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ALTERNATING CURRENT SIGNALING SYSTEM

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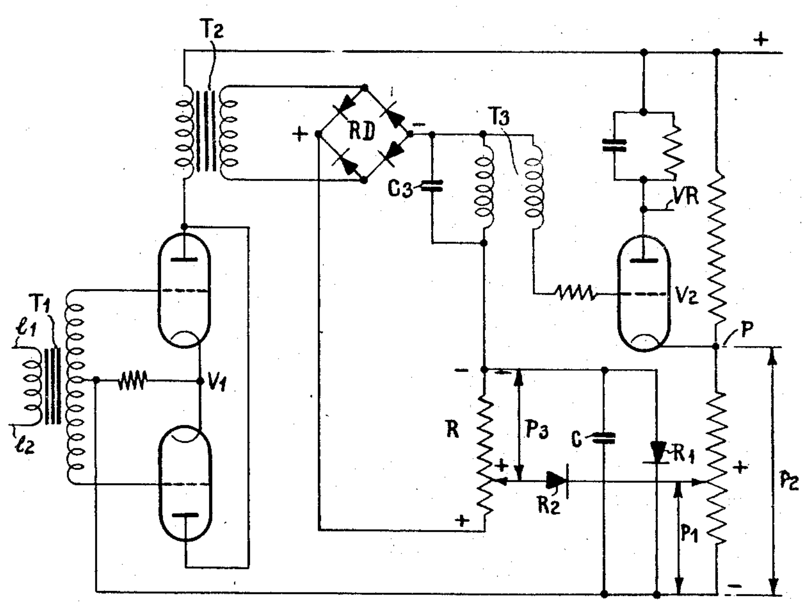

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ALTERNATING CURRENT SIGNALING SYSTEM

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The present invention concerns improvements in or relating to alternating current signaling systems and more particularly to the reception of alternating current signals in the form of pulses, whether of cyclic or non-cyclic character, and has for its object the translation of such signals into equivalent direct current pulses with the minimum of distortion.

Such signaling systems are used where the transmission of direct current pulses is either impossible or only possible with serious transmission distortion.

According to the invention a frequency multiplying arrangement is provided for the purpose of increasing the frequency of the incoming signals, and thereby reducing the time of response of the tuned receiver.

According to a further feature of the invention, use is also made of the frequency multiplier for reducing the time of release, and thereby reducing distortion in the operation of the receiver.

The invention will be described with specific refererence to one such system, namely, the transmission of signaling and dialing impulses over telephone lines. As is well known, it is common to transmit such impulses over a trunk line from one exchange to another to control automatic switching apparatus in the distant exchange to set up desired connections. They are employed also for various signaling and supervisory purposes. The choice of the frequencies used for these impulses in a telephone system is restricted to a band extending from some 500 cycles to 1000 cycles, partly on account of the use by other services of the ranges outside this band, and partly because the transmission characteristics of such lines are most favourable within this band. For example, frequencies of 600 or 750 cycles are commonly used for these purposes, the latter being considered more favourable for dialing.

Such frequencies are not, however, eminently satisfactory for dialing, since, in the case of 750 cycles, one cycle represents 1.33 milliseconds, the effective loss of which, in reception and translation, would mean a loss of 1.33% with the common dialing speed of 10 impulses per second. Moreover, such receivers have in general to be tuned to respond to such frequencies and a permissible tolerance on the effective frequency has to be allowed of some +25 cycles; furthermore, such receivers must incorporate means for rendering them commercially immune from operation by speech. The tuning of these receivers is generally effected at the line signal frequency, with the result that the incremental and decremental periods on the resonant circuits extend over a considerable portion of the pulse time, and can give rise to further distortion.

It can be shown, that if distortionless reproduction is required from such an alternating voltage envelope whose incremental and decremental periods are of the same nature but of inverse characteristics, the ensuing apparatus must effectively operate and release at points on these periods where the voltage has reached a value equal to one half the maximum. As the inception of the incremental period corresponds to the beginning of the applied pulse of the signaling current, then the transmission time due to the resonant circuit is the time required for the incremental period (or decremental period) to attain half its maximum value. Furthermore, it can be shown that for a resonant circuit of given magnification factor, and a given ratio between the desired operational bandwidth and the frequency, this transmission time is inversely proportional to the resonant frequency. By magnification factor is meant the fraction

$$\frac{wL}{r}$$

where $w=2\pi$ frequency, L the inductance in henries and r the effective series resistance when tuned with a capacity of C farads; this fraction being generally referred to as Q.

It will be seen therefore, that if the effective response of the ensuing apparatus is adjusted for distortionless reproduction at the resonant frequency in the above manner, by means such as a direct current bias of half the maximum peak response at the resonant frequency, then as the input frequency is altered from resonance the reproduction will be maintained until the response of the resonant circuit has fallen by one half. Over this range of frequencies however, the reproduction will be progressively distorted by an amount depending to a large extent on the initial transmission time. Hence, if the response frequency of the resonant circuit can be increased, the distortion with frequency variations within the desired bandwith can be progressively reduced.

It will be appreciated that the line frequency may be multiplied at the input of the receiver by any well-known system such as a frequency doubler or tripler, used singly or in series with or without thermionic valve amplifiers, until a frequency is attained where the transmission time and the associated distortion are conveniently small. A resonant circuit, whose Q is such that the desired fractional bandwith reproduction is attained when its response has fallen to one half, is tuned to this frequency and responds thereto. A direct current bias, about one-half the peak resonant frequency response of the resonant circuit, derived from the line frequency and therefore of value proportional to the line level and the resonant circuit response, is applied in series with the resonant circuit voltage to the ensuing apparatus of any well-known type which effectively operates and releases at the same voltage, due allowance having been made for the operating level of such apparatus.

In this manner, multiplying the input signaling frequency also multiplies the bandwidth by the same amount, so that the postulated constancy of the ratio between the bandwidth and frequency is maintained. Likewise, variations in input level, above the initial response required on the resonant circuit to produce distortionless reproduction, are automatically compensated for by the adjusted ratio of resonant circuit voltage to direct current bias.

Taking the specific case of a line current of 750 cycles per second, this applied by a suitable transformer to the first frequency multiplying stage. This may consist of a frequency doubler, such as the well-known full wave rectifier using copper oxide elements or a push-pull valve rectifier stage whose anodes are strapped together, or a frequency tripler, such as an inductance with an easily saturatable magnetic core. The output at twice or three times the input frequency is utilised by a resonant circuit at this frequency to feed another frequency doubler or tripler stage, or to operate the ensuing apparatus. It may be arranged to tune each multiplying stage in order to reduce the input frequency component to the negligible quantities. In this manner the input of 750 cycles can be successively converted to 1500, 3000, 6000 cycles, etc.

The direct current component is preferably derived from a point in the frequency multiplying stages where a reasonably uniform frequency response is obtainable. This may readily be effected in the case of a rectifier frequency doubler, by making use of the direct current component on a series resistance. This component is in the form of full wave rectified pulses and must be smoothed before being applied for the purpose of biasing.

It will be realised from the above, that the direct current bias must be present to its full extent at or before the transmission time of the resonant circuit and must remain until this time has elapsed at the cessation of the input signal pulse. As the bias is generated by the signal pulse it must have a small charging time constant and a longer decay time constant. In addition, the effective bias applied to the ensuing apparatus must be less than that generated by an amount equal to the minimum operating level of the ensuing apparatus, as otherwise the postulated operation at the half maximum amplitude of the resonant circuit will not be maintained at all input levels. In order to achieve both of these characteristics the generated bias (at half maximum resonant circuit amplitude) is fed through a rectifier in the forward direction and via an opposing bias equal to the minimum operating level of the ensuing apparatus to a condenser across whose terminal is connected a further rectifier in the reverse direction. Thus the generated bias will not be effective until it exceeds the opposing bias, whilst the latter is prevented from appearing on the condenser when no signal is applied to the receiver, by the combined action of the two rectifiers; likewise when the generated bias exceeds the opposing bias it will charge the condenser rapidly, and the latter will discharge slowly through the back resistances of the rectifiers when the signal ceases, providing an effective smoothing action in addition.

The drawing illustrates by way of example a specific embodiment by which the foregoing result may be achieved when the input signaling frequency is of the order of 500 to 1000 cycles such as is used for telephone systems.

In the drawing the signaling currents are received over the conductors l1 and l2. These may be connected to a telephone line over which is fed the signaling current only or over which speech frequency may also be fed. T1, T2 and T3 represent transformers appropriately designed for the relative signal frequencies. T3 is tuned by the condenser C3 to the multiplied signal frequency. V1 represents a frequency doubling arrangement employing a pair of valves. RD represents a second frequency doubling arrangement employing metal rectifiers. R represents a resistance in the output circuit of the frequency doubler RD. R1 and R2 represent rectifiers for controling the potential across the condenser C and bias for the valve V2. P represents a potentiometer and VR represents the connection to whatever responding device or circuit it is desired to control over the plate of valve V2. This device or circuit forms no part of the present invention, and may be any suitable valve relay arrangement adapted to be operated by the impulses received over the conductors l1 and l2.

The operation is as follows:

The frequency of all currents received over lines l1 and l2 is doubled by the valve doubler V1 so that a signaling frequency of say 750 cycles becomes 1500 cycles. These currents are again doubled in frequency by the metal rectifier doubler RD thus bringing a line signaling frequency at, say 750 cycles, up to 3000 cycles, the latter frequency then being used to energise the resonant circuit T3C3. The metal rectifier doubler RD also creates a potential across the resistance R which serves to provide a negative D. C. bias in opposition to the effect on the grid of the valve V2 of the positive half-cycles of the alternating voltage on T3C3.

The tapped portion of the D. C. voltage on R is adjusted to be equal to one half the maximum resonant circuit amplitude in order to satisfy the before-mentioned relationship for distortionless reproduction, but as also mentioned before must not appear on the grid of V2 until it exceeds the operating level of valve V2, in order that thereafter operation and release of valve V2 may continue to take place at the half peak resonant response of a resonant circuit T3C3. In addition this D. C. bias voltage must appear on the grid of valve V2 at or before the attainment of the half peak resonant response to an input signal and be maintained until at least this time has elapsed after the cessation of the input signal pulse. This time interval has been previously referred to as the transmission time of the circuit.

The application and control of the required signal bias voltage on resistance R to the grid of valve V2 in the manner described above can be achieved by the arrangement of rectifiers R1, R2 and condenser C about to be described.

Referring to the figure it will be seen that the static bias on valve V2 with respect to the negative busbar, is *p2* (from the potentiometer P). This bias is such as normally to prevent operation of valve V2 (and consequently of the subsequent valve/relay circuit), and exceeds the bias at which valve V2 would normally just operate by any amount *p1*. Consequently *p1* can be termed the operating level of valve V2. The required portion of the signal bias voltage on resistance R is denoted by *p3* and tends rapidly to charge condenser C via the forward direction of R2 so that a negative signal bias appears on the grid of valve V2. In so doing the signal bias must first overcome the opposing bias voltage at *p1* and if the latter is made equal to the operating level of V2, the desired condition for maintenance of action at the half peak resonant response of resonant circuit T3C3 is attained. Furthermore at the cessation of the input signal pulse the net signal bias on condenser C will tend to remain at substantially the same value owing to the high discharge path resistance presented by the back resistance of rectifier R2. The second requirement of rapid application and slow removal of the net signal bias voltage to the grid of valve V2 is therefore met.

In practice it is desirable to place a second rectifier R1 across condenser C, in the manner shown. The back resistance of the rectifier R2 will not in general (if of the copper oxide type) be comparable with the insulation resistance of condenser C and therefore in the non-signal condition the potentiometer bias *p1* will appear as a positive grid bias on condenser C, thus diminishing the postulated static bias on valve V2. By connecting rectifier R1 in the manner shown no such positive grid bias can appear on condenser C and little effect is produced on the negative signal bias desired on condenser C. In this manner the rectifier R1 effectively shunts condenser C to any voltage other than the desired net signal bias which can be built up rapidly through R2 but will decay slowly via the back resistances of rectifiers R1 and R2. Moreover, it should be noted that this controlling circuit also provides adequate smoothing of the full-wave rectifier potential on resistance R, as applied to the grid of valve V2.

It will be seen that as each multiplying stage is made most responsive to the multiplied frequency, then the receiver will only effectively respond to the given line signaling frequency. In addition, since the bias is generated from the line frequency, or its equivalent, then the system described automatically becomes commercially immune from operation by speech, on the well-known principle that the latter contains only a small percentage of the signaling frequency, and a large percentage of other frequencies. Thus all speech frequencies will produce a biasing effect which will substantially overcome the response of the ultimate resonant circuit to the smaller percentage of signaling frequency in speech.

In applying the system described, it is found that each frequency multiplying stage introduces some considerable loss of energy as between the input and the multiplied frequencies. This results effectively in a loss of voltage, which may be overcome by the employment of a transformer or auto-transformer winding on the resonant circuit or circuits, to overcome this with any desired degree, depending upon the primary and secondary load impedances.

Since the effect of the system described is to tend to give an operating alternating current envelope closely approximating to the input frequency pulse envelope, by making the transmission time small, then it is apparent that high speed repetition and short break periods can be utilised. The system is therefore found capable of providing dialling impulses with little distortion.

The system described is not limited to the use of one signaling frequency but can be used with a plurality of frequencies provided each frequency is treated in the manner described. Similarly, the system described is applicable to other forms of signaling using alternating currents such as single or multi-channel voice frequency telegraphs with corresponding improvements in the response of the receiver.

I claim:

1. In a grid control arrangement for a thermionic valve, a signal receiving circuit connected to said grid, a resistor in said circuit, a source of biasing potential having one side connected to the cathode of said valve, a bridge across said source comprising, in series, a unidirectional conductive device, said resistor and a second unidirectional conductive device, the first of said devices being connected in said bridge in a conductive direction with respect to said source and the second of said devices being connected in said bridge in a non-conductive direction with respect to said source, and a condenser bridging said first device and charged only when the voltage across said resistor due to a signal received over said receiving circuit exceeds the voltage of said source.

2. In a grid control arrangement for a thermionic valve, a circuit over which signals having an alternating current component are received including, in series, a resistor and the primary winding of a transformer, a biasing circuit connected to the grid of said valve including, in series, a first source of biasing potential, a second source of biasing potential and a secondary winding of said transformer, means for connecting said resistor in shunt with one of said sources, said means including a unidirectional current carrying device poled to prevent current from said one source from traversing said resistor.

3. In a grid control arrangement for a thermionic valve, a source of fixed direct current potential, means connecting said source to the grid of said valve to bias said grid negatively, a resistor, means connecting said resistor in shunt to said source, said last means including a unidirectional current carrying device poled to prevent current from said source from traversing said resistor, a circuit over which signals having an alternating current component are received, and means for causing said signals to traverse said resistor to produce therein a varying potential, said varying potential effective to vary the bias placed upon said grid by said source.

4. In a grid control arrangement for a thermionic valve, a source of constant direct current potential, a source of intermittent undulating direct current potential, a condenser, means permanently connecting said condenser and said two sources in a series circuit, said sources being poled in apposition to one another in said circuit, means always effective to prevent said first source from charging said condenser, said second source effective to charge said condenser over said

series circuit only when said undulating potential exceeds said constant potential in value, and means connecting said condenser to the grid of said valve to vary the bias on said grid in accordance with variations in the charge upon said condenser.

5. In a grid control arrangement for a thermionic valve, a source of constant direct current potential, a source of intermittent undulating direct current potential, a condenser, means permanently connecting said condenser and said two sources in a series circuit, said sources being poled in opposition to one another in said circuit, one of said sources effective, whenever its potential is equal to or greater than the potential of the other of said sources, to prevent said other source from charging said condenser, said other source effective, whenever its potential is greater than the potential of said one source, to charge said condenser variably over said circuit in accordance with the amount by which the potential of said other source exceeds that of said one source, means always effective to prevent said one source from charging said condenser, and means connecting said condenser to the grid of said valve to vary the bias on said grid in accordance with variations in the charge upon said condenser.

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