

Dec. 16, 1952

J. MÜLLER ET AL

2,622,140

HIGH-FREQUENCY CONTROL SYSTEM FOR TRAFFIC SIGNALS

Filed Feb. 27, 1948

3 Sheets-Sheet 1

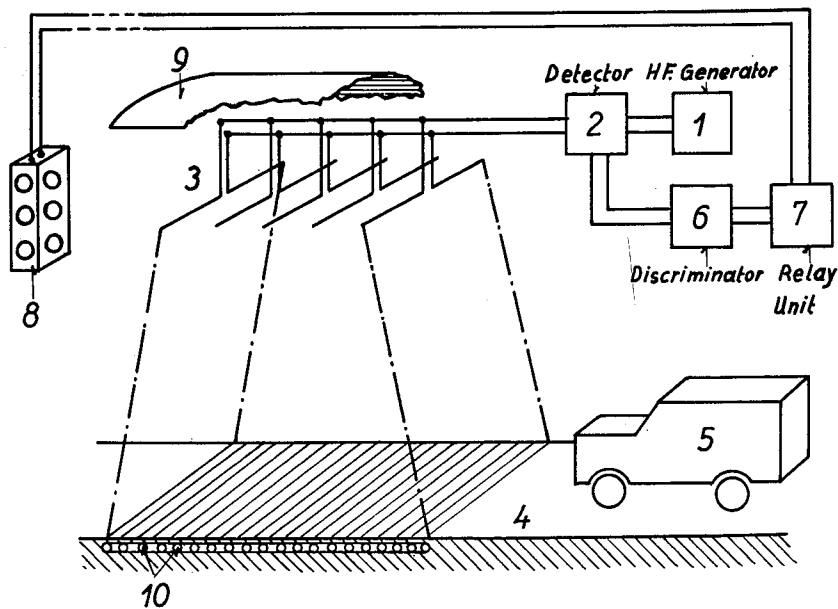


Fig. 1

INVENTORS:

JOSEF MÜLLER, JEAN PATRY,

WILLY BAUMBERGER, ALBERT KLEIN

BY

Carl W. Berg

ATT'Y

Dec. 16, 1952

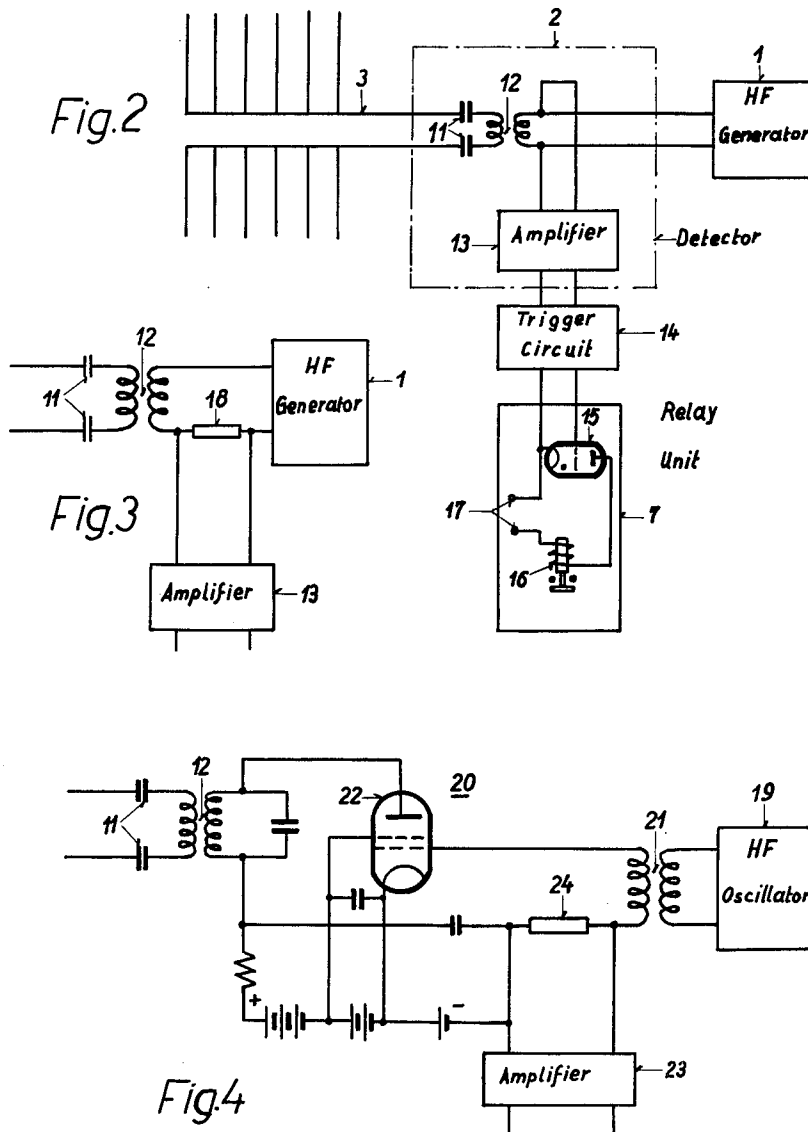
J. MÜLLER ET AL

2,622,140

HIGH-FREQUENCY CONTROL SYSTEM FOR TRAFFIC SIGNALS

Filed Feb. 27, 1948

3 Sheets-Sheet 2



INVENTORS:

JOSEF MÜLLER, JEAN PATRY,

WILLY BAUMBERGER, ALBERT KLEIN

BY: *Carl M. [Signature]* ATT'Y

Dec. 16, 1952

J. MÜLLER ET AL

2,622,140

HIGH-FREQUENCY CONTROL SYSTEM FOR TRAFFIC SIGNALS

Filed Feb. 27, 1948

3 Sheets-Sheet 3

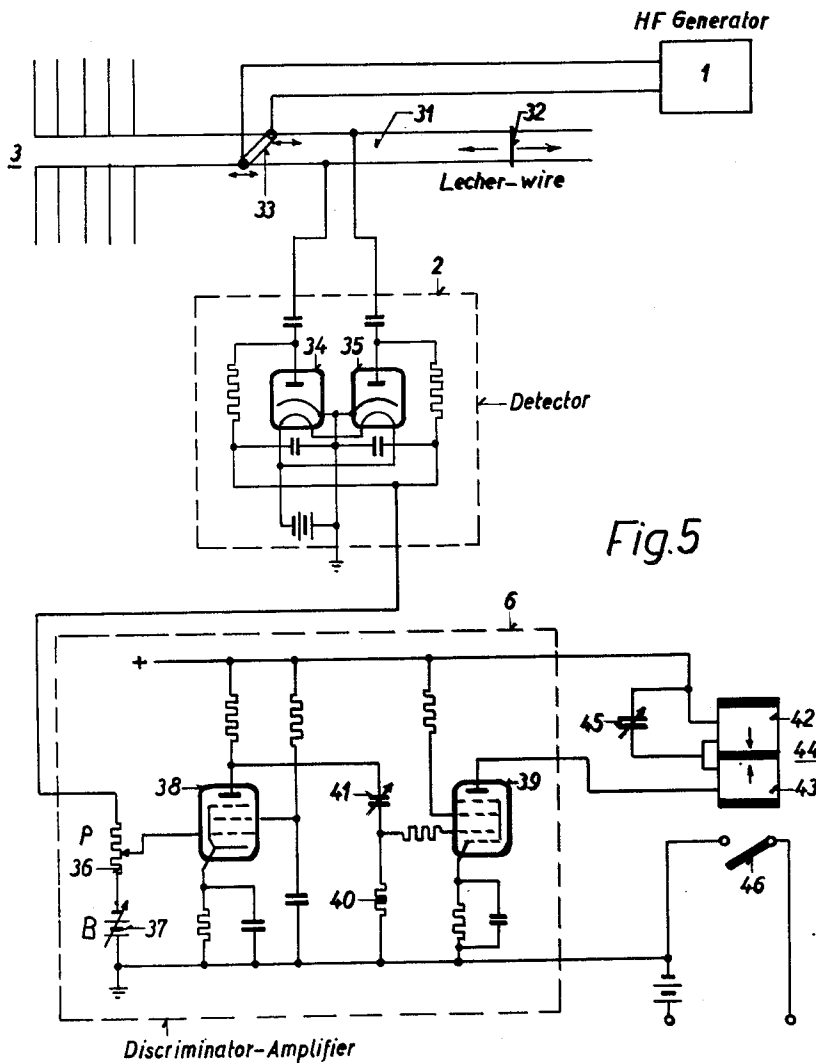


Fig. 5

INVENTORS:

JOSEF MÜLLER, JEAN PATRY,

WILLY BAUMBERGER, ALBERT KLEIN

BY: *Carl W. Perry* ATT'Y

UNITED STATES PATENT OFFICE

2,622,140

HIGH-FREQUENCY CONTROL SYSTEM FOR
TRAFFIC SIGNALS

Josef Müller and Jean Patry, Zurich, Willy Baum-
berger, Puidoux, and Albert Klein, Zurich, Swit-
zerland, assignors to Albiswerk Zuerich A. G.,
Zurich, Switzerland, a Swiss company

Application February 27, 1948, Serial No. 11,464
In Switzerland September 5, 1946

Section 1, Public Law 690, August 8, 1946
Patent expires September 5, 1966

9 Claims. (Cl. 177—337)

1

Our invention relates to vehicle-controlled signal systems which automatically assign the right of way in accordance with the varying demands of traffic.

Such signal systems require a control equipment which issues control impulses in such a manner as to secure a traffic regulation with a best feasible adaptation to local traffic conditions.

This purpose is served by the known road treadle contacts built into the different traffic lanes of a street crossing and actuated by each vehicle to release a control impulse. Treadle contacts of this kind require extensive ground installations that are apt to be affected by water and inoperative when covered by snow and ice.

It has also been proposed to employ transmitter-receiver systems operating with visible or invisible optical radiation, or with sound waves of very high frequency, or with electromagnetic waves. Although such transmitter-receiver systems for radiation of various kinds avoid the shortcomings of a treadle-actuated installation, they are deficient in other respects. The control equipment for the signal must not respond to pedestrians, nor to trolleys and other vehicles of the other traveling direction. This precludes installations in which a transmitter, located at one side of the street, directs a horizontal beam of radiation onto a receiver at the other side of the street. Transmitter and receiver must be disposed close to each other above the road section under supervision. The radiation, directed from the transmitter onto the traffic lane should be reflected, from an object to be responded to, toward the receiver. Due to the greatly varying reflecting properties of vehicles, for optical and acoustical radiation under different atmospheric conditions, these types of radiation are very badly suited for such installations. Also transmitter-receiver systems for high-frequency radiation, as heretofore proposed, fail to guarantee a satisfactory control.

It is an object of our invention to provide a traffic-responsive signal control system that, while avoiding the disadvantages of treadle contacts, is also capable of meeting the above-mentioned other requirements more satisfactorily than any of the radiation emitting control systems heretofore available.

Another object of our invention is to devise a traffic signal control of the radiation type which operates without a receiver proper, i. e. which permits simplifying the traffic-responsive sensing and impulse emitting means by having a single

2

electronic unit emit the radiation and also respond to the effects caused by a traffic object or vehicle intercepting the radiation.

Other objects of the invention are to readily permit confining the radiation beam of a radiation-type traffic detector to a desired area of a traffic lane so as to safely exclude interference due to traffic on adjacent lanes or areas, and to provide a traffic detector of greatly improved sensitivity and selectivity.

The invention is based upon the recognition that the input impedance of an antenna varies in dependence upon conditions within the radiation field or space. With a radiator for high-frequency waves, the radiation space, due to its total reflection and absorption phenomena, reacts back on the radiator as a complex load. The impedance (radiation resistance) of the radiator, i. e. the ratio of the applied voltage to the current taken up by the radiator, varies together with variations within the radiation space. This dependence of directional radiation impedance upon the field conditions in the radiation space is utilized, according to the invention, for controlling a traffic signal.

According to our invention, we dispose at least one directional radiator, fed from a high-frequency generator, above the road area under supervision so that a laterally limited beam of radiation is directed toward the area, and we provide this transmitter system with translating means which convert the variations of antenna input impedance, caused by an object traversing the radiation field, into corresponding electric control impulses for a traffic signal.

According to another feature of the invention, we equip the impedance-responsive impulse producing devices with discriminator means so that a signal controlling impulse is issued only when the intensity and duration of the impedance variation exceed given minimum values.

According to further features of our invention, we design the high-frequency radiator as a broadside array of dipoles and operate it at a frequency whose wave length is not appreciably larger than the linear dimensions of the traffic objects to be responded to. According to a more specific feature, the dipoles are designed and energized to operate in parallel resonance and have a length substantially equal to the wave length of the frequency radiation, these length magnitudes being preferably in the same order of magnitude as the average linear dimensions of the traffic objects.

The above-mentioned and other objectives and

3

features of our invention will be apparent from the following description in conjunction with the appertaining drawing in which Figure 1 is a schematic illustration of a traffic detector and signal control system according to the invention, while Figs. 2 to 5 show diagrammatically four respective embodiments of the variation-sensing and impulse controlling section of such a system.

According to Figure 1, a directional radiator 3, consisting of an array of five parallel dipole antennas, lying in a common plane, is energized from a high-frequency generator 1. The radiator emits a laterally limited beam of radiation toward the ground area 4 under supervision, for instance, a traffic lane at a street crossing. For producing a beam of best possible homogeneity, several, at least three, dipoles are required. The operating point of the individual dipoles and the reflecting properties of the radiated ground area determine a definite normal impedance (radiation resistance) of the directional radiator, i. e. a given ratio of high-frequency current and high-frequency voltage at the input circuit of the directional radiator or at any other point of the transmission line between generator and radiator. As explained, an object, such as the vehicle 5, traversing the radiation beam and having linear dimensions approximately equal to the wave length of the radiated frequency, causes a variation in impedance of the radiator. A detector device 2 is provided which senses these impedance changes and converts them into electric impulses. A direct impedance gauge circuit may be used for this purpose, e. g. an impedance-measuring bridge circuit. However, the changes in radiation impedance may also be determined as current or voltage changes by means of a high-frequency current or voltage indicator. Of course, in all these cases a corresponding matching member between the high-frequency transmission and the radiator will be necessary. Besides, at the suitable frequencies (about 300 megacycles), the circuit tap points for current and voltage measurements must be properly selected.

It is also possible to design the generator and couple it to the directional radiator in such a manner that the impedance variation of the radiator directly influences a characteristic operating quantity, e. g. the grid current, of the generator. This permits translating the impedance variations of the radiator into electric impulses by means of a detecting device responsive to the particular operating quantity of the generator.

The indicative impulses issuing from the detector 2 depend, as to amplitude and time curve, upon the kind and velocity of the object responded to. They are, therefore, passed through a frequency-dependent discriminating device 6 whose time constant and sensitivity are adjusted so that only impulses of a desired amplitude and duration are released to a relay unit 7 for the control of the signalling device 8. To this end, the discriminating device 6 is preferably designed as an impulse amplifier of adjustable time constant.

The operating point for the dipoles lies, preferably, within the range of parallel resonance because then the impedance curve is very steep so that small variations in field conditions cause large variations in impedance. To this end, the length of the dipoles must be approximately equal to half the wave length of the radiated frequency.

A reflector 9 may be mounted above the dipoles

4

in order to secure a better utilization of the high-frequency energy. The reflector may consist of sheet metal or wire mesh, or of an arrangement of reflector dipoles.

In order to prevent a disturbing variation of the normal impedance due to rain, snow, temperature, etc., it is of advantage to provide for a good reflectivity of the irradiated ground area. This can be attained by surfacing the area with a material whose dielectric constant is as high as possible. This constant should at least have a value of four. By embedding metallic reflectors (plates, grids or wires) into the road area, such as shown at 10, the required reflectivity is secured in any event.

If it is desired to discriminate between objects as to their direction of travel, two or more directional radiators may be disposed above the respective lane areas, each having its own detector device for changes in radiation impedance, the indicating impulses from these detectors being differently responded to by a single discriminating device depending upon the timely sequence of the impulses.

In this case, and also if a complete installation with several separately supervised traffic lanes is to be built, the various directional radiators may be fed from a single generator.

As mentioned above, the traffic-responsive variations of radiation impedance may be determined in various ways, in particular as changes in radiator input voltage or current, as changes in voltage to current ratio, or as changes in an electric operating magnitude of the generator. These possibilities are elucidated by the embodiments shown in Figs. 2 to 4 and described presently.

According to Fig. 2 the array 3 of dipoles is connected to the transmission line by an impedance matching coupling comprising capacitors 11 and an inductive coupling member 12. The voltage across the transmission line is applied to an amplifier from tap points located away from voltage nodes. The signal from the amplifier is applied to an electronic trigger unit 14 which issues its trigger impulses to the grid circuit of a thyatron 15. The plate circuit of the thyatron is shown to be connected to the coil 16 of an electromagnetic relay in series with plate-current supply terminals 17. It will be understood that the detector, amplifier, trigger and other units may be integrated or built together in any suitable manner, for instance, to a single electronic tube arrangement and that the desired impulse producing, filtering or discriminating functions may be assigned to any suitable unit or tube circuit section. For instance, the trigger circuit may consist of an impulse amplifier of such characteristic that a firing impulse is issued to the thyatron only if the voltage across the input terminals of amplifier 13 drops below given magnitude, and either amplifier 13 or unit 14 may contain a timing circuit so that a given duration of the voltage reduction is also necessary for triggering the tube 15. The relay 16 represents the impulse responsive relay of a signal control device which need not depart from those known for treadle-actuated or electromagnetically controlled signal systems.

If the detector unit 2 is to respond to changes in current, its amplifier, according to Fig. 3, may be input-connected across a resistor or any other available series impedance of the transmission line so that the voltage applied to the amplifier

13 is substantially proportional to the load current of the radiator, the rest of the system being otherwise similar to that of Fig. 2. It is obvious, that voltage response according to Fig. 2 and current response according to Fig. 3 may be combined by applying the two respective voltages to a ratio measuring circuit so that the control intelligence derived from the two voltages is more strictly a measure of the radiation resistance of the dipole array.

In the embodiment shown in Fig. 4, the high-frequency generator is composed of an oscillator 19 and a power amplifier 20 interconnected by a suitable coupling 21. Oscillator and amplifier are of customary design, except that the grid circuit of the amplifier tube 22 is coupled to an amplifier 23, for instance, across a resistor or other series impedance 24 of the grid circuit. The grid current of tube 22 varies in dependence upon variations of the antenna input impedance and causes a corresponding voltage variation to occur across the input terminals of amplifier 23. The amplified signals are applied to discriminator and impulse transmitter sections as described in the foregoing.

In the embodiment shown in Fig. 5, the coupling between high-frequency generator 1 and dipole array 3 is designed as a Lecher wire to facilitate matching of the antenna and transmission line impedances. The shorting bar 32 and the feed points of a terminal bar 33 are preferably displaceable, as is indicated by arrows. By properly positioning the bars 32 and 33 relative to each other, the points of attachment to the detector unit 2 can readily be kept away from voltage nodes. The detector unit 2 consists essentially of an electronic voltmeter with two symmetrically arranged diodes 34 and 35. Such high-frequency voltmeters are known as such so that details of unit 2 need not be further described. The output voltage of the detector is applied across the resistor of a potentiometric rheostat 36 in series with a source 37 of direct-current voltage. Source 37 imposes a polarizing bias on the tube voltmeter so that the impulse amplifier 6, of which the rheostat 36 forms part, is not affected by the normal voltage impressed on the detector 2, but responds only to variations of that voltage.

The amplifier 6 comprises two tubes 38, 39 whose circuits include resistors, of which one is denoted by 40, and capacitors of which one is denoted by 41. The amplifier circuits are essentially conventional, except that the output circuit includes in series the two coils 42, 43 of a differential relay 44 and a capacitor 45 in parallel connection to only one of the two coils. Relay 44 corresponds to relay 16 in Fig. 2, i. e. its contact 46 controls the operation of the traffic signal devices proper.

The sensitivity of the amplifier 6 can be adjusted by correspondingly adjusting the slide contact of rheostat 36 so that only voltage variations above a given minimum amplitude are effective to control the relay 44. The time constant of the impulse amplifier is essentially determined by the capacitors 41, 45 and by the resistance values of resistor 40 and coil 42 respectively. By adjusting the capacitors 41 and 45, this time constant can be so chosen that the relay 44 is affected only by voltage variations that extend a given minimum period of time. Consequently, the impulse amplifier 6 also operates as a discriminator.

Normally, the anode current of amplifier tube

39 flows through both windings 42, 43 of relay 44 whose fields cancel each other so that contact 46 remains open. However, a sudden increase in plate current, as caused by a detected voltage change of sufficient magnitude and duration, is temporarily only effective in coil 43 but not in coil 42 because the capacitor 45, due to the sudden increase in voltage drop across coil 42, is charged and hence absorbs the current increase. A sudden decrease in plate current of tube 39 is likewise temporarily effective in coil 43 only, while the current in coil 42 remains at first at the previous value due to the fact that capacitor 45 now discharges through coil 42. Consequently, any sudden change in output current of amplifier 6 results in an unbalanced excitation of the two coils of the differential relay so that contact 46 is actuated and issues a control impulse to the traffic signal devices.

It will be apparent from the exemplified embodiments that the invention permits of various modifications and alteration, and can be embodied by devices other than those specifically illustrated and described, without departing from the essential features of the invention as defined by the claims annexed hereto.

We claim as our invention:

1. In combination with a road lane for vehicle travel, a traffic signal installation comprising a directional high-frequency radiator disposed above a surface area of the road lane and having a beam directed downwardly onto said area, a high-frequency generator connected to said radiator to provide energization therefor and having a frequency corresponding to a wave length in the order of magnitude of the average vehicle length, detector means connected with said radiator and responsive to input-impedance variations of said radiator due to vehicles passing through said beam, and traffic signal means connected to said detector means to be controlled by said impulses.

2. A vehicle-controlled traffic signal system, comprising a high-frequency generator having a wave length in the order of magnitude of the average vehicle dimensions, a broadside array of antennas connected to said generator and being, when installed, horizontally disposed above a traffic lane area under supervision to direct a laterally confined beam downwardly toward said area, said antennas having a horizontal length substantially equal to said wave length, detector means connected to said array and responsive to variations in input impedance of said array due to vehicles passing through said beam, and signal control means connected to said detector means to be controlled by said variations.

3. A traffic-controlled signal system, comprising a high-frequency generator having a wave length in the order of magnitude of the average vehicle length, a directional radiator disposed above a surface area under supervision for beaming high-frequency radiation toward said area, said radiator being composed of at least three dipoles disposed substantially in a common horizontal plane and having each a length substantially equal to said wave length to operate in parallel resonance, detector means responsive to variations in input impedance of said radiator due to vehicles passing through said beam, and signal control means connected to said detector means to be controlled in dependence upon given minimum conditions of said variations.

7

4. A traffic signal system according to claim 2, comprising a reflective surface member disposed above said array and having a substantially horizontal reflective surface extending substantially over the entire length and width of said array.

5. In combination with a vehicle traffic lane, a traffic signal installation comprising a directional high-frequency radiator disposed above a surface area of the road lane and having a beam directed downwardly onto said area and laterally substantially limited to said area, a high-frequency generator connected to said radiator to provide energization therefor, said surface area having a surface layer whose dielectric constant has an average value of at least four, detector means connected with said radiator and responsive to input-impedance variations of said radiator due to vehicles passing through said beam, and traffic signal means connected to said detector means to be controlled by said impulses.

6. In combination with a vehicle traffic lane, a traffic signal installation comprising a directional high-frequency radiator disposed above a surface area of the road lane and having a beam directed downwardly onto said area and laterally substantially limited to said area, a high-frequency generator connected to said radiator to provide energization therefor, metallic reflection means embedded in said area of said lane, detector means connected with said radiator and responsive to input-impedance variations of said radiator due to vehicles passing through said beam, and traffic signal means connected to said detector means to be controlled by said impulses.

7. A traffic signal system according to claim 2, comprising a transmission line connecting said generator to said array, said detector means having a circuit member connected in said transmission line and responsive to the current flowing through said line from said generator to said array.

8

8. A traffic signal system according to claim 2, comprising a frequency-dependent discriminator means of adjustable time constant being connected between said detector means and said signal control means for releasing control pulses to said signal means when said variations exceed given intensity and duration values.

9. A traffic-responsive signal control system, comprising a directional high-frequency radiator to be disposed above a surface area so as to direct a beam toward said area, a high-frequency generator connected to said radiator to provide energization therefor, detector means responsive to variations in input impedance of said radiator due to objects passing through said beam, frequency-dependent discriminator means of adjustable time constant comprising an impulse amplifier and being connected with said detector means for releasing control impulses in dependence upon given intensity and duration of said variations, and signal control means connected to said discriminator means to be controlled by said impulses.

JOSEF MÜLLER.

JEAN PATRY.

WILLY BAUMBERGER.

ALBERT KLEIN.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,658,953	Theremin	Feb. 14, 1928
1,898,432	Edwards et al.	Feb. 21, 1933
1,917,243	Edwards et al.	July 11, 1933
2,031,951	Hartley	Feb. 25, 1936
2,290,771	Shepard	July 21, 1942
2,238,041	Dickens	Apr. 15, 1944