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WAVE TRANSMISSION AND SHAPING

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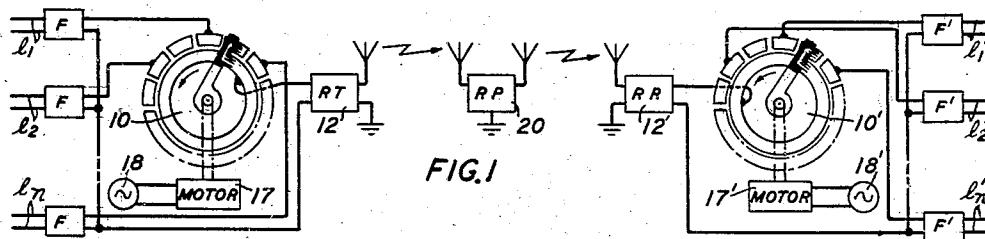


FIG. 1

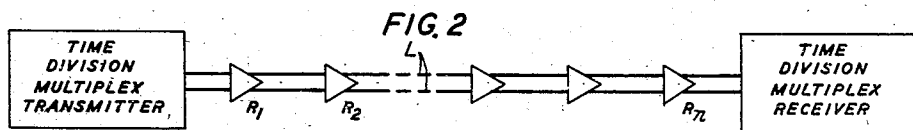


FIG. 2

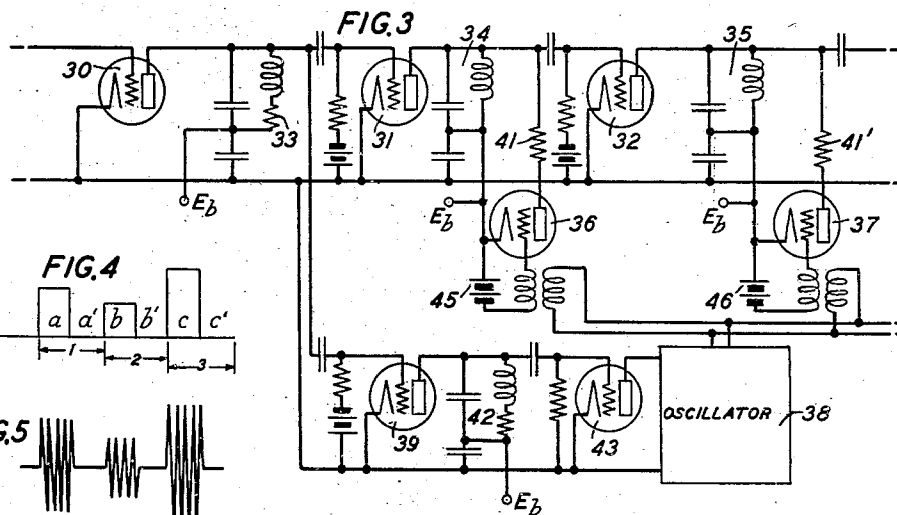


FIG. 3

FIG. 4

FIG. 5

FIG. 6

FIG. 7

FIG. 8

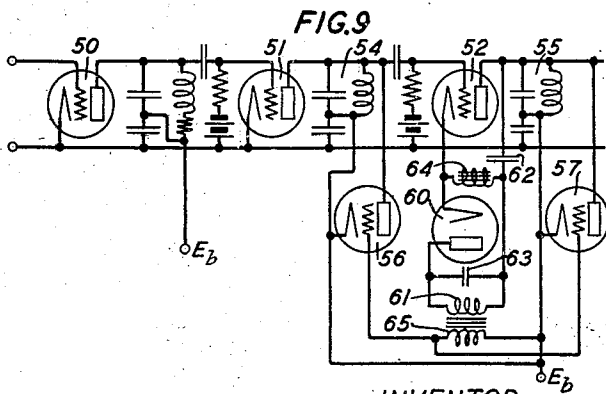


FIG. 9

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WAVE TRANSMISSION AND SHAPING

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The present invention relates to the transmission or reception of high frequency electrical waves and more particularly to signal wave shaping. In one broad aspect the invention relates to selective damping or curbing. In a related aspect the invention relates to suppression of the trailing portions of signal wave impulses in circuits having highly reactive impedance.

The invention has particular application to time-division multiplex transmission and will be illustrated in connection with such a system. In time-division multiplex the different signal input circuits are in effect connected to the line or other transmitting medium one at a time in rapid succession such that fragmentary portions of the different signals are sent over the system in rotation. If the system in its entirety possessed only resistive impedance (so that there were nothing to limit the frequency band transmitted) the different signal fragments would theoretically retain their original shape and there would be no overlapping of the successive fragments. According to the viewpoint of the Fourier analysis, an infinite band of frequencies would be transmitted for each signal fragment and the wave components representing this infinite band would cancel out at all times except within the interval devoted to the particular signal fragment, and within that interval they would add up vectorially to produce the exact shape of the pulse. Any attempt to restrict the transmitted band to less than infinite width would result in distorting the signal impulse. A filter or resonant circuit or long transmission line having a considerable reactive component of impedance, for example, would distort the impulse and cause overlapping of successive impulses and result in cross-talk.

Since pure resistance systems are never realized in practice, but selective circuits are a practical necessity particularly in high frequency modulated wave transmission practice, the problem of overlapping impulses caused by the trailing portion of the impulse wave becomes of basic importance in time-division multiplex systems.

The general object of the invention is to provide variable damping of a circuit or system with time in such a manner as to correct for distortion.

In the specific form of the invention to be illustrated and described herein a vacuum tube has its plate impedance connected across a resonant circuit (or other circuit to be damped) and this plate impedance is kept high during the times when the desired portion of a wave is

passing but is made low during the time when undesired wave energy would otherwise persist in the circuit. The plate impedance of such tube is controlled by its grid and the control may be derived from the signal wave impulses or separately exercised.

The nature of the invention and its various objects and features will be more fully understood from the following detailed description of the particular systems chosen for illustration.

Fig. 1 is a diagrammatic sketch of a radio system to which the invention is applicable;

Fig. 2 is a similar sketch of a transmission line to which the invention is applicable;

Figs. 3 and 9 are schematic circuit diagrams of forms which the invention may take and which may be incorporated into the systems of Figs. 1 and 2 in a manner to be described; and

Figs. 4 to 8 show wave diagrams to be used in the further description of the invention.

In Fig. 1, incoming lines l_1, l_2, l_n at the left or transmitting station lead up to the rotary distributor 10 and each has one side connected to a respective distributor segment, the other side of each line being connected to one input terminal of radio transmitter 12. The rotating arm of the distributor 10 is connected to the other input terminal of transmitter 12.

The lines l_1, l_2 , etc., may be telephone, telegraph or other signaling lines. Each line has a filter F connected in it to limit the frequency band to the appropriate range for the type of signal being transmitted, which in the case of speech might extend from 200 to 3000 cycles by way of example.

An entirely analogous arrangement is employed at the right-hand or receiving terminal where in this case the lines l'_1, l'_2, l'_n are receiving lines associated by way of rotary distributor 10' with radio receiver 12'.

One intermediate radio repeater 20, typical of a succession of spaced repeaters intermediate between the terminal stations, is shown for receiving radio waves from 12, reamplifying them and sending them out, usually on a different wave-length, for reception at 12'.

The arms of distributors 10, 10' are operated by motors 17, 17' driven from oscillators 18, 18' or other sources in any known manner to rotate in close synchronism and phase with each other and with a frequency of rotation at least twice as high as the highest frequency passed by the filters F, F' , that is, at least twice as high as the highest utilized signal frequency. Fragments of signals on lines l_1, l_2, l_n are thus sent into radio

transmitter 12 in rapid succession and eventually the same fragments are recovered at terminal 12' and distributed to the corresponding receiving lines so that in each receiving line the fragments piece together to re-form the signal intended for that line.

Radio transmitter 12 may be assumed to incorporate the necessary apparatus for producing and sending out the signal-modulated radio waves, such as oscillation generating, modulating and amplifying devices of known type, together with frequency selective circuits to be referred to further on. Radio receiver 12' may be assumed to incorporate the usual types of frequency selecting circuits, amplifying and demodulating devices. The intermediate repeater or repeaters incorporate elements of a receiver and a transmitter together with selective circuits for selectively receiving the waves, amplifying them and retransmitting them with shifted frequency.

The manner in which the invention is to be practiced in connection with a radio system such as that just described will be given in detail presently. It will be understood that the description of the radio system has been given in quite general terms because the invention is of broad application and, therefore, not dependent upon any particular type of system or the use of specific types of devices.

Fig. 2 will now be described briefly as another general type of transmission system with which the invention may be practiced. This differs from the Fig. 1 system mainly in type of transmission medium used, the medium being line L, such as an open-wire line, a coaxial conductor line or a pair in a lead sheathed cable. The terminal stations may be the same as in Fig. 1, the line conductors of line L replacing the antennae and ground conductors of Fig. 1.

It will be noted that the distributors 10, 10' have active segments alternating with idle or blank segments, the latter being unconnected to any of the lines so that there are time intervals elapsing between the times in which connections are being made with the successive signal lines. This is illustrated in Fig. 4. The time interval t is allotted to line l_1 (time extending to the right in this figure) but this interval t is divided into parts a and a' . The rotating arm is in contact with the line l_1 active segment during a , resulting in an impulse during time a , and is passing over the next successive idle segment during a' . Similarly for lines l_2 , etc., impulses b and c are indicated as being transmitted followed by spaces b' and c' . In the figure the active and idle periods are indicated as equal, which is preferable, although the invention is in no wise limited to the use of any particular arbitrary ratio.

The Figs. 4 to 8 are placed in vertical alignment so that time periods corresponding to the active or impulse producing periods (a , b , c) and the spacing intervals (a' , b' , c') may be readily identified in the different figures. Fig. 5 shows the result of modulating the radio frequency wave by the impulses of Fig. 4, assuming highly resistive impedance circuits are used in the process. Fig. 6 illustrates the trailing out effect produced in such waves by transmitting them through circuits of highly reactive impedance such as filters or ordinary tuned circuits. It is seen that the a impulse wave may trail out not only throughout the a' interval but over into the b period or further. It is this trailing wave

which produces cross-talk, the magnitude of which is indicated in Fig. 6 for the a to b channels by the relative amplitude of the trailing portion of the a wave occurring in the b impulse period. This process can be pictured as taking place at every point in the system where filters, tuned circuits or other reactive impedance elements are used. Actually cross-talk will occur in some degree between every channel and every other channel in a system other than the ideal system in which an infinitely wide band of frequencies is used and all impedances are purely resistive.

The invention provides a novel means and method of reducing cross-talk in a system in which highly reactive impedances are used, by automatically damping the trailing portions of the waves while allowing the useful portions to pass through the system.

One manner of accomplishing this will now be described in connection with Fig. 3. This figure represents a tuned amplifier of special construction according to the invention and is to be considered as incorporated into the systems of Figs. 1 and 2 at every point where tuned circuits are used. For example, in Fig. 1, the transmitter 12 includes a circuit or circuits tuned to the radio wave being transmitted; likewise the repeaters 20 each contain a plurality of tuned circuits and so may the receiver 12'. The same is true of the terminals and repeaters of Fig. 2.

Fig. 3 is shown as having an initial untuned stage 30 followed by two tuned stages 31, 32, the number not being significant. The interstage plate impedance for the plate of stage 30 has suitable damping resistance 33 to prevent this impedance from having a resonant characteristic such as might produce undesirable trailing of the waves. A tuned interstage circuit 34 and a similar tuned interstage 35 are tuned to the radio or carrier wave channel. Tuned circuit 34 is shunted by the plate impedance of tube 36, and tuned circuit 35 is shunted by the plate impedance of tube 37. Tubes 36 and 37 are arranged to have their plate impedances varied to vary the damping of tuned circuits 34 and 35. For this purpose oscillator circuit 38 is provided. It is tuned to the switching or commutating frequency of the rotary distributors and may have its frequency controlled by any suitable means to maintain its frequency in close synchronism and phase therewith. At the transmitting and receiving stations oscillator 38 may be the oscillator 18 or 18' which rotates the channel switching distributor or an oscillator which governs the frequency of the distributor. At repeater points it would be a separate oscillator. In the circuit of Fig. 3 an amplifier tube 39 has its input connected across the output of stage 30. Its circuit is less broadly tuned than that of amplifier 30 for it is not necessary to prevent overlapping of the channel signals in order to derive the channel frequency ripple. The circuit 42 may therefore be more sharply tuned than is necessary for separation of channel signals. Tube 43 is a detector which secures the ripple frequency current and impresses it on the grid of the oscillator 38 holding the oscillator in step with the switching frequency at all times.

The wave produced by oscillator 38 is of the form shown in Fig. 7, a sine wave of rather large amplitude. This is impressed simultaneously on the grid circuits of shunt tubes 36 and 37.

The operation of the circuit of Fig. 3 is as follows: A periodic succession of wave trains, ideally like those of Fig. 5 but in practice more like those of Fig. 8, is impressed on the input stage 30 and is amplified by stages 30, 31 and 32. The tuning in the circuit, at 34 and 35, and other reactive effects tend to cause the wave to trail out into some such form as that in Fig. 6 as already explained. During the active or used periods *a*, *b*, *c*, etc., the wave from oscillator 38 is executing its negative swings (see Fig. 7) and is driving the grids of shunting tubes 36 and 37 negative. The grids of these tubes are normally suitably biased to a high-impedance condition, for example to near cut-off or beyond by batteries 45 and 46 so that these tubes are maintained in their non-transmitting, high or infinite impedance condition during the *a*, *b*, *c*, etc., periods. Consequently, the tuned circuits 34 and 35 are effectively unshunted. During the idle intervals *a'*, *b'*, *c'*, however, tubes 36 and 37 have their grids driven positive by oscillator 38 (of Fig. 7) and the plate impedances drop to a low value, effectively shunting the tuned circuits 34 and 35. This action effectively shunts off the trailing portions of the waves, giving a resulting wave shape similar to that of Fig. 8 with reduced cross-talk. Another way of viewing the action is to consider that the tendency of the circuits to produce the trailing wave effect in the idle periods is reduced by removing their reactive impedance effects and rendering their characteristics more nearly resistive. Resistances 41 and 41' may be used to supplement the plate resistances of tubes 36 and 37 if necessary.

Fig. 2 differs from Fig. 1 in that the medium of Fig. 1 (the ether) has no reactive component whereas a transmission line does have reactive characteristics that tend to prolong an impulse into a long trailing wave. This effect in the case of any uniform line is proportional to the length. By using sufficiently short repeater sections (i. e. a sufficient number of repeaters in any given case) this effect can be kept below a specified maximum on each section. By employing a periodically damped repeater, such as in Fig. 3, as described, the portion of trailing wave already existing in the idle intervals in the arrival wave as well as that which the tuned circuits of the repeater tend to produce can be removed as already described. In such case the tubes 36, 37 damp not only the tuned circuits 34, 35 but also the preceding line section that tends to continue discharging into the repeater. Where the line section between two repeaters is short, the trailing wave produced by it will not be sufficient to require wiping out of itself but it will be wiped out by tube 36 when this tube eliminates the trailing wave of circuit 34. Where the line between repeaters is long enough to produce trailing waves that in themselves will give rise to cross-talk, a damping tube may be suitably coupled across the line at a point ahead of stage 30 and its impedance controlled by oscillator 38 in the same manner as in the case of tubes 36 and 37. The type of coupling employed, whether direct or through a transformer, should be such as to allow the tube to offer a minimum shunting effect across the line for the signal proper while highly attenuating the trailing wave.

Fig. 9 shows an alternative type of self-damping repeater that may be used in the systems of Figs. 1 and 2 in the same way as the Fig. 3 type. In Fig. 9 the oscillator has been omitted and the

wave form of the signal impulses is relied on to control the damping.

The stages 50, 51 and 52 may be the same as stages 30, 31 and 32 of Fig. 3, and tuned circuits 54, 55 correspond to tuned circuits 34 and 35. The damping tubes are 56 and 57, having their plate impedances connected in shunt to tuned circuits 54, 55. A rectifier tube 60 is connected in series with inductive winding 61 and stopping condenser 62 across the plate-cathode terminals of stage 52 and by rectifying a part of the output current, produces impulses of the switching or commutating frequency in inductance 61. Condenser 63 is a radio frequency by-pass condenser and coil 64 is a direct current or low frequency choke coil. Coil 65 is inductively coupled to coil 61 and is connected in the grid circuits of tubes 56 and 57.

In operation, when the wave trains are impressed on the circuit there is a tendency due to the time constants for the wave to increase in amplitude, reach a maximum and decrease in some such manner as in Fig. 6. During the portion of growing amplitude rectifier 60 is passing a direct current pulse from the growing high frequency amplitude across circuit 55, which pulse induces an electromotive force in winding 65 of such direction as to send the potentials of the grids of tubes 56 and 57 negative, causing their plate impedances to be high. During the portion of the wave trains that have decreasing amplitude, the potential in winding 65 reverses, causing tubes 56 and 57 to offer low shunting impedance and attenuate the radio frequency trailing wave.

Figs. 3 and 9 illustrate two absorber tubes only, but for best results every tuned circuit or coupled circuit in a repeater, transmitter or receiver should have an absorber tube. Two methods of control have been illustrated by way of example, and it will be obvious that these may be modified variously to suit conditions.

The rotary distributors illustrated in Fig. 1 are of the mechanical type, for simplicity. In practice it may be preferable to use some non-mechanical type such as a cathode ray type or gas or vacuum tubes cyclically operating, or other suitable type. An example of the former is disclosed in P. Mertz application Serial No. 192,471, filed February 25, 1938, and an example of the latter is disclosed in U. S. Patent to Holden No. 2,099,065, issued November 16, 1937. In any case, synchronous operation may be obtained by suitable means known in the art and the same type of synchronizing means can be used at each station where tuned circuits occur to synchronously insert resistances during the inter-impulse spaces to dampen the circuits.

The input and output connections to the amplifier may be made in conventional fashion in most cases. The input circuit may be the source of low power time-division carrier signals at a transmitting station, or may be ordinary antenna and tuned circuits reasonably broadly tuned at repeater or receiver locations. The output circuit may work onto a line, onto an antenna or may work into a power stage similarly controlled to those indicated, or it may go to the detector. The signals emanating from an amplifier of this type will be as indicated in Fig. 8 and are not identical with the hypothetical ones of Figs. 4 and 5. These signals, however, will be proportional in amplitude to the original signals and will, therefore, carry the original information. In succeeding amplifier stages there should be

a slight time delay introduced as it is desirable to make as much use of the maximum energy of the wave form of incoming signals of the form in Fig. 8 as possible.

In an amplifier of this type the periodic introduction of resistance in the tuned circuits produces a type of broadening action. The broadening of the circuits, however, is not identical with that of circuits having fixed resistance. In this case the circuits will receive those frequencies for which they are tuned and have suitable constants. The introduction of the resistance to damp out the trailing wave produces in these circuits additional frequencies for which the circuit does not respond readily before the introduction of the resistance. The band of delivered frequencies is broader than the band of received frequencies.

Since the invention is regarded as of basic scope, it is not to be construed as limited in its broader aspects to the means chosen for illustrative embodiment herein, but its scope is indicated in the claims which follows.

What is claimed is:

1. In combination, means to impress on a circuit electrical impulses in periodically recurring time intervals with intervening spacing intervals, said circuit having reactance tending to prolong the impulses into the subsequent time intervals, a damping resistance the value of which can be varied between wide limits connected in shunt relation to said reactance, and means to suppress the prolonged parts of said impulses in said circuit comprising means operating to vary the value of said resistance between its limits in time-correspondence with said impulses to provide low shunting resistance across said reactance in said spacing intervals.

2. The combination according to claim 1 in which said means comprises a reactive impedance and rectifier for distinguishing the rising portions from the falling portions of the impulses, and means controlled by said rectifier in response to the falling portions of the impulses for varying said resistance to its low value.

3. The combination according to claim 1 in which said means comprises a generator of wave impulses of the periodicity of said electrical impulses, and means controlling the value of said resistance by the generated impulses.

4. In a wave repeater circuit, amplifier tubes and tuned circuits connected to said tubes for selective amplification of waves of particular frequency, and means operating in synchronism with a component frequency of the waves being amplified for periodically varying the damping of said tuned circuits.

5. In combination, a circuit having a highly reactive impedance, a space discharge device having its plate impedance shunted across said impedance, means transmitting waves through said circuit having an impulse frequency, said highly reactive impedance tending to distort the shape of the impulses and means to counteract such distorting action comprising means periodically reducing the plate impedance of said device to a low shunting value at the impulse frequency.

6. In a wave repeater for high frequency waves having a relatively low frequency component, a resonant circuit tuned to the high frequency of the wave being repeated, a space discharge tube having its space path shunted across said resonant circuit, and a control circuit operating at said relatively low frequency for varying the space impedance of said tube periodically at said low frequency to dampen the resonance of said circuit periodically at said relatively low frequency.

7. A repeater according to claim 6, in which said control circuit comprises a rectifying and filtering circuit for deriving a voltage of said low frequency from the low frequency component of said high frequency waves.

8. In combination, means generating electrical impulses with idle periods between successive impulses, a system for transmitting such impulses having a portion tending to trail out one impulse to overlap in time another impulse, and means for suppressing the trailing wave portions comprising means operating only in said idle periods for highly attenuating said trailing wave portions, said last means comprising a space discharge tube having its space path impedance shunted across the portion of the system tending to trail out said fragments, a grid for such tube, and means for driving the potential of said grid in the positive direction during each idle period.

9. A wave shaping circuit for a transmission circuit having highly reactive impedance comprising a space discharge device having its space path impedance bridged across said highly reactive impedance, a grid for controlling said space path impedance, and means to impress varying potentials on said grid such as to maintain its space path impedance a maximum during the building-up time of impulses traversing said transmission circuit and minimum in the dying-down time of said impulses.

10. In a signaling system for signals having a wave frequency and an envelope frequency, said system having a highly reactive impedance tending to cause trailing out of the waves, a space discharge tube for periodically damping said impedance to reduce such trailing out effects, said tube having its space discharge path connected across said impedance, and means for controlling the impedance of said tube at the envelope frequency.

11. In a system for transmitting waves in periodically spaced wave trains with nominally idle periods between wave trains, a circuit made selective to the wave frequency by use of suitable reactances, means to attenuate waves tending to persist in the system in the nominally idle periods comprising a variable resistance connected across said selective circuit, and means to control the value of said resistance at the wave train frequency to cause the resistance to damp the selective circuit during the nominally idle periods.

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