June 8, 1965 M. E. MOHR 3,188,390

SIGNAL TRANSMISSION WITH SECRECY

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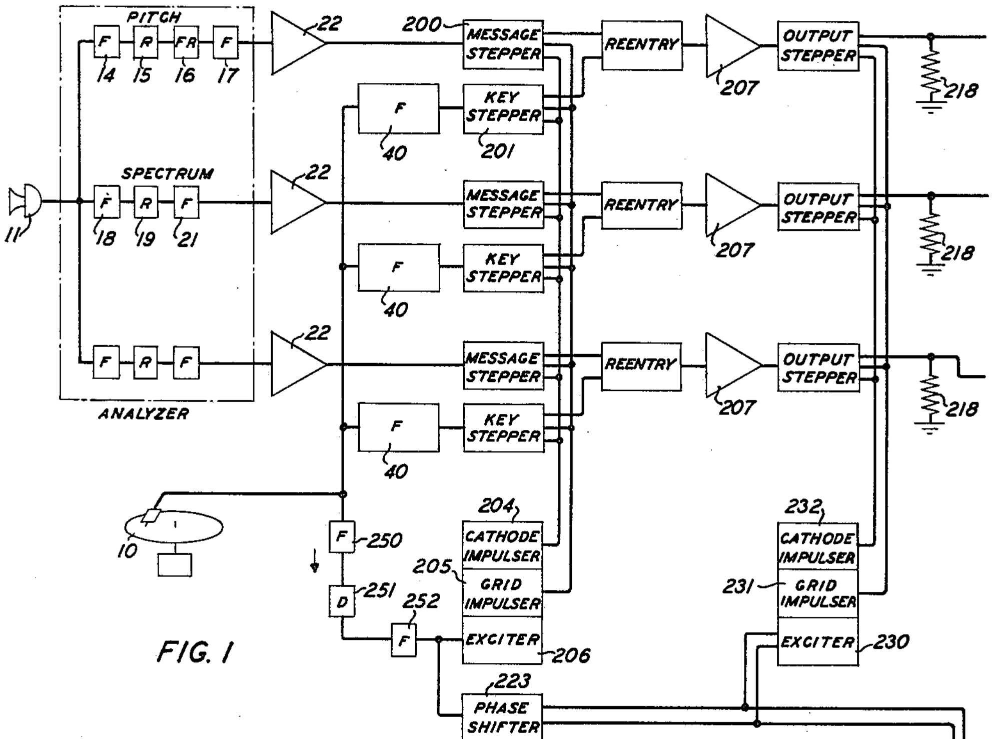
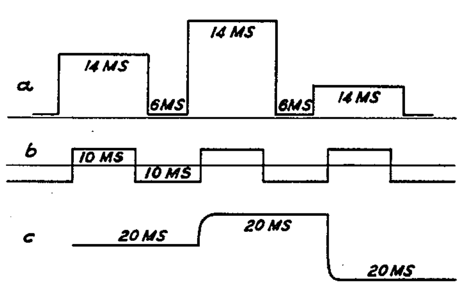


FIG. 1

FIG. 3



INVENTOR
M. E. MOHR
BY
ATTORNEY

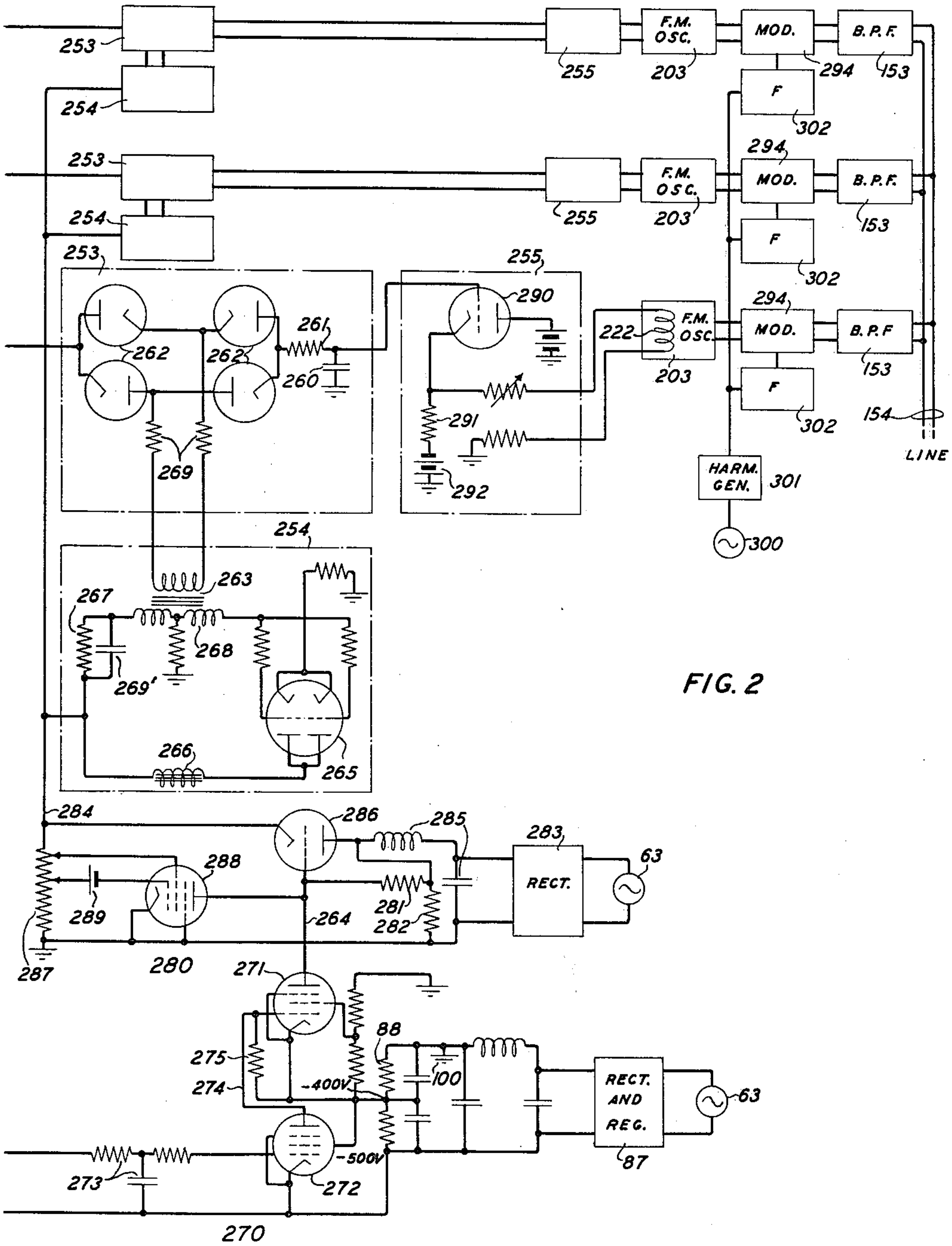


FIG. 2

INVENTOR
M. E. MOHR
BY H. A. Burgess
ATTORNEY

United States Patent Office

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SIGNAL TRANSMISSION WITH SECRECY

Milton E. Mohr, Summit, N.J., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

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5 Claims. (Cl. 179—1.5)

The present invention relates to message transmission with privacy and is in the nature of a modification of and improvement upon the privacy system disclosed in the application of Lundstrom and Schimpf, Serial No. 456,322, filed August 27, 1942.

In that application disclosure, input speech waves are first analyzed, as in the vocoder, into pitch-defining and amplitude-defining or spectrum currents existing in separate circuits; secret key waves are added to these various currents, and the resulting waves are put through reentry circuits and, in one form of circuit, through output steppers. The output steppers comprise groups of gas-filled tubes whose grids are exposed for periodic brief instants of time to the waves from the reentry circuits to cause varying numbers of the tubes in a group to fire at different times depending upon the instantaneous amplitude of the waves applied to the stepper grids at the instants of exposure. In this way, stepped output waves are produced. In order to restore the gas-filled stepper tubes to normal just prior to each new exposure, their plate voltage is driven to zero for a short interval. This results in short spaces of zero current between the impulses of output current. In the Lundstrom-Schimpf disclosure, for example, the current pulses have uniform length of 14 milliseconds and are separated by 6 millisecond spaces.

In some cases such as in radio transmission in which certain fading effects are encountered, it may be desirable to produce for transmission a stepped wave which does not fall periodically to zero but which is an uninterrupted current of stepped form.

This may be especially true where the stepped waves or impulses are to be used for frequency modulating carrier or subcarrier waves, in which case the spaced pulses produce greater excursions of frequency than does an uninterrupted, stepped wave.

The object of this invention is to convert pulses with intervening dips or spaces into a stepped wave in which the dips or spaces are eliminated.

In the form of the invention to be disclosed herein, this object is accomplished by sampling the pulses at their peak amplitudes and placing a proportionate charge on a condenser, which is maintained until the next sampling time when the charge is made proportional to the pulse amplitude existing at that sampling instant. The voltage across this condenser varies with time in the form of the stepped wave which is desired.

The invention will be more clearly understood from the following detailed description taken in connection with the accompanying drawings in which:

FIGS. 1 and 2, when placed beside each other with FIG. 1 at the left, show a schematic circuit diagram of a transmitting terminal of the type shown in the Lundstrom-Schimpf application modified to incorporate the improvement feature constituting the present invention; and

FIG. 3 shows diagrams of current versus time to be referred to in the description.

In the description which follows, all of that part of the system which is disclosed in detail in the Lundstrom and Schimpf application will be only briefly sketched in order to afford a setting for describing in detail the present invention. In the drawing, the same reference numerals are used to designate elements as are used in the Lundstrom-Schimpf disclosure for those circuit elements that are common to both disclosures.

Speech waves from microphone 11 or other input circuit are impressed on the analyzer shown as consisting of a pitch channel and a member of spectrum channels, such as ten, of which only two are indicated. The pitch channel includes filter 14, rectifier 15, frequency measuring circuit 16 and low-pass filter 17, and the spectrum channels include filter 18, rectifier 19 and low-pass filter 21, all as shown by similarly numbered elements in the Lundstrom-Schimpf disclosure. Each of these channels, following the analyzer, includes an amplifier 22 which in practice may be a magnetic amplifier as in the Lundstrom-Schimpf disclosure. It will be understood that up to the amplifiers 22 these channels each carry a direct current of slowly varying amplitude, the maximum frequency component present being about 25 cycles. The amplified channel currents are impressed on the message steppers 200 which convert the channel currents to square pulses of varying amplitude. These currents have added to them key pulses also of square pulse form coming from the output terminals of a key stepper 201 associated with each message stepper. The key steppers are fed with key material from record 10, the key for each channel being selected on a frequency basis by means of individual filters 40. In the reentry circuit the summations of message plus key pulses are left unchanged so long as they are not in excess of a given amplitude corresponding to about the maximum amplitude of the message pulses themselves. If they exceed this amplitude they are reduced by a fixed amount such that the resultant pulses in the output of the reentry circuit occupy no greater amplitude range than the message pulses do at the output of the message steppers. The currents after reentry are amplified at 207 and sent into the output steppers which reform the impulses into better form for transmission. The pulses appearing at the output sides of these output steppers, as already noted, are of 14 milliseconds duration separated by 6-millisecond spaces, and the pulses vary in amplitude in fixed steps. The form of these pulses is indicated in FIG. 3, at *a*.

The timing of the steppers 200, 201 and the output steppers is controlled from a 50-cycle wave derived from the record 10. Two waves of a few hundreds of cycles frequency separated by 50 cycles frequency difference are selected by filter 250 and beat together in detector 251 to derive a 50-cycle wave which is selected by filter 252 and impressed on exciter circuit 206. The latter controls the cathode impulser 204 and grid impulser 205 to supply interrupted voltages to the plate and grid circuits of the stepper tubes to cause them to be exposed for firing, at certain times, in response to the input voltage waves and to terminate the pulse period by interrupting the plate current. The output steppers are similarly controlled from exciter 230, grid impulser 231 and cathode impulser 232. Since there is a time displacement between the exposure and restoring instants for the two tandem sets of steppers, a phase shifter 223 is used to permit of such displacement while still using the same 50-cycle timing wave.

In the Lundstrom-Schimpf disclosure the output pulses from the output steppers are applied directly to the frequency modulation oscillators 203. In accordance with the present invention, certain apparatus is inserted between these two points of the system to provide for eliminating the dip or space between pulses. This apparatus will now be described.

This apparatus is shown for convenience as contained within boundary lines or boxes 253, 254 and 255 for each channel, together with an exciter circuit **270** and pulsing supply circuit **280** common to all channels.

Before describing this apparatus in detail reference will first be made to FIG. 3. As stated, the output stepper output current is indicated at *a* as consisting of 14-millisecond pulses of varying height spaced apart 6 milliseconds. Since the spaces are to be eliminated, the pulses when reformed in accordance with this invention will be **20** milliseconds in length and will step directly from one height to the next as indicated at *c* (except for a slight rounding of corners due to reactances in the circuit). This is done by, in effect, exposing a condenser to the pulse throughout its middle portion, say for 10 milliseconds, and then cutting off the exposure for the next 10 milliseconds allowing the condenser to hold its charge for this second 10-millisecond period. The condenser is then exposed to the next pulse for 10 milliseconds, and so on. These exposure and cut-off times are indicated by the positive halves of the wave shown at *b*. It is seen that the condenser storage bridges over the 6-millisecond spaces between the *a* pulses. The voltage appearing across the condenser is the desired stepped, uninterrupted wave and this is indicated at *c*.

Reverting to FIG. 2, the condenser in question is condenser **260** in box **253** and it is exposed to the voltage existing across resistor **218** in the output side of the output stepper whenever the pairs of diodes **262** are thrown to low impedance condition by voltage applied to them from transformer **263**. At all other times they have high impedance. The voltage applied to the diodes is of square wave form, shown at *b* in FIG. 3, and is derived via apparatus in box **254** from pulsing circuit **280** over lead **284**, as will be more fully described. As shown by comparison of curves *a* and *b* the diodes become conducting just after the grid exposure pulse on the output steppers has established a new signal value. 10 milliseconds later they become non-conducting due to the reversal of the square wave voltage, and remain so until the next cathode impulser and grid impulser pulses have occurred and a new signal value has been established. During the non-conducting interval the condenser holds its charge unchanged, and at the beginning of the next conducting interval it quickly assumes a new voltage corresponding to the new signal value.

The circuit shown in box **254** is for the purpose of permitting the same +150-volt pulsing supply **280** to serve a plurality such as eleven of such circuits in parallel, and deliver a satisfactory square wave shape to each. To obtain isolation of the eleven circuits, it is necessary to feed the pulsed wave to them through transformers (**263**). The pulsing regulated power supply **280** (to be described presently) has a very low impedance during the conducting interval and a high impedance during the cut-off interval, which, when operating into a reactive load, such as transformer **263** and condenser **269**, would distort the wave shape. Therefore, the controlled plate resistance of the tube **265** is used to provide a relative low impedance during this cut-off interval without requiring that this resistance remain across the pulsing supply during the conducting interval. This is accomplished by using another winding **268** on the transformer **263** which drives the grid of the tube **265** negative when the pulsing supply is conducting and positive when the supply is cut off. Since, however, there is a small delay between the time the pulsing supply becomes conducting and the time the tube cuts off, it is necessary to include a small delay in the tube plate circuit to avoid momentarily overloading the pulsing supply. The inductance **266** is included for this purpose.

The resistance **267** is included as a means of balancing the direct current ampere turns in the secondary winding transformer at **263** without danger of saturation and wave lowing an equivalent and opposing current to flow in the primary winding. This permits the use of a small sized transformer at **263** without danger of saturation and wave

shape distortion. Resistances **269** limit the diode rectification currents.

In one case where the pulsing supply was interrupted at 50 cycles per second, the condenser **269′** and a value of 4 microfarads, resistor **267** was of the order of 60,000 ohms and the transformer **263** was of the small input type wound to have high impedance. These values are not to be taken as limiting but are given by way of example and can be varied widely to suit conditions.

The exciting circuit **270** comprises a pair of pentodes **271** and **272** supplied with plate and screen voltage from potentiometer resistance **88** connected across the filtered output of rectifier **87** fed from power source **63**. The wave received through phase shifter **223** (FIG. 1) is, as stated, a 50-cycle wave each half-cycle of which is, therefore, of 10-milliseconds duration. Tube **271** is conducting at all times except when cut off by tube **272**, which occurs every other half-cycle or every other 10 milliseconds period. The phase at which tube **272** starts to conduct is fixed with respect to the output stepper operate times by means of phase shifter **273** comprising series resistance and shunt capacity in proper proportion to give the desired relative timing. As the control grid of tube **272** is driven in the positive direction the tube begins to pass current which flows (negatively) from the plate through lead **274** and resistor **275** to the —400-volt point on resistor **88**, to the —500-volt point and to the cathode of tube **272**. This current flowing through resistor **275** cuts off tube **271**. At the end of a half-cycle (10 milliseconds) the wave reverses on the control grid of tube **272** reducing the current through the tube to zero and tube **271** becomes conducting, its space current flowing from the plate through lead **264** and through resistors **281** and **282** in series to ground **100** at one end of resistor **88** and to the cathode of tube **271** at —400 volts. This causes a highly negative voltage to be applied to lead **264** for 10-millisecond periods, this voltage being sufficient to swing the grid of tube **286** beyond cut-off and interrupt the current supplied to conductor **284** from rectifier **283**.

The pulsing circuit **280** comprises a power supply in the form of an alternating current source **63** and rectifier **283** followed by a filter **285** and regulating and switching tube **286**. Ordinarily the tube **286** is passing current to the terminal resistance **287** one terminal of which is connected to lead **284** and the other terminal of which is connected to ground. Tube **288** acts as a measuring device to detect small fluctuations in voltage in resistance **287** and control the impedance of regulating tube **286** in such direction and to such extent as to hold the terminal voltage across resistor **287** closely constant. Battery **289** is connected between the control grid of tube **288** and a tap point on resistor **287** of nominally the same (but opposite) voltage to ground as the voltage of the battery. The plate of tube **288** derives positive voltage from the positive terminal of rectifier **283** through series resistor **281**. When the terminal voltage across resistor **287** has normal value the tube **288** is placing such a bias on the grid of regulator tube **286** as to maintain the normal supply of current to resistor **287**, in the absence of a blocking from tube **271** voltage on lead **264**. Applications of negative voltage to lead **264** by tube **271** as described cause tube **286** to interrupt the current and deliver pulses to lead **284**. This pulsing circuit in and of itself forms no part of the present invention but is claimed in the application of another.

It will be noted that when diodes **262** are in their conducting condition, they afford a bilaterally conducting low impedance path between resistor **218** and condenser **260**. If the voltage existing across resistor **218** is higher than the terminal voltage across the condenser **260**, charging current flows into the condenser to raise its voltage to equal that across resistor **218**. If the condenser voltage exceeds the voltage across resistor **218**, some condenser discharge current flows back through the diodes (and is dissipated in the circuit resistances) to equalize the voltage across the condenser to that across resistor 218. The resistance 261 is inserted to give the condenser circuit a time constant of about 1 millisecond since this is found to improve transmission through fading conditions where radio transmission is used.

The voltage across condenser 260 is applied to the grid of a direct current amplifier 290 the plate circuit of which includes the modulating inductance 222 of the frequency modulated oscillator 203 of the type disclosed more fully in the Lundstrom-Schimpf application. The use of this amplifier insures that the load impedance connected across condenser 260 is so high as not to discharge the condenser but to allow it to maintain its charge during the 10-millisecond storage period. This amplifier 290 has large stabilizing resistances including 291 and the other resistances shown between the cathode and ground. The load circuit through winding 222 is connected across resistance 291 and battery 292. The proportioning of the elements is such that the current in the winding 222 varies between zero and some negative quantity corresponding to the limits of the current variations in resistor 218.

Instead of using different normal frequencies in the frequency modulated oscillators 203 in the different channels, all oscillators use the same normal frequency and the frequency modulated output bands are sent into amplitude modulators 284 which step the channel band frequencies to successively higher levels to space them properly in the frequency spectrum for suitable transmission. For this purpose a source of base frequency waves 300 of highly constant frequency and a harmonic generator 301 are used to supply channel shifting frequencies to the various shifting modulators 294 through selecting filters 302. This use of the same frequency for all of the frequency modulated oscillators together with the channel shifting modulators forms no part of the present invention.

The filters 153 select one side-band of the modulated output waves from modulators 294 for transmission over the line or channel 154 which may be the actual transmission path to the distant receiver station or may lead to a radio transmitter or other type of transmission channel.

The receiving terminal is not illustrated since it may be the same as that disclosed in the Lundstrom-Schimpf application. There may be need of a different proportioning of certain of the low-pass filters or different adjustments but the circuit arrangement can be the same.

What is claimed is:

1. In a privacy communication system in which coded message waves are in the form of impulses of differing amplitude with equal spaces between them, means for transforming such waves into an uninterrupted output voltage wave of stepped amplitude comprising means to sample the coded message waves at equal intervals at their peak amplitudes, means to place a charge on a condenser that is proportional to the coded message waves at the instants of sampling, and means for continuously taking off as output the voltage existing across said condenser.

2. In a transmission system comprising parallel channels carrying varying amplitude currents, means in each channel to convert said currents to uninterrupted stepped currents comprising in each channel a condenser and a valve circuit for operatively connecting said condenser across the channel at periodic intervals to be charged

under control of said first-mentioned currents, a common timing circuit for the valve circuits of all of said channels, for supplying a timing voltage for timing said intervals and means in each channel for preventing distortion of the timing voltage by interaction from the other channels.

3. In a transmission system including a plurality of channels each carrying impulses of varying strength separated by spaces of no current, a circuit for converting the impulses in each channel to continuous current comprising in each channel a bilaterally conducting variable resistance device connected in series in the channel followed by a condenser shunted across the channel, and means common to said channels for making the resistance of each of said devices low during the existence of said pulses to permit a proportionate voltage to be developed across the respective condenser and for making the resistance of each of said devices high during the existence of said spaces to retain the charges on said condensers.

4. In a transmission system including a plurality of channels each carrying impulses of varying strength separated by spaces of no current, a circuit for converting the impulses in each channel to continuous current comprising in each channel a voltage responsive variable resistance device in series relation in the channel followed by a capacity connected across the channel and a common control circuit for changing the resistance of said devices simultaneously between a substantially non-conducting value and a negligibly low value, means to supply voltage pulses over said common circuit to all of said devices to change their resistance comprising a two-winding transformer per channel, connected between said common circuit and an individual device, for conductively isolating said devices from said common circuit, and means to control the shaping of the voltage pulses transmitted through said transformers comprising a space discharge device having its space path connected across said common circuit and means to control its impedance in accordance with a voltage developed in a winding of said transformers.

5. In a privacy system including a signal analyzer circuit comprising a plurality of channels each including a secret key combining circuit followed by an output stepper for delivering output pulses of varying strength with intervening spaces, a circuit for changing the output current to continuous current of stepped wave form comprising a device capable of varying its resistance from practically infinite to practically zero value in response to applied voltages, connected in series relation in each channel followed by a condenser connected across said channel, an outgoing circuit connected across said condenser, and means to control said devices comprising a common source of pulsing voltage supply, transformers individual to said channels and coupling said common source to said devices to transmit control pulses to the latter, a pulse-shaping circuit for each transformer comprising a space discharge tube having its space path connected across said common supply source and means to vary its impedance in accordance with secondary voltage variations on the corresponding transformer.

No references cited.

ROBERT H. ROSE, *Primary Examiner.*