June 25, 1935. G. A. MATHIEU ET AL 2,005,795

HIGH FREQUENCY MULTIPLEX SIGNALING SYSTEM

Filed April 21, 1931 3 Sheets-Sheet 1

Fig. 1

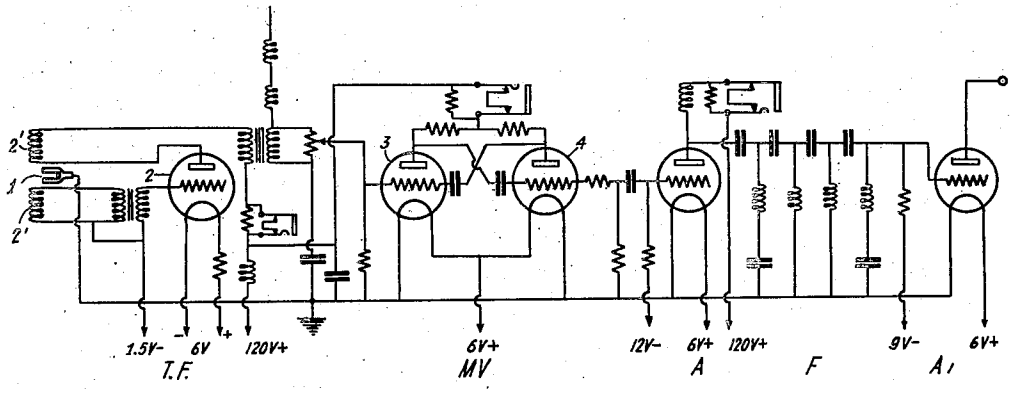
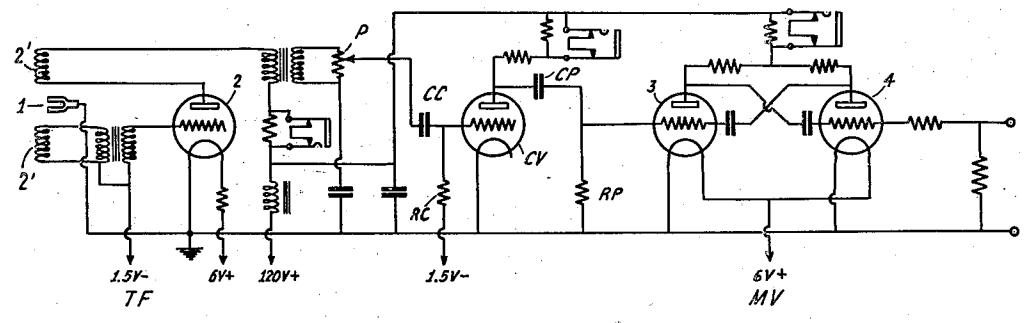


Fig. 1b



INVENTORS
GASTON ADELIN MATHIEU
OWEN STANDIDGE PUCKLE

BY

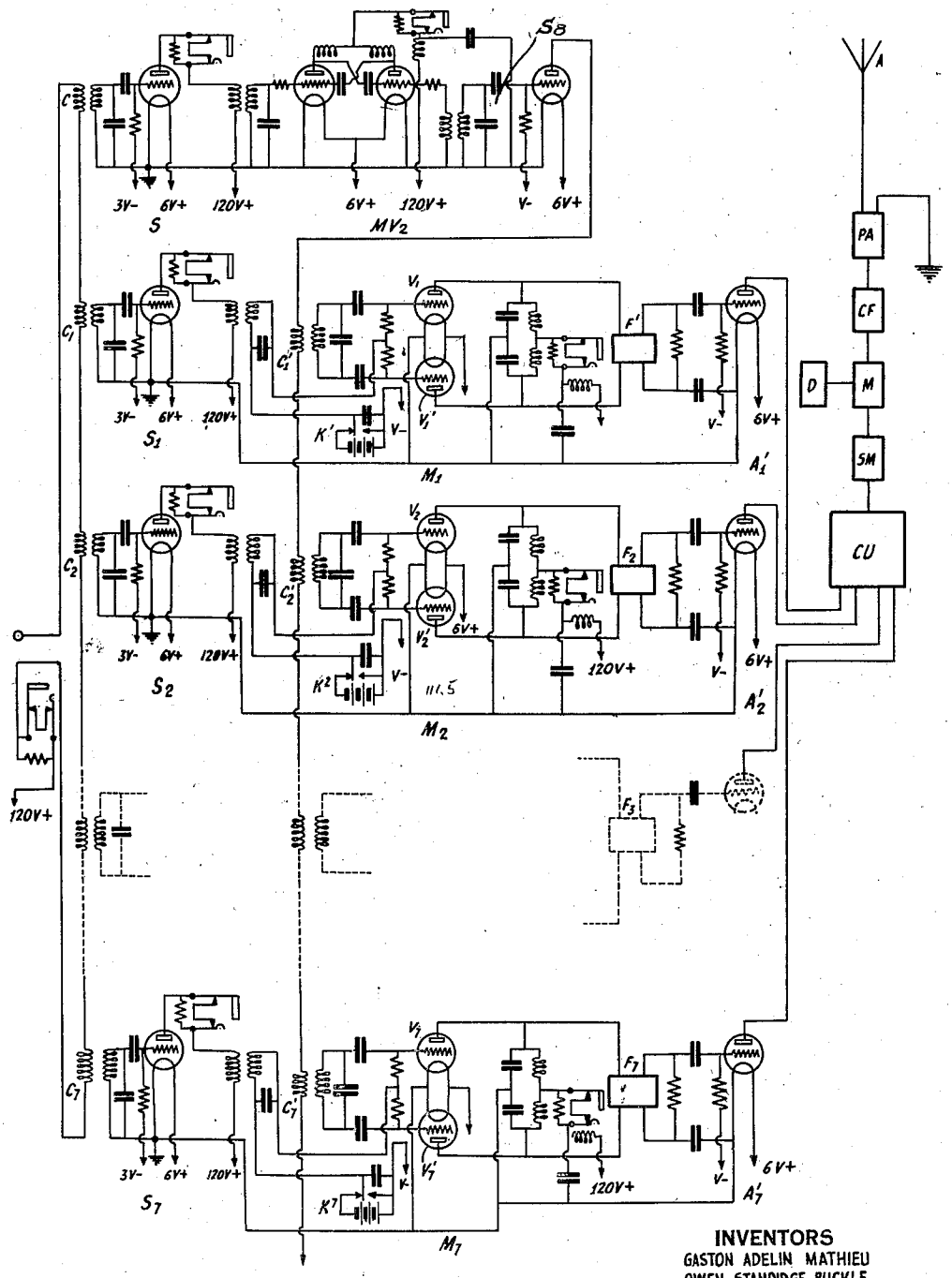
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HIGH FREQUENCY MULTIPLEX SIGNALING SYSTEM

Filed April 21, 1931 3 Sheets-Sheet 2

Fig. 1a



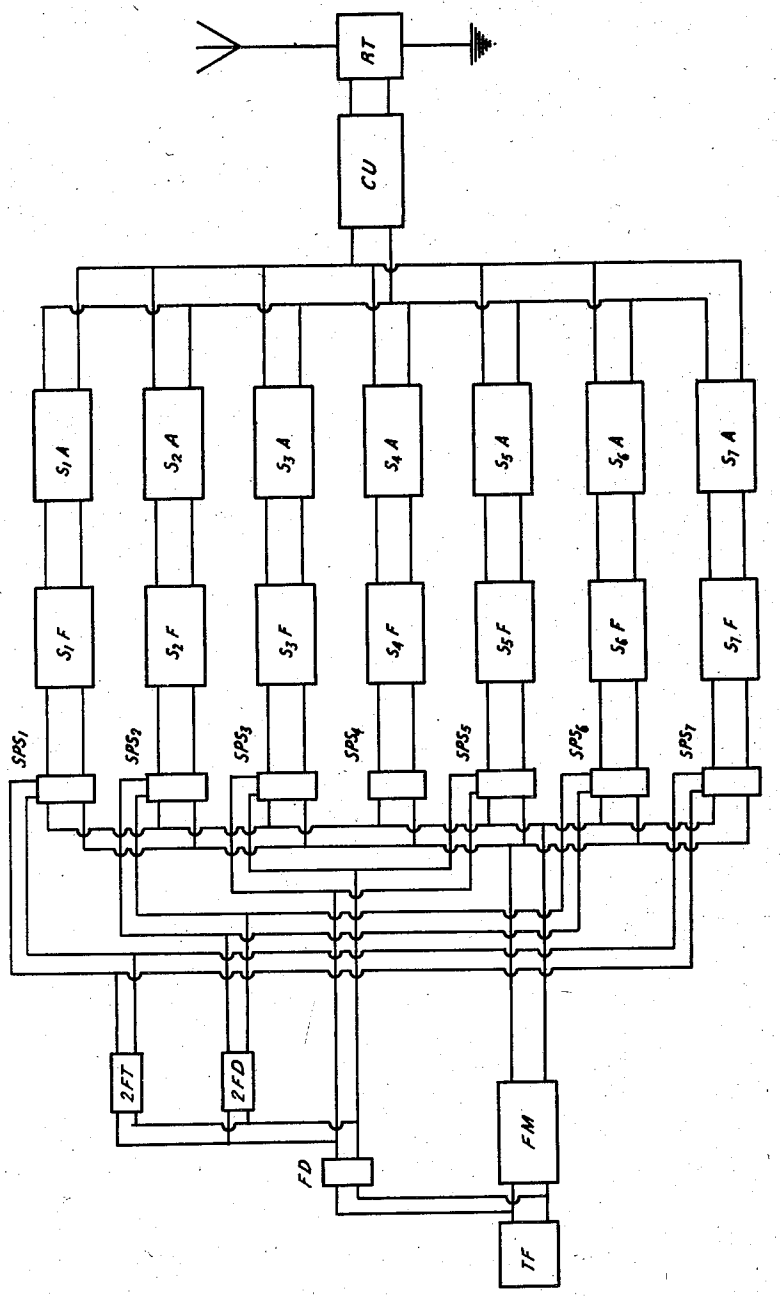
INVENTORS
GASTON ADELIN MATHIEU
OWEN STANDIDGE PUCKLE
BY
ATTORNEY

June 25, 1935. G. A. MATHIEU ET AL. 2,005,795

HIGH FREQUENCY MULTIPLEX SIGNALING SYSTEM

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Fig. 2



INVENTORS
GASTON ADELIN MATHIEU
OWEN STANDIDGE PUCKLE
BY
ATTORNEY

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HIGH FREQUENCY MULTIPLEX SIGNALING SYSTEM

Gaston Adelin Mathieu and Owen Standidge Puckle, London, England, assignors to Radio Corporation of America, a corporation of Delaware

Application April 21, 1931, Serial No. 531,676
In Great Britain April 29, 1930

10 Claims. (Cl. 250—9)

This invention relates to multi-channel or multiplex signaling systems and has for its object to provide a stable and comparatively easily installed transmitting system whereby a plurality of channels may be established.

In one way of carrying out this invention a multi-channel or multiplex transmitting system comprises a master time period device, a multi-frequency generator or a multiplier controlled by said device and giving a plurality of frequencies higher than the frequency of said device, a second frequency generator or multiplier controlled by one of the output frequencies from said first generator and adapted to produce a frequency which is high relative to the output frequencies from said first generator, a plurality of combining circuits for combining the output frequency from said second generator with the remaining output frequencies from the first generator to produce a plurality of adjacent frequencies near in value to the output frequency of said second generator, said combining circuits being associated with means for controlling them in correspondence with signals or the like desired to be transmitted over the channels of the system, and means for filtering and combining the outputs from the combining circuits the combined output being then employed to control a radio or similar high frequency transmitter.

The outputs from the combining circuits may be fed to one or more composite units and employed to energize one, or more than one, transmission line or radio transmitter. Where a single channel is employed to energize one transmission medium no composite unit is required.

The invention is illustrated in the accompanying drawings in which Figs. 1 and 1*a* show in diagrammatic form one installation in accordance therewith. Figure 1*b* shows a detail modification. Figure 2 shows a further modification of the arrangement of Figs. 1 and 1*a*.

Due to the size of the circuit necessary to illustrate the present invention it is thought desirable to show the circuit in two portions, one portion being on sheet 1 and the other portion being on sheet 2. The anode of the final tube in that portion of the circuit of Figure 1 is in practice connected in series with the windings C, C_1, C_2, etc., of Figure 1*a*.

Referring to Figs. 1 and 1*a*, the apparatus at TF is a master time period device consisting of a tuning fork 1 which is electrically maintained in oscillation by means of a thermionic valve 2 and appropriate coils 2′ in the usual well known way. In order that the installation now being described may be better understood examples of frequencies in the various parts of the apparatus will be given. It is to be understood, however, that these numerical examples are by way of illustration only, the invention being in no way limited to the employment of the particular frequencies given. The invention will be described as applied to a seven channel system but again the said invention is not limited to the use of this particular number or indeed to any number of channels.

The tuning fork generator TF generates a frequency of 500 cycles per second, which frequency is employed to control a multi-vibrator at MV. This vibrator comprises a pair of thermionic valves 3, 4 arranged in a circuit which is similar to that of the well known Abraham-Bloch multi-vibrator circuit except that the input voltage instead of being applied to the plate is applied to the grid of the valve 3. The output from the multi-vibrator MV is then amplified at A and passed through a filter F designed as a high-pass filter passing only frequencies above 9,600 cycles per second. The output of the filter which will consist of a multiplicity of frequencies from about 10,000 cycles upwards is then again amplified at A_1 and passed through what may be termed the primary of a coupling circuit, said "primary" consisting of coils C, C_1, C_2 . . . C_7. There are in the present arrangement eight such coils which may be arranged in a variety of different ways, for example, in series-parallel or, as shown, in series with one another.

For the sake of simplicity in the drawings only five coils are shown. The coil C is coupled to a selector at S adapted to select a frequency of 10 k. c., this frequency being fed to a second multi-vibrator at MV_2. The coil C_1 is coupled to a selector at S_1 adapted to select a frequency of 10.5 k. c. The coil C_2 is coupled to a selector S_2 adapted to select a frequency of 11.5 k. c. The remaining coils C_3 C_4 C_5 C_6 C_7, coils C_4 C_5 and C_6 are not shown, are coupled to selectors adapted to select frequencies of 12.5 k. c., 13.5 k. c., 14.5 k. c,, 15.5 k. c., and 16.5 k. c., respectively. The output from the second multi-vibrator MV_2 is passed through a selector S_8 adapted to select a frequency of 100 k. c. and the output from this selector is passed through coupling coils C'_1 C'_2 C'_3 . . . C'_7 which are coupled to the input circuits of combining valve circuits M_1 M_2 . . . M_7 respectively. The combining circuits each consist, as shown, of a pair of valves V_1 V'_1, V_2 V'_2 . . . V_7 V'_7. The outputs from the selectors

S_1 to S_7 are also fed to the input circuits of the combining valves as shown so that the output circuits of said combining valves will contain beat frequencies 110.5, 111.5, 112.5, 113.5, 114.5, 115.5, 116.5 k. c. respectively. The grid bias values applied to the combining valves are controlled by means of keying relays, keys or equivalent devices K' . . . K^7 which devices are operated in accordance with the signals desired to be transmitted over the various channels. In this way the outputs from the combining valves are made to "carry" the various signals. The output circuits from the combining valves contain band pass filters adapted in each case to pass only the upper, or lower, side bands resulting from the combined energy. These filters are indicated by reference letters F_1 . . . F_7. Band pass filters F_1 will therefore pass 110–111 k. c., band pass filter F_2 will pass 111–112 k. c., and so on, band pass filter F_7 passing 116–117 k. c.

The use of these band pass filters helps to prevent interaction between the various channels and the liability to such interaction is also reduced by the choice of odd multiples of the master fork frequency so that any inter-channel modulation will lie at frequencies between the channels where it is of least effect and where it will be highly attenuated by the band pass filters. The outputs from the filters are amplified at A'_1 A'_2 . . . A'_7 and fed to a composite unit indicated at CU where they are mixed, the mixed frequencies being fed via a sub-modulator SM to a modulator M. The drive associated with the modulator M is indicated at D and the modulated carrier output from the device M is then filtered at CF to suppress the carrier and the lower, or upper, side band, the upper, or lower, side band only being fed to a power amplifier PA and radiated from an antenna A. With the numerical examples given and assuming the radio frequency carrier to be 20,000 k. c. the total band radiated will be from 20, 110.5 k. c. to 20, 116.5 k. c. plus or minus the keying frequency of the first and seventh channels. The band width will then for the seven channels be approximately only 7,000 cycles wide.

The same arrangement may be used at the receiving end in a reverse direction. The received signal may be heterodyned to produce a frequency band having a width of from 110.5 k. c. to 116.5 k. c. plus and minus the upper and lower signal frequencies, the heterodyning frequency being the same as that of the carrier frequency.

The tuning fork at the receiving end will with its associated apparatus, produce the same frequencies as that at the transmitting end and these frequencies will be used to heterodyne firstly, the 110.5 to 116.5 k. c. band producing a band of 10.5 to 16.5 k. c. and secondly, the actual signal frequencies. Upon the production of the 10.5 to 16.5 k. c. band, the component channels may be separated by means of filtering circuits to enable the individual signals to be heard separately.

As an alternative method, the process may be carried a step further for radio transmission purposes, the actual radio carrier wave being obtained from the original fork control with the aid of one or more extra stages.

In addition an extra frequency may be drawn from the system, say 500 cycles for the purpose of modulating one or more of the channels for tuning in and "lining up" purposes.

It is thus evident that all the frequencies required may be obtained in one operation and that they will all be stable since they are all controlled by one tuning fork.

If desired, two or three channels may be employed together for transmission of telephony.

Figure 1*b* shows a modified arrangement for coupling the tuning fork generator TF to the multi-vibrator MV. In this arrangement the output from TF is applied via a condenser and resistance circuit CC, RC to the grid of a coupling valve CV whose plate circuit includes resistance RP and capacity CP. Potential variations set up in the plate circuit of the valve CP are applied to the multi-vibrator MV. The amount of control exercised by the fork can be altered by varying the value of the condenser CC or by changing the position of the moving contact of the potentiometer P, an increase in the capacity and/or in the potentiometer setting causing the fork to bring the multi-vibrator into step more quickly and increasing the "tightness" of the control.

It is found that an arrangement as above described presents several important advantages in practice, among these being that only a small potential is required to obtain control; the load upon the master tuning fork is quite small so that liability to undesired frequency variation is reduced; and the control obtained is stable and comparatively simple.

In Figures 1, 1*a* and 1*b* the apparatus prior to the composite unit has been shown in considerable detail by means of the usual conventional representations. It is thought that these representations render the drawings self-explanatory as regards this detail and that no further explanation is required for a full understanding thereof.

In the further modification shown in Figure 2 a tuning fork generator TF, constituting a master time period device, has its output terminals connected to a frequency multiplying device FM consisting, for example, of three frequency triplers in cascade. If the output from the device TF is, say, 500 cycles, the output from the unit FM will be 13500 cycles. The output from the terminals of the device TF are also connected to the input terminals of a frequency doubler FD whose output terminals (at which will appear a frequency of 1000 cycles) are connected to the input terminals of a second frequency doubler 2FD and also to the input terminal of a second frequency tripler 2FT. The output from the device 2FD will be 2000 cycles and the output from the device 2FT will be 3000 cycles. The 13500 cycle output is modulated separately by the 1000, 2000 and 3000 cycle outputs and each of the resulting upper and lower side bands are separated out to give frequencies of 10500 cycles, 11500 cycles, 12500 cycles, 13500 cycles, 14500 cycles, 15500 cycles and 16500 cycles respectively.

The separating devices and filters for the obtaining of these last mentioned seven frequencies are indicated at SPS_1 . . . SPS_7 and S_1F . . . S_7F.

The outputs from the filters are amplified by means of amplifiers indicated at S_1A . . . S_7A. The resulting amplified outputs are mixed together, for example, in a combining unit CU, the output of which is employed for modulating any convenient device, such as a radio transmitter, indicated at RT.

The arrangement shown in Figure 2 may be adapted for reception in a manner analogous to that already described in connection with Fig-

ures 1 and 1a, i. e., similar frequencies to those provided at the transmitter are provided at the receiver, the said frequencies being employed for demodulating purposes.

By the term "differentially" as used in the appended claims with regard to the application of high frequency currents to the grids of the tubes of the push-pull combining circuits V_1, V_1', V_2, V_2', etc. is meant that the currents are applied in opposite sense to the grids of the tubes constituting the push-pull circuits.

Having thus described our invention and the operation thereof, what we claim is:

1. Multi-channel or multiplex transmitting system comprising a master time period device, a multi-frequency generator or a multiplier controlled by said device and giving a plurality of frequencies higher than the frequency of said device, a second frequency multiplier controlled by one of the output frequencies from said first generator and adapted to produce a frequency which is high relative to the output frequencies from said first generator, a plurality of push-pull connected combining circuits, a circuit for differentially applying the output frequency from said second generator to each of said combining circuits, circuits for applying different ones of the remaining output frequencies from the first generator to different ones of said combining circuits cophasally to produce a plurality of beat note frequencies near in value to the output frequency of said second generator, said combining circuits being associated with means for controlling them in correspondence with signals or the like which it is desired to transmit over the channels of the system, and means for filtering and combining the outputs from the combining circuits, the combined output being then employed to control a radio or similar high frequency transmitter, substantially as described.

2. An arrangement as claimed in claim 1 in which the master time period device is a tuning fork controlled valve generator.

3. Signaling means comprising a master time period device, a multi-vibrator coupled thereto and adapted to give a plurality of frequencies higher than the frequency of the master time period device, a high-pass filter fed from the output of the multi-vibrator and adapted to pass only frequencies above a predetermined frequency, a coupling circuit energized from the output of said filter and comprising the primaries of a plurality of coupling devices, said primaries being in series with one another, a plurality of frequency selecting means connected each with the secondary of one of said coupling devices, a second multi-vibrator device energized from the output of one of said plurality of frequency selecting means, a plurality of combining circuits, each connected to one of the remaining frequency selectors of said first plurality of frequency selectors to receive energy therefrom, each of said combining circuits being coupled to said second multi-vibrator device to receive energy therefrom, means connected with each of said combining circuits for impressing signal modulations on the energy in the combining circuits, and means for combining and utilizing the resultant signal modulated energy.

4. An arrangement as claimed in claim 3 in which the output from the second multi-vibrator or frequency multiplying device is filtered before being fed to the combining circuits and in which the output from each combining circuit is fed through a band pass filtering device prior to combination of the signal modulated frequencies.

5. Signaling means comprising a master time period device, a plurality of frequency multipliers coupled in series with the output terminals of said device, means for beating one of the multiplied frequencies with each of the other multiplied frequencies separately to produce separate beat notes of different frequency, means for simultaneously modulating in accordance with desired signals each separate beat frequency, and means for combining and utilizing the signal modulated beat frequencies.

6. An arrangement as claimed in claim 5 in which the output terminals of the master time period device are coupled to the associated frequency multiplying device by variable coupling means whereby the amount of control exercised by said master time period device may be adjusted.

7. An arrangement as claimed in claim 5 in which the frequency multipliers are fed from the master time period device by way of coupling means including a coupling tube whose grid circuit is coupled to the output circuit of the master time period device through means, such as a potentiometer and a variable condenser.

8. A multiplexing system comprising a source of oscillations of constant frequency, first frequency multiplying means connected therewith, a plurality of harmonic selector circuits coupled thereto, a plurality of combining circuits, each having a pair of thermionic tubes, each tube having input and output electrodes, the output electrodes of each pair being connected in push-pull relation, second frequency multiplying means, circuits for coupling each of said combining circuits to one of said selector circuits for energizing the input electrodes of the pair of tubes of each of said combining circuits cophasally by energy from said first named frequency multiplier, and circuits for energizing the input electrodes of the pair of tubes of each of said combining circuits in phase opposition by energy from said second frequency multiplier, each of said combining circuits including keying means associated with the input electrodes of the tubes thereof whereby the beat notes produced in said combining circuits may be keyed at signal frequency.

9. A multiplexing system comprising a source of oscillations of constant frequency, first frequency multiplying means connected therewith, a plurality of harmonic selector circuits coupled thereto, a plurality of combining circuits, each having a pair of thermionic tubes, each tube having input and output electrodes, the output electrodes of each pair being connected in push-pull relation, second frequency multiplying means, circuits for coupling each of said combining circuits to one of said selector circuits for energizing the input electrodes of the pair of tubes of each of said combining circuits cophasally by energy from said first named frequency multiplier, and circuits for energizing the input electrodes of the pair of tubes of each of said combining circuits in phase opposition by energy from said second frequency multiplier, and a separate keying device connected to like electrodes of the tubes of each of said combining circuits to permit keying of the beat notes produced in said combining circuits at the signal frequency, said beat notes which are keyed at the signal frequency

being all combined and impressed on a single carried for transmission.

10. The method of producing a plurality of oscillations spaced apart in the frequency spectrum by fixed intervals which includes producing a plurality of harmonics of a base frequency, and a single higher harmonic of said base frequency, beating said higher harmonic with each of said other harmonics, signal modulating the beat frequencies produced, selecting a beat frequency from each of the resultant modulations, combining said selected beat frequencies, beating the resultant energy with additional energy, and obtaining therefrom a single sideband which is radiated over the ether.

GASTON ADELIN MATHIEU.
OWEN STANDIDGE PUCKLE.