of the *a* tubes.

It is possible that the initial application of potential might be followed by the multivibrators assuming such a condition that each of the *a* tubes is non-conducting, or off. In this event, the negative triggers **20** would not affect any of the *a* grids; and the circuit would remain quiescent.

To obviate this difficulty, a self-starting trigger tube **70** is provided, to which positive input triggers are applied in parallel with tube **64**. When the gating switch is operating normally, the average potential on conductor **71**, which is connected to the respective anodes of the *a* tubes through the three resistors **72**, is sufficiently low to bias tube **70** below cut off. Since conductor **71** is connected to grid **73** of tube **70**, this tube will, during normal operation of the gating switch, be completely inoperative by virtue of the below-cut-off bias on its grid. If the undesirable condition is encountered in which all *a* tubes are non-conducting, the average D. C. potential on conductor **71** will be raised sufficiently to bring the bias on the grid of tube **70** into the operating region. Hence, the positive input triggers applied at terminal **75** will be translated and amplified through tube **70**, and will appear on the anode of tube **70** as negative switch triggering signals. These signals will be translated through capacitor **76** and the first R. C. circuit **60**—**61** to the grid of tube **40***b*. Since it has been assumed that **40***a* was non-conducting and **40***b* conducting, this negative signal will cause **40***b* to cut off, turning on **40***a*. Conduction in **40***a* will lower the average potential on conductor **71** and grid **73** to the point where tube **70** is inoperative. Inasmuch as **40***a* is conducting, and therefore receptive to negative triggers, the circuit is now in a normal condition, ready to receive triggering signals **20** from tube **64**. Self-starting tube **70** drops out of the picture, and the circuit continues normal switching operation with the reception of each positive input trigger on terminal **75**.

The gating switch illustrated in Figs. 3 and 4, and described immediately above, is suitable for any application where it is desired to have a gating signal appear in rotative succession on one of a plurality of output terminals, in response to triggering signals applied to the input of the gating switch.

While this invention should not be limited to any specific circuit constants, the following are given as illustrative of values of circuit components which may be utilized in the circuit of Fig. 4.

Tubes 40a—40b, 41a—41b, 42a—42b	6SN7
Capacitors 44, 45, 46 and 61	150 micro-microfarads
Capacitors 50, 51 and 52	50 micro-microfarads
Resistors 60	560,000 ohms
Resistors 62	47,000 ohms
Resistors 63 and 72	1 megohm
Capacitor 76	.001 microfarad

Although we have shown and described certain specific embodiments of the invention, we are fully aware of the many modifications possible thereof. This invention is not to be restricted except insofar as is necessitated by prior art and the spirit of the appended claims.

We claim:

1. An electronic switching circuit comprising a plurality of pairs of tubes, each pair comprising a first tube and a second tube having separate inputs and outputs interconnected as a trigger circuit having two alternative stable states, circuit means connecting the output of the first tube of each of said pairs to the input of the first tube of another of said pairs, trigger signal input means connected to the input of the second tube of each of said pairs, and a normally inoperative triggering tube having an input connected to the output of the second tube of each of said pairs and an output connected to the input of the first tube of one of said pairs, said triggering tube being operative in response to a predetermined condition in said second tubes, to apply a switch triggering signal to the input of the first tube of said one of said pairs.

2. An electronic switching circuit comprising a plurality of pairs of tubes having at least cathode, anode, and control grid electrodes, each pair comprising a first tube and a second tube interconnected as a trigger circuit having two alternative stable states, first circuit means connecting the anode of the first tube of each of said pairs to the control grid of the first tube of another of said pairs, trigger signal means, second circuit means connecting said trigger signal means to the control grid of the second tube of each of said pairs, a self-starting means including a trigger tube having at least a cathode, an anode, and a control grid, separate impedance means respectively connecting the anode of each of said second tubes to the control grid of said trigger tube, and third circuit means connecting the anode of said trigger tube to the control grid of a first tube of one of said pairs of tubes, said self-starting means operative responsive to a predetermined state in each of said second tubes to change the state of said one pair of tubes.

3. An electronic switching circuit comprising a plurality of pairs of tubes having at least cathode, anode, and control grid electrodes, each pair comprising a first tube and a second tube interconnected as a trigger circuit having two alternative stable states, first circuit means connecting the anode of the first tube of each of said pairs to the control grid of the first tube of another of said pairs, trigger signal means, second circuit means connecting said trigger signal means to the control grid of the second tube of each of said pairs, a self starting means including a trigger tube having at least a cathode, an anode, and a control grid, separate impedance means respectively connecting the anode of each of said second tubes to the control grid of said trigger tube, fixed biasing means connected to the cathode of said trigger tube operative to render said trigger tube non-conducting when any of said second tubes is conducting and conducting when all of said second tubes are non-conducting, and means connecting the anode of said trigger tube to the control grid of a first tube of one of said pairs.

CHARLES W. JOHNSTONE.
LEONARD P. MAUTNER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,873,785	Ranger	Aug. 23, 1932
1,914,407	Demarest	June 20, 1933
1,951,524	Nicolson	Mar. 20, 1934
1,956,397	Nicolson	Apr. 24, 1934
2,136,621	King et al.	Nov. 15, 1938
2,146,862	Shumard	Feb. 14, 1939
2,369,662	Deloraine	Feb. 20, 1945
2,404,918	Overbeck	July 30, 1946
2,405,930	Goldberg	Aug. 13, 1946
2,406,165	Schroeder	Aug. 20, 1946
2,406,760	Goldmark	Sept. 3, 1946
2,426,454	Johnson	Aug. 26, 1947
2,435,207	Dimond	Feb. 3, 1948
2,444,950	Nichols	July 13, 1948