March 18, 1941. J. C. STEWART 2,235,339

TRANSMITTER

Filed May 24, 1937 2 Sheets-Sheet 1

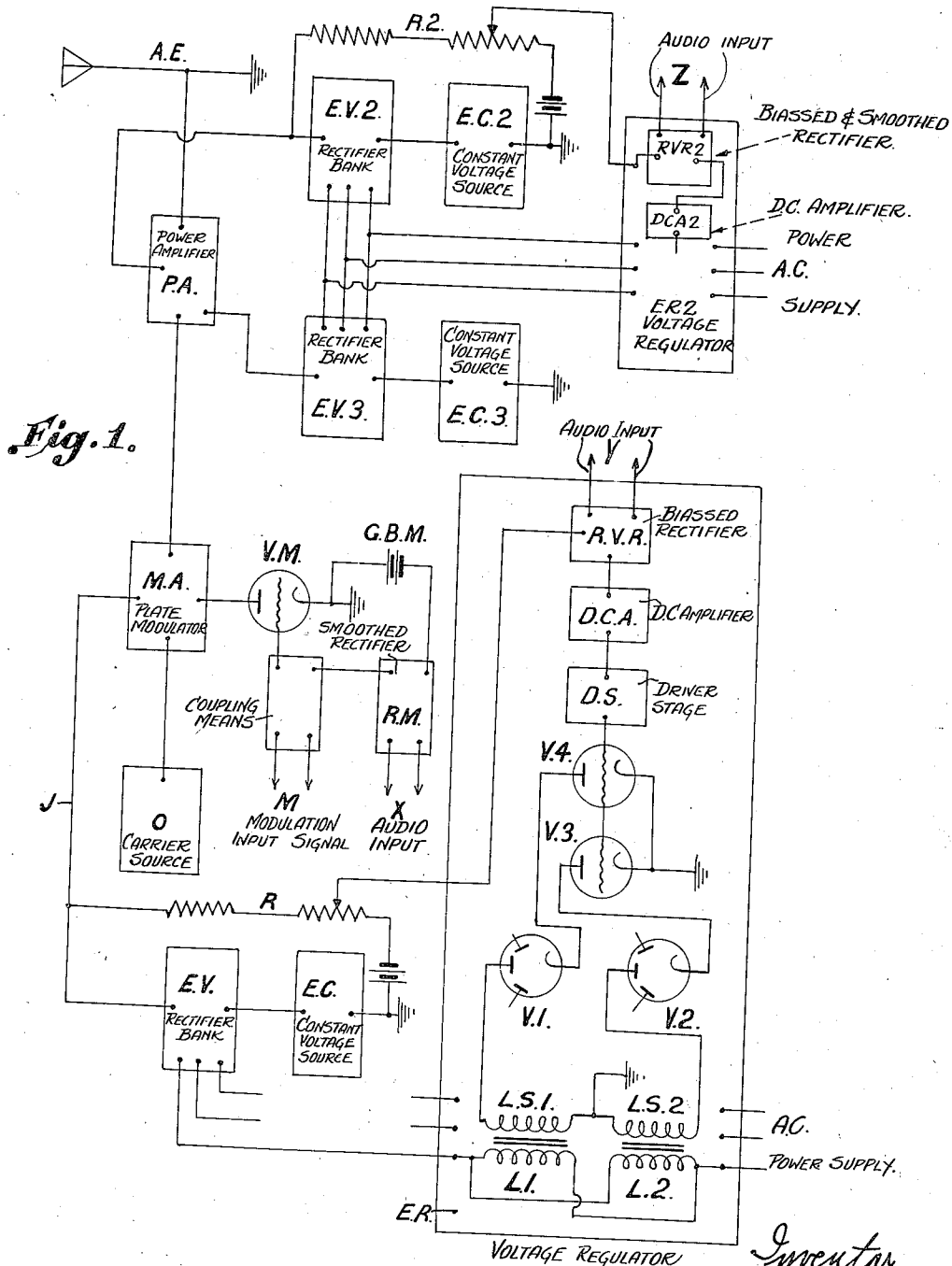


Fig. 1.

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Fig. 2.

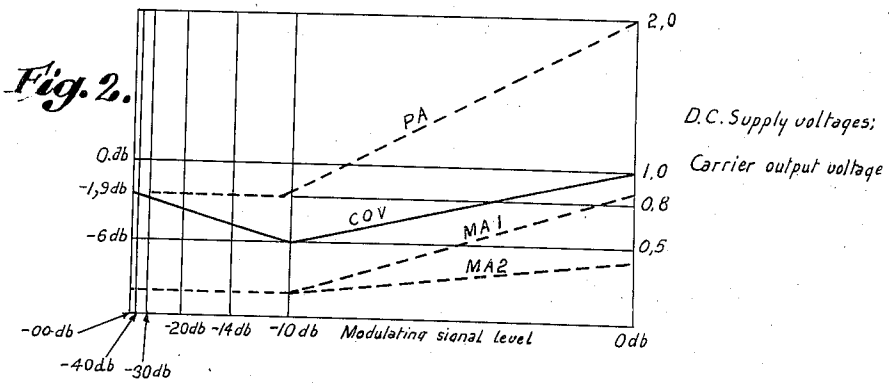


Fig. 3.

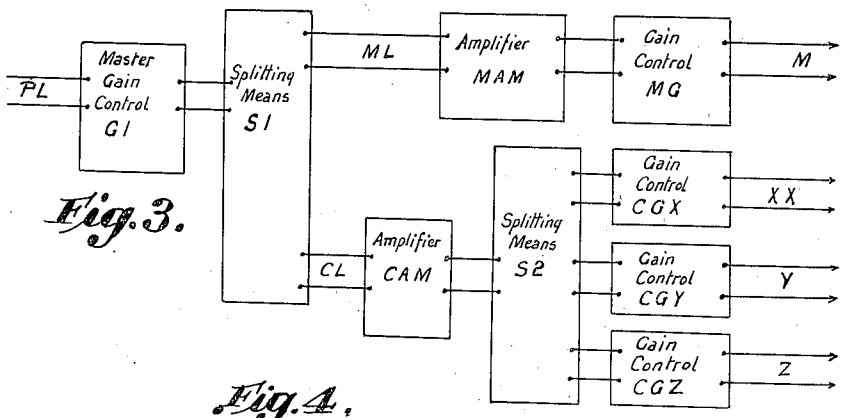


Fig. 4.

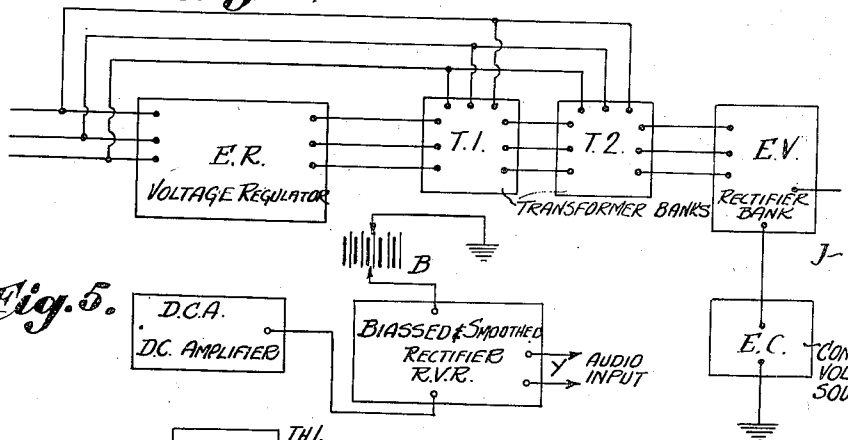
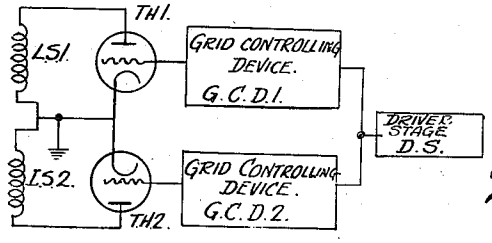


Fig. 5.

Fig. 6.



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UNITED STATES PATENT OFFICE

2,235,339

TRANSMITTER

James Charles Stewart, Mount Eden, near Auckland, New Zealand

Application May 24, 1937, Serial No. 144,526
In New Zealand June 6, 1936

5 Claims. (Cl. 250—17)

This invention relates to electric wave signalling systems such as amplitude modulated carrier wave transmitters, audio or programme frequency apparatus and the like.

The object of the invention is to provide electric wave signalling arrangements in which, compared to arrangements commonly used, a substantial saving of power is effected without affecting detrimentally the quality and other characteristics of the signals. A further object is to provide arrangements of this type in which apparatus of reduced rating compared to that usually employed may be used without reducing the effective range or utility of the system. A still further object of the invention is to provide apparatus whereby when no programme or signal is being handled, the supply voltages or any of them are other than the values necessary for full output (for example, in an audio amplifier, plate voltage and plate current are reduced) but whereby, when a programme or signal is being handled, the said supply voltages or any of them are varied, the amount of such variation being substantially in dependence upon the strength or voltage of the signals. Further objects and advantages of the invention will be disclosed in the appended description of its application.

In apparatus arranged in accordance with the invention the signal handling ability of any stage is varied substantially in dependence upon the voltage or strength of the signals. In the best forms, the signal handling ability increases from substantially zero to just sufficient extent to handle the signals momentarily present.

One particular example of apparatus arranged according to the invention is the amplitude modulated carrier wave transmitter in which the signal handling ability is varied by means of variations of anode, carrier and other voltages, and which is hereinafter described in detail. From this particular example the methods and principle of the invention can be understood; and so other embodiments of the invention not given will readily be apparent.

In the substantial absence of signals, the carrier output voltage is given an initial or "no-signal" value; and therefrom the carrier output voltage is decreased in dependence upon increasing strength of the signals until the signals reach an arbitrary strength within the volume-level. Thereafter, with further increase in the strength of the signals, the carrier output voltage is increased in dependence upon increasing strength of the signals.

In achieving the maximum reduction of unwanted signal handling ability a variable plate supply voltage in the final circuit is used in combination with a variable-carrier output voltage, preferably of the type just specified. Of course, other supply voltages will generally require variation in order to achieve the required carrier output voltage and the required plate supply voltage simultaneously.

In the preferred method for supplying a variable voltage, a constant source is connected in series with a variable source, and in some forms, the variable source has the usual filtering circuits removed or omitted.

One particular novel variable voltage source comprises a bank of rectifiers fed from an A. C. mains through a regulating means comprising in tandem with each leg of a polyphase supply a transmission network some of whose elements are pairs of iron cored reactors. Each reactor has a reactive winding and also a saturating winding, these two windings having the greatest possible mutual coupling. The reactive windings of each pair are connected in parallel; while controllable means with rectifying properties are connected to receive from the two saturating windings of each pair saturating currents with at least a D. C. component, the two saturating windings of each pair being connected in such polarity that the asymetries of the two saturating currents are displaced by half a cycle. The voltage output from the rectifier bank is varied by the application to the controllable means of energy (generally rectified) at potentials varying in dependence upon the strength of the signal and under control of the signal waves.

The accompanying drawings show diagrammatically the application of the invention to a radio transmitter of the amplitude modulated type.

In these drawings:

Fig. 1 is a schematic diagram of the transmitter;

Fig. 2 is a curve showing the manner in which the carrier output is varied;

Fig. 3 is a diagram showing the derivation of programme frequency voltages for control purposes,

Fig. 4 is an alternative arrangement for regulating the voltage supplies of the transmitter.

Fig. 5 is a schematic diagram of an alternative arrangement for deriving controlling potentials, and

Fig. 6 is a diagram of alternative arrangement for saturating iron cored reactors.

In the arrangement shown in Fig. 1 carrier oscillations of the required frequency are generated in the oscillator stage O and modulating energy is generated by the modulating valve VM, series modulation being adopted. MA is a class C modulated amplifier stage and PA is a class B linear power amplifier and AE is a radiator.

The modulating valve VM has means GBM for applying a constant but reduced value of negative grid bias in series with means RM for providing a negative bias proportional to the envelope value of the signal voltage. The means RM may be of any known type such as a rectifier fed with signal energy at a suitable level at X. The components of the means RM and their time constants are so chosen that the building up of the bias voltage is substantially complete within one cycle of the highest modulating frequency at which appreciable rapid variation of programme or signal energy occurs and so that the time of decay of the bias voltage is longer than one cycle of the lowest modulating frequency to be handled. Modulating potentials are supplied in any convenient and known manner at M to the grid of the modulating valve.

The modulating stage MA is supplied with high tension voltage through the line J from a constant voltage source EC and a variable voltage source EV. The constant voltage source is of usual low impedance and good regulation and comprises any known and suitable arrangement of components designed to produce a steady smooth D. C. output. Its output is fed to MA through the variable voltage source EV which comprises a bank of rectifiers of suitable capacity arranged to deliver a uni-directional output of voltage variable in value with its input voltage. The source EV has no smoothing means. The source EV is fed with polyphase A. C. energy from the mains AC through voltage regulating means ER. In this regulator each leg of the mains has a transmission network of iron cored inductors L1 and L2 connected therein. Each inductor has a secondary winding (LS1 and LS2) associated therewith. The secondary windings LS1 and LS2 as shown are connected to rectifiers V1 and V2 in series with which are the cathode-anode paths of the valves V3 and V4. The control grids of these valves are supplied with controlling voltages from the driver stage DS which in turn is controlled by the phase reversing D. C. amplifier stage DCA. The biassed rectifier RVR is supplied at Y with programme energy at a suitable level. A voltage derived by known means such as the potentiometer R and proportional to the excess of plate supply voltage over idling plate supply voltage is applied in series with and in opposition to the output voltage of RVR to DCA. The stages RVR, DCA and DS are of any suitable and known type. The time constants of RVR are chosen according to the same plan as those of RM. When programme energy is supplied at Y the control grids of V3 and V4 are influenced in accordance with the envelope voltage thereof.

By reason of the biassing of the stage RVR, the output of rectified programme energy from the stage remains zero until a predetermined volume level of programme depending upon the relative magnitudes of biassing voltage and of applied programme level has been reached. After this volume level of programme has been exceeded and the applied programme voltage has overstepped the threshold value constituted by the bias, then the voltage output of rectified programme energy from the stage RVR increases in dependence upon the increase of the programme voltage. Consequently when the volume level is less than this predetermined or arbitrary value, conditions in the regulating means ER are unchanged. But when this arbitrary level is exceeded the increasing output from RVR makes the grids of V3 and V4 more positive in dependence upon increase of programme voltage, and the impedances of the valves V3 and V4 are varied.

They are made more conductive so that the rectified currents in the circuits of V1, V4 and V2, V3 are increased, said currents being derived from the windings LS1 and LS2. This increase of unidirectional current saturates more the inductors L1 and L2 so that the voltage input to EV is increased. The increased A. C. components in these secondaries also have voltage increasing effects by lowering the equivalent shunting impedances coupled across L1 and L2. Thus, in accordance with rise of programme voltage above the predetermined level, the voltage applied to EV and hence to the stage MA and VM in series is increased.

The voltage of the source EC is less than that which would be normally required for operation of the stage MA and VM at full output. The ratio of the voltage supplied by the constant source EC to the full capacity voltage depends upon the degree of suppression of the idling carrier below full output and also upon the characteristics of the modulator valve VM.

The high tension plate supply for the stage PA is supplied from two sources in series, a constant source EC2 and a variable source EV2, the general characteristics of which are similar to those of EC and EV with appropriate differences in output voltage and capacity to suit the greater requirements of the stage PA. The ratio of the voltage supplied by the source EC2 to the full capacity voltage depends upon the degree of suppression of the idling carrier below full output. Grid bias for the stage PA is supplied from a constant source EC3 and a variable source EV3. The two variable sources EV2 and EV3 have their input voltages regulated by means ER2 (including means RVR2) and R2 which are similar to the regulating means ER, RVR and R and which are supplied with controlling programme voltages at a suitable level at Z.

Splitting methods are well known in the prior art whereby the controlling signal voltages fed to X, Y and Z may be derived from the one source of signals whence comes the modulating signal voltage fed to M. A circuit which may be used is shown in Fig. 3. Signal voltages are supplied through the line PL to gain control means G and thence to splitting means S1. Part of the output of S1 proceeds through line ML to modulating amplifier means MAM, thence to gain control means MG, and thence to the modulating valve VM (shown in Fig. 1) via M. Another part of the output of S1 proceeds through line CL to control-channel amplifier means CAM, and thence to splitting means S2. The three outputs of S2 proceed to three separate gain control means CGX, CGY and CGZ which feed signal power to X, Y and Z respectively.

When the transmitter is in operation, the grid bias of the modulating valve VM increases with rising signal voltage (see page 2, column 1, lines 10 to 14, inclusive). This reduces the carrier strength in accordance with the known operation

of so-called "series modulation" circuits and consequently reduces the power input in the modulator plate and to the linear power amplifier plate. The combined peak of carrier voltage and modulation sideband voltages impressed on the carrier is kept substantially constant until a predetermined critical modulation signal voltage is reached. This is accomplished by suitably adjusted gains from the source of signals to RM and to M. When this arbitrary voltage, which is determined by the setting of the bias of the rectifier RVR, is exceeded the plate supply voltage fed to the modulator stage MA increases with further increase of programme voltage, because of the saturation and the effectively coupled shunting of the inductors L1 and L2 as previously explained. At or about this point of programme voltage the plate supply voltage and also the grid bias of the linear power amplifier PA increase with further rise of programme voltage.

While the programme voltage is below the critical value the rate of lowering of the carrier voltage with increase of programme voltage is adjusted by the gain control means regulating the input at X so that plate signal saturation on outwards modulation peaks does not occur in the linear power amplifier.

When the programme volume level exceeds the critical value the gain control means regulating the input to Y is adjusted to vary the rate of increase of the modulator plate supply voltage so that inwards over-modulation does not occur. Also when the programme volume level exceeds the critical value the rate of increase of the linear power amplifier plate supply voltage compared with programme voltage is adjusted by gain control means regulating the input to Z so that the outwards modulation peaks will be free from plate signal saturation.

Without limiting the invention, the following are suggested as desirable values to which to adjust the transmitter performance for a programme extending 40 db. and having an average volume level 14 db. below full capacity:

Carrier at full output	Zero level
Idling carrier	Minus 1.9 db.
Carrier at critical volume level	Minus 6 db.
Critical audio volume level	Minus 10 db.
Voltage of sources EC2 and EC3	40 percent of the respective full capacity voltages.

The manner in which the carrier voltage may change in the apparatus described and adjusted in accordance with the above table, is shown by the line COV in Fig. 2. It is assumed that the modulating signal strength ranges from zero level (written 0 db.) to minus 40 db. At full modulation (zero level) it is assumed that the carrier output is 1.0 and that in the idling condition (no modulation) the carrier output is 0.8. As modulation is increased the carrier output falls, due to increased bias upon the modulating valve VM produced by RM under the influence of increasing programme voltage. The decrease is preferably effected so that as the modulation increases towards a critical value, say minus 10 db., the modulation peaks are approximately equal to the carrier level at no modulation. As modulation increases and the carrier level decreases, the stage of over-modulation is approached but before this stage is reached, due to the effect of increasing programme voltages upon the voltage regulating means ER and ER2, increased voltages are applied to the stages MA and PA and the carrier is expanded from the minimum value (of say, 0.5) to its full value so that the higher modulation voltages may be handled without distortion. The change in carrier voltage is shown by the full line COV. Considerable power is therefore saved as, except at the highest modulation levels, the carrier is always at a relatively low value. A comparatively high idling value of carrier say 0.8, is chosen so that in receivers having A. V. C. the noise level is kept down when the modulation is low or absent.

At or about the arbitrary programme level chosen, say minus 10 db., the units ER and ER2 begin to increase the voltages applied to the stages MA and PA so that they vary as shown in Fig. 2 by the dotted lines MA1 or MA2 for the stage MA, and by the dotted line PA for the stage PA. The sources EC and EC2 supply the approximately constant voltages indicated by the horizontal portions of the lines and the units EV and EV2 produce the increase indicated by the sloped portions. The voltage of EC3 plus EV3 is of the same pattern as the voltage of EC2 plus EV2 but of appropriate difference in magnitude. The two lines MA1 and MA2 are shown in Fig. 2 in order to represent the fact mentioned earlier that the ratio of the voltage from EC to the voltage at full modulation from EC plus EV depends also on the characteristics of the valve VM, and so will naturally vary from type to type.

In Fig. 4 there is shown a modification of the method of controlling the input voltage to any of the variable sources EV, EV2 or EV3. Each lead of the polyphase circuit from the regulator ER to the source EV, for example, has included therein two windings which are respectively the secondaries of transformers T1 and T2, the primaries of which are connected to the mains. These secondaries deliver voltages respectively in quadrature and the magnitudes of the voltages in the secondaries of T1 and T2 are adjusted so that the idling voltages in the polyphases connections J2 are any arbitrary value. Preferably, these voltages are zero. In operation the output voltages from T1 and T2 subtract vectorially from the output voltage of ER so that in the idling condition residual voltage from ER can be substantially cancelled.

In the above descriptions the means R and RVR, and the like, have been described as one means for controlling the operation of the means ER and the like.

An alternative arrangement, illustrated in Fig. 5, consists in bringing the connection from the means RVR, or the like, to a bias source B suitable for the means DCA, or the like, instead of (as shown in Fig. 1) to the output of the means R, or the like.

In operation, signal power applied at Y generates controlling potentials which are transmitted through DCA and which control the means ER as already described in reference to Fig. 1.

In Fig. 6 there is shown an alternative arrangement for producing saturation in the reactors L1 and L2 of Fig. 1. Grid controlled gas discharge tubes (or thyratrons) Th1 and Th2 have their grids connected to known grid controlling devices GCD1 and GCD2 respectively, and these are in turn connected to DS which is identical with DS of Fig. 1. The plate circuits of Th1 and Th2 are connected in series respec-

tively with LS1 and LS2 which are identical with LS1 and LS2 of Fig. 1.

In operation, as described previously, when the strength of the signal rises, voltage proportional to the strength of signal is transmitted through DS, and this influences the firing of Th1 and Th2 through the action of GCD1 and GCD2. The magnitude of the currents in LS1 and LS2 is thus influenced in well known way by Th1 and Th2, and so, as described previously, the saturation of the reactors L1 and L2 is controlled.

In the above description and in the claims appended hereto certain terms have been used. These terms as used have the meanings set out hereunder.

"Supply voltage" means any voltage excepting a signal wave voltage or a modulation sideband voltage which may be required to be incorporated in the circuit of an electric wave signal handling arrangement for the standard operation thereof, and will include carrier wave input voltage.

"In dependence upon" used in reference to a varied or controlled voltage or the like means existence (as understood in physics) of a single-valued function substantially defining the pattern of variation. Despite the fact that the function may define the time pattern of the dependent from the time pattern of the independent variable, strictly only in the case of indefinitely slow variation rates, except when time delays or the like are specifically referred to, the variation is still described as "in dependence upon."

"Final circuit" of an electric wave signal handling arrangement means that electrical loop in the said arrangement wherein power associated with one or more of the operating or supply voltages is converted to the power flow which constitutes the output wave of the arrangement.

"Signal handling ability" means the peak voltage of that sustained wave which can be generated without substantial distortion being introduced by voltage overload. Thus in a plate circuit, the signal handling ability may for example be different for an audio wave and for a single side band.

I claim:

1. In a variable-carrier signalling arrangement, apparatus generating carrier-frequency output voltage and amplitude-modulation sideband waves originating from signal frequency waves, in combination with a first means effective in the presence of and actuated by energy under the control of signal waves of less than an arbitrary strength within the volume-range of the said signals, said first means changing the said carrier output voltage to values substantially in dependence upon values of the strength of the said signal waves and less than the value of said carrier output voltage in the substantial absence of signal, and with a second means effective in the presence of and actuated by energy under the control of signal waves of greater than said arbitrary strength, said second means changing said carrier output voltage to values substantially in dependence upon values of the strength of the said signal waves and greater than the value of the said carrier output voltage in the presence of signal waves of said arbitrary strength.

2. In a variable-carrier signalling arrangement, apparatus according to claim 1 and having a final circuit and a supply voltage for said final circuit, in combination with a third means effective in the presence of and actuated by energy under the control of the said signal waves, said third means changing the value of the said supply voltage to values substantially in dependence upon values of the strength of the said signals.

3. In a variable-carrier electric wave signalling arrangement, a final circuit in which may occur electric waves comprising both carrier-frequency output voltage and also amplitude-modulation sideband waves originating from signal-frequency waves, a substantially un-modulated supply voltage source for said final circuit, and a modulation circuit distinct from said final circuit, in combination with a first means effective in the presence of and actuated by energy under the control of said signal waves, said first means changing the value of said carrier output voltage to values substantially in dependence upon values of the strength of the said signals, and with a second means effective in the presence of and actuated by energy under the control of the said signal waves, said second means changing the value of the said supply voltage to values substantially in dependence upon values of the strength of the said signals.

4. In a variable-carrier signalling arrangement, apparatus as claimed in claim 3, and in which during any substantially short moment, for the instantaneous peak envelope voltage of signal waves which is occurring, the signal handling ability afforded in the said final circuit by the said supply voltage is substantially equal to the peak voltage of the electric wave which is occurring in the said final circuit.

5. In an electric wave signal handling arrangement incorporating a supply voltage source, an iron cored reactor circuit for varying said supply voltage in response to saturation of said iron, and means for saturating said iron in response to controlling potentials, means for generating controlling potentials which vary substantially in dependence upon values of the strength of the signals, comprising, in combination, a first means for deriving voltage proportional to the difference between said supply voltage in the absence of signals and said supply voltage whilst varied, a second means for deriving voltage which is uni-directional and is in substantially linear dependence upon the envelope voltage of the said signals, and a third interconnecting means for deriving the difference constituting the said controlling potentials, between the voltages from said first and said second deriving means.

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