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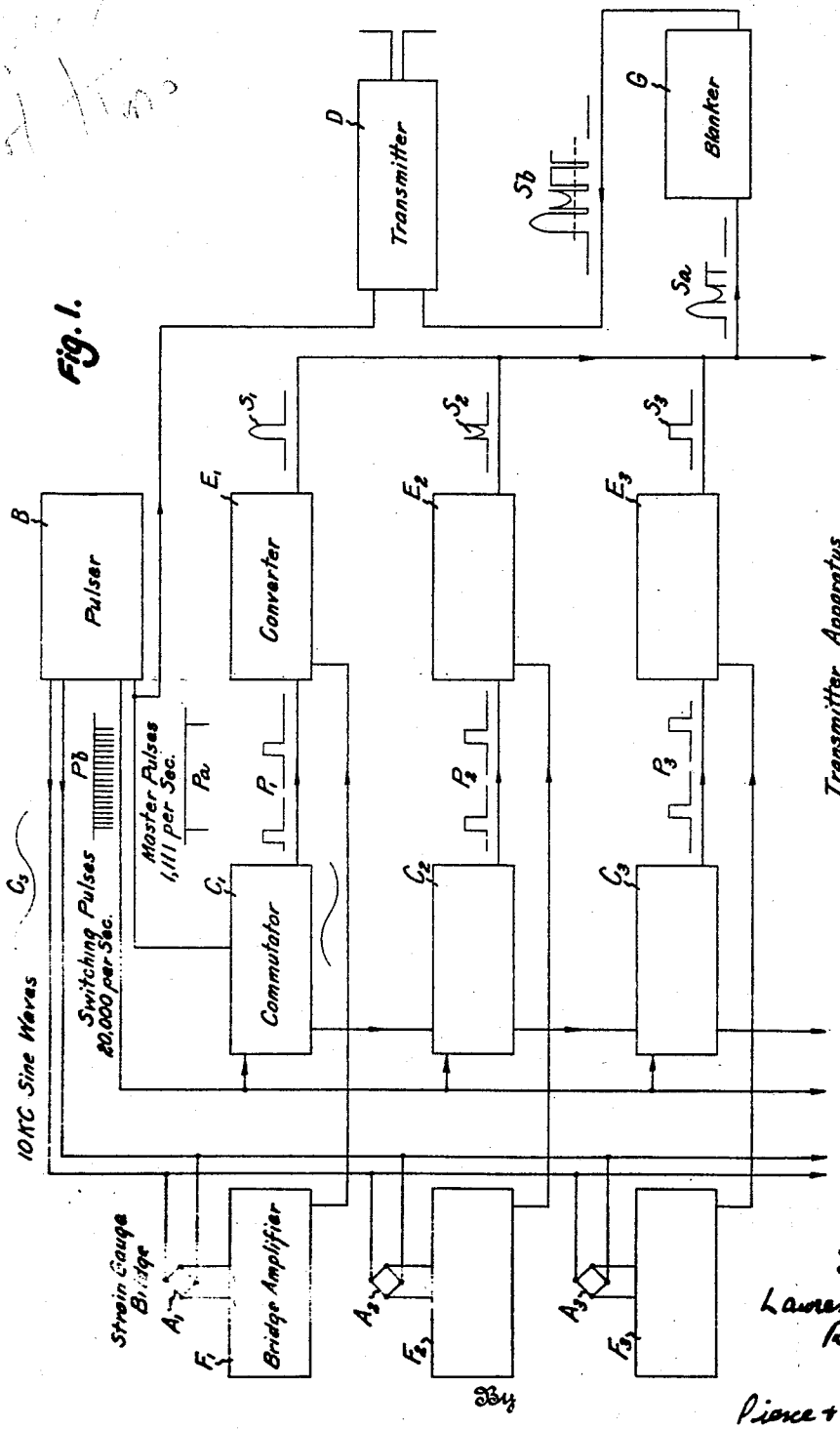
July 27, 1948. L. L. RAUCH 2,445,840

MULTISIGNAL TRANSMISSION

Filed Dec. 3, 1945 5 Sheets-Sheet 1

Fig. 1.



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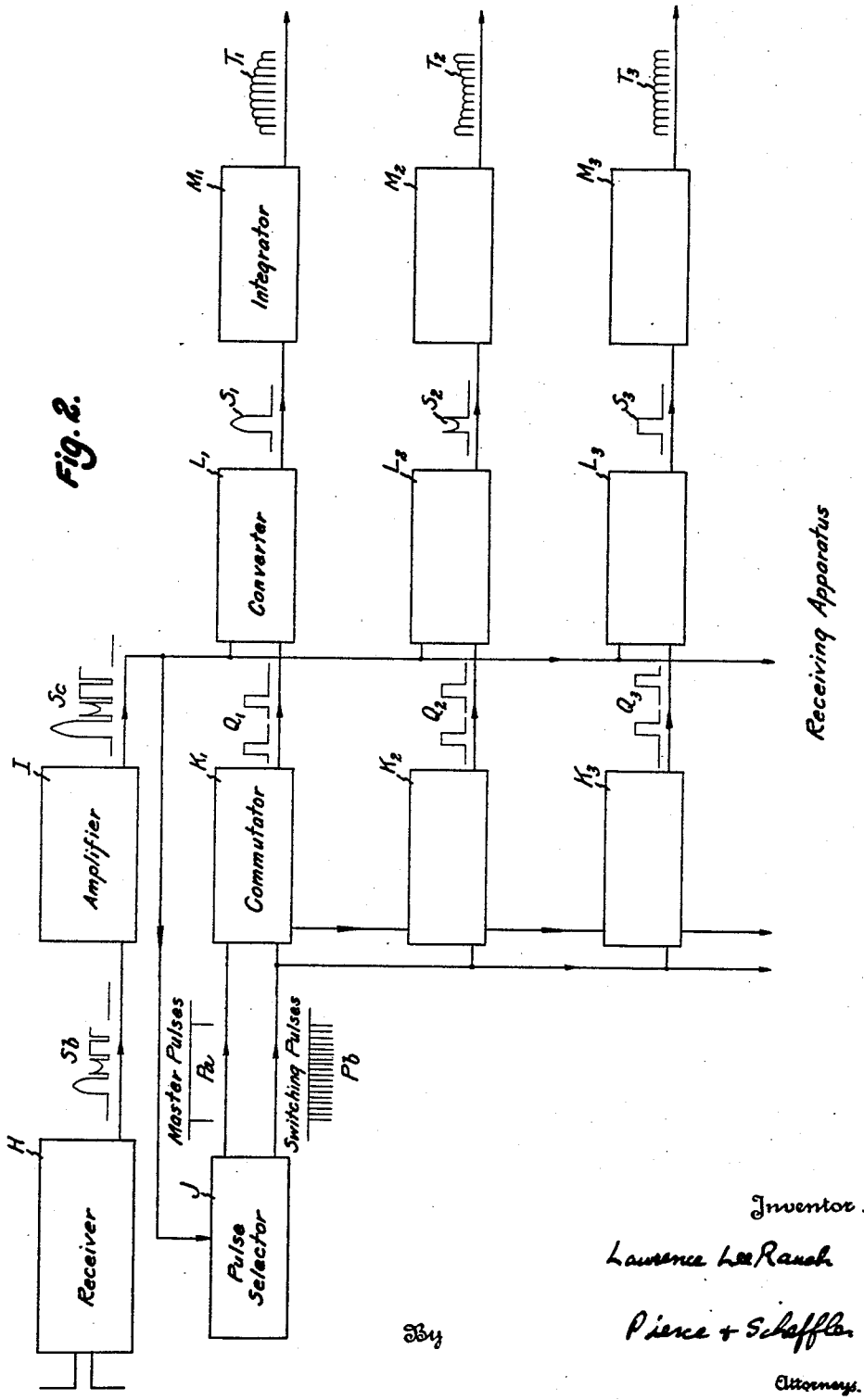

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MULTISIGNAL TRANSMISSION

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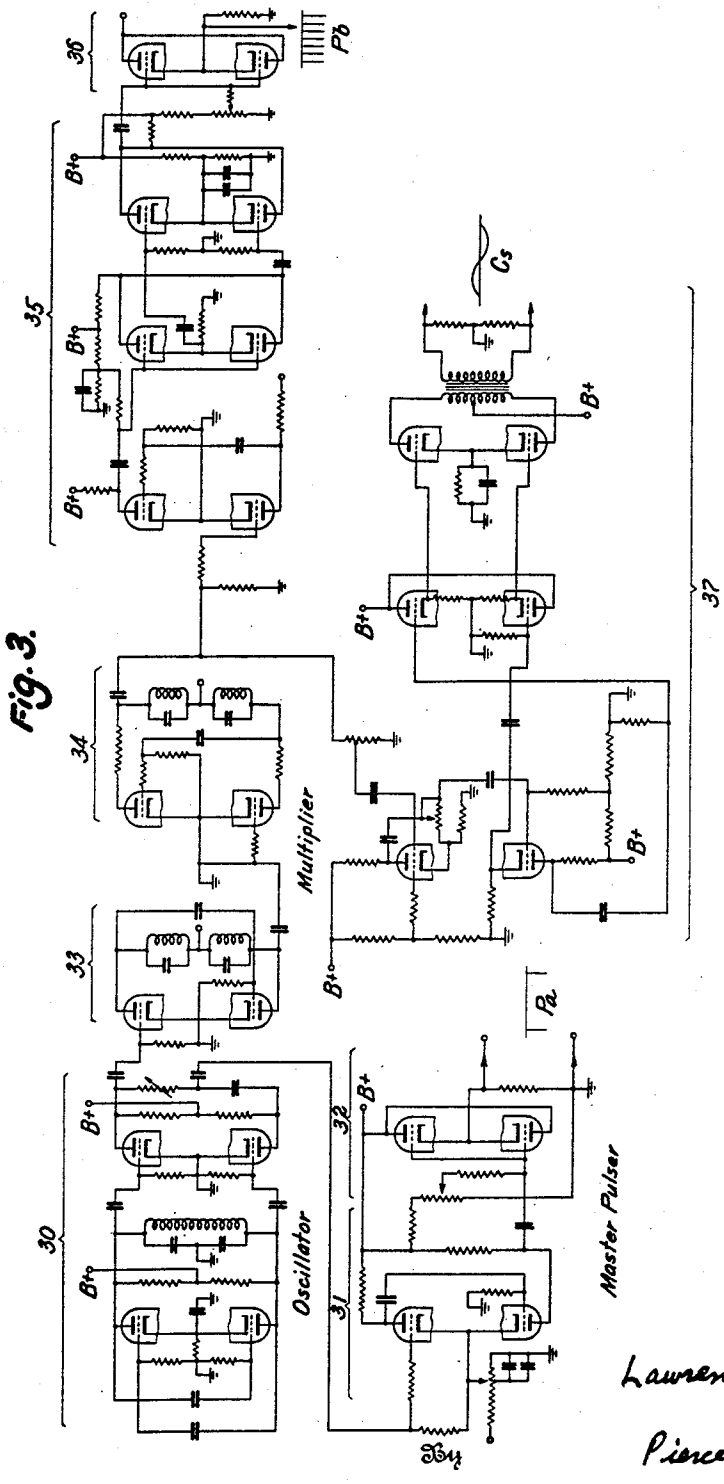

Fig. 3.

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MULTISIGNAL TRANSMISSION

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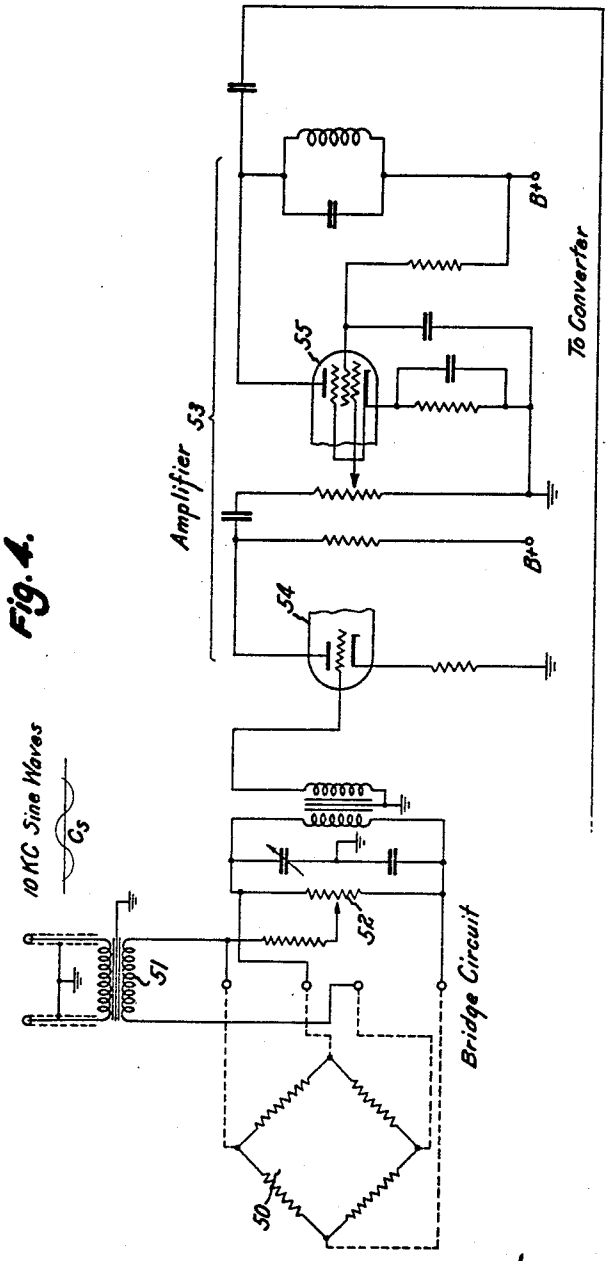

Fig. 4.

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MULTISIGNAL TRANSMISSION

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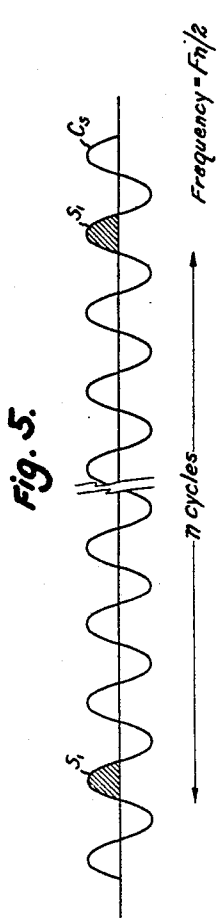

Fig. 5.

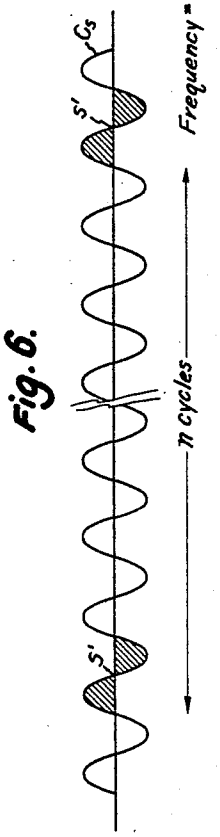

Fig. 6.

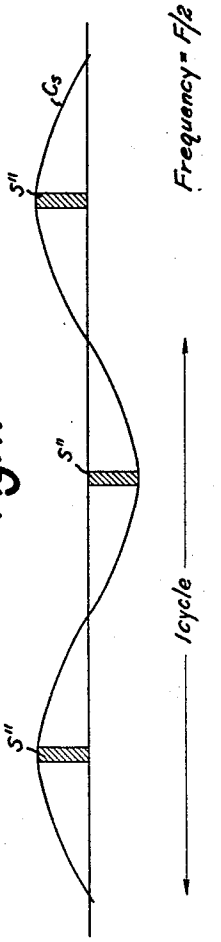

Fig. 7.

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2,445,840

MULTISIGNAL TRANSMISSION

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Application December 3, 1945, Serial No. 632,578

6 Claims. (Cl. 177—351)

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The invention relates to a multi-signal transmission system and particularly to method and apparatus for transmitting over a single channel signals from a plurality of intelligence sources.

An object of the invention is the provision of a method and apparatus for energizing a plurality of intelligence sources to provide signals adapted to be transmitted on a common transmission channel.

A further object of the invention is the provision of a multi-signal transmission system wherein the frequency and phase of the signals of the individual intelligence channels are correlated with the rate of sampling of each intelligence channel to provide a high transmission efficiency.

While the specific features of the invention may be varied to suit the condition of different problems, in general the invention comprises a method and apparatus for the transmission over a single channel of signals from a plurality of intelligence sources whereby the intelligence sources are connected in cyclic serial order with a common output channel at a preselected periodic sampling frequency F for sampling periods having a duration not exceeding $1/Fn$ where n is the number of intelligence signals to be transmitted, and the intelligence sources are energized with a common alternating potential having a frequency not less than one-half F and, preferably, not more than Fn and having a fixed phase relation to the sampling periods.

The method and apparatus of the invention are particularly useful in systems for transmitting data, such as instrument reading, strain gauge and accelerometer readings and the like, to ground stations for recording and, for the purpose of illustrating the principles of the invention, the invention will be more particularly described with reference to a system for the telemetering of aircraft flight data from a plurality of instruments to a ground station, more fully described in application Serial No. 625,590, filed October 30, 1945.

The transmission system specifically described herein includes an electronic commutator adapted to connect in cyclic serial order a plurality of intelligence channels with a single output channel for radio transmission to a receiver which may include a similar commutator adapted to connect the received signals in corresponding cyclic serial order to a plurality of indicating and/or recording devices.

The specific characteristics of the transmission system are largely governed by the number and

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character of the signals to be transmitted. Each signal must be sampled at a rate high enough to detect variations in the signal. In general, the sampling rate in samples per second must be somewhat greater than two times the highest frequency to be reproduced. With a signal sampling rate of F times per second and a number of signal channels n, the switching speed must be nF times per second. When high switching speeds are required, mechanical commutation becomes inadequate. In order to provide effectively high switching speeds, the transmission system is preferably provided with an electronic commutator comprising a plurality of electronic tube switch circuits corresponding in number to the signal channels to be sampled, the first switch circuit of the commutator being actuated by a master pulse at the beginning of each switching cycle and the successive switch circuits being actuated by switching pulses corresponding to the number of signal channels.

The periodic pulses are passed from each of the switch circuits of the commutator to a modulator of the invention whereby the corresponding intelligence channel is connected with the common transmission channel of the system during the duration of a pulse, thereby, in effect, modulating each pulse with the intelligence signal. The modulator or converter may comprise a triode, to the plate of which an intelligence signal is applied and to the grid of which periodic positive pulses are applied whereby the intelligence signal is passed by the triode for the duration of the pulse.

The invention will be more particularly described with reference to the accompanying drawings showing an illustrative embodiment of the invention.

In the drawings:

Fig. 1 is a block diagram of a multi-signal transmitter embodying the method and apparatus of the invention;

Fig. 2 is a block diagram of a receiving system adapted to receive and segregate the signals transmitted by the transmitter of Fig. 1;

Fig. 3 is a circuit diagram of the pulse generator of the transmission system of Fig. 1;

Fig. 4 is a circuit diagram of the bridge circuit and amplifier of the transmission system of Fig. 1, and

Figs. 5, 6 and 7 are diagrammatic representations of the relations between the source energizing voltage and the sampling pulses when the frequency of the energizing voltage is $Fn/2$, Fn and $F/2$, respectively.

The transmission system

A typical airborne transmission system is shown diagrammatically in Fig. 1. It operates at a sampling frequency F of 1111 per second. Eighteen signal channels, *n*, are provided for transmission of signals from eighteen strain gauge bridges A_1, A_2 . . . distributed at critical points on the aircraft. The switching frequency or pulse frequency, F*n*, is therefore 20,000 per second.

The pulse generator B, shown in detail in Fig. 3, provides a 10 kc. sine wave C*s* to drive the strain gauge bridges. It also provides master pulses P*a* at 1111 per second which are fed to the first switch circuit C_1 of the commutator, as well as to the transmitter D, and switching pulses P*b* at 20,000 per second which are fed to the commutator switch circuits C_1, C_2 . . . .

Corresponding to each strain gauge bridge there is a converter circuit E_1, E_2 . . . to which the segregated signal pulses P_1, P_2 . . . are fed from the corresponding switch circuits of the commutator at the rate of 1111 per second. The signal from the strain gauge bridges, amplified by the associated amplifiers F_1, F_2 . . ., as shown in detail in Fig. 4, are fed to the corresponding converters and emerge as modulated pulses S_1, S_2 . . ., having a frequency of 1111 per second and a pulse duration of $1/20{,}000$ of a second.

The modulated pulses S*a* are fed to the blanker G which broadens and clips the switching pulses and inserts them in the signal. The modulated pulses S*b* are then supplied to the transmitter D.

The receiving apparatus

A suitable form of receiving apparatus is shown in block diagram in Fig. 2. It comprises a receiver H suitable for the reception of the frequency modulated signals transmitted by the transmitter. The received signal S*b* taken from the discriminator of the receiver is fed to the amplifier I and to the pulse selector J.

The amplified signal S*c* is fed to the converters L_1, L_2 . . ., which are similar in arrangement and function to the converters E_1, E_2 . . ., of Fig. 1. The master pulse P*a* from the pulse selector is supplied to the first trigger channel K_1 of the commutator, while the switching pulses P*b* are fed in common to all of the channels of the commutator. The commutator supplies timed pulses Q_1, Q_2 . . . serially to the converters in synchronism with the individual modulated pulses from the amplifier I. These individual modulated pulses S_1, S_2 . . . are then fed to corresponding integrators M_1, M_2 . . . .

In the integrators the individual modulated pulses are grouped to form integrated signals T_1, T_2 . . ., having wave forms corresponding to the variations in the data of the instruments A_1, A_2 . . . of Fig. 1.

The pulser

An effective pulsing circuit of the multiplier type is shown in Fig. 3. It is driven by a balanced L. C. oscillator circuit **30** tuned to the sampling frequency of 1111 per second. The 1111 cycle signal from the oscillator is amplified, clipped and differentiated in circuit **31** and fed into output cathode follower **32** to give the negative master pulses P*a*.

The 1111 cycle signal is tripled in each of the resonant circuits and class C amplifiers **33, 34** to provide a 10,000 cycle signal. This signal is amplified, clipped, differentiated and rectified in circuit **35** and fed into output cathode follower **36** to give the negative switching pulses P*b* at 20,000 per second. The 10,000 cycle signal is also fed to circuit **37** to provide the 10,000 cycle sine wave C*s* used to drive the strain gauge bridges.

The phases of the switching pulses and of the 10,000 cycle bridge driving potential may be independently adjusted.

The bridge circuit

An illustrative bridge circuit and amplifier is shown in Fig. 4. In the circuit shown, each arm of the strain gauge bridge **50** may be an active gauge. The bridge is driven through a carefully shielded transformer **51**. A potentiometer **52** provides for initial bridge balancing. The bridge signal is amplified in two-stage tuned amplifier **53** with an overall gain of about ten thousand, controlled by a divider between the triode **54** and the pentode **55**.

In the method and apparatus particularly described with reference to Figs. 1–4, the duration of the positive pulses P_1, P_2 . . . from the commutators is exactly one-half the period of the 10,000 cycle bridge driving frequency, and the pulses are phased so that the sampling starts when the bridge driving voltage is approximately zero and stops when the voltage is again approximately zero a half period later. Thus, the bridge signal is sampled for half a cycle every eighteenth cycle, as shown in Fig. 5, wherein C*s* represents the instrument signal and the sampling periods S_1 are shaded.

Other relations of the sampling pulse to the instrument signal may be used advantageously. For example, by making the sampling pulse duration equal to the period of the instrument signal a complete cycle is sampled, as shown at S' in Fig. 6. If the number of intelligence channels *n* is odd instead of even, alternate or "up and down" sampling results. The latter methods have the advantage of not introducing D. C. components into the signal to be transmitted. An advantageous method of obtaining the "up and down" sampling is to energize the intelligence sources with an alternating potential having a frequency of one-half the sampling frequency F. The phase of the sinusoidal voltages in this method progresses from one intelligence source to the next so that each is sampled at a peak of the sinusoidal voltage, as shown at S'' in Fig. 7.

The amplifying, pulsing, pulse selecting, transmitting, and receiving circuits shown and described herein are merely illustrative examples which may be widely varied without departing from the principles of the invention as defined in the claims.

I claim:

1. A system for transmitting over a single channel signals from a plurality of intelligence sources comprising means for connecting said intelligence sources in cyclic serial order with a common output channel at a preselected periodic sampling frequency F for sampling periods having a duration not exceeding 1/F*n* where *n* is the number of intelligence signals to be transmitted, and means for energizing said intelligence sources with a common alternating potential having a frequency not less than one-half F and having a fixed phase relation to said sampling periods.

2. A system for transmitting over a single channel signals from a plurality of intelligence sources comprising means for connecting said intelligence sources in cyclic serial order with a common output channel at a preselected periodic sampling frequency F for sampling periods hav-

ing a duration not exceeding $1/Fn$ where n is the number of intelligence signals to be transmitted, and means for energizing said intelligence sources with a common alternating potential having a frequency of $Fn/2$ and substantially in phase with said sampling periods.

3. A system for transmitting over a single channel signals from a plurality of intelligence sources comprising means for connecting said intelligence sources in cyclic serial order with a common output channel at a preselected periodic sampling frequency F for sampling periods having a duration not exceeding $1/Fn$ where n is the number of intelligence signals to be transmitted, and means for energizing said intelligence sources with a common alternating potential having a frequency of F/2 and having a fixed phase relation to said sampling periods.

4. A system for transmitting over a single channel signals from a plurality of intelligence sources comprising means providing periodic pulses having a frequency Fn where F is the rate at which the signal from each intelligence source is to be sampled and n is a whole number not less than the number of intelligence sources to be sampled, means for energizing said intelligence sources with a common alternating potential having a frequency not less than one-half F and having a fixed phase relation to said periodic pulses, and means for modulating said periodic pulses in cyclic serial order with the signals from said energized intelligence sources.

5. In a multi-signal transmission system, means for connecting a plurality of intelligence sources in cyclic serial order with a common output channel at a preselected periodic sampling frequency F for sampling periods having a duration not exceeding $1/Fn$ where n is the number of intelligence signals to be transmitted, and means for energizing said intelligence sources with a common alternating potential having a frequency not less than one-half F and having a fixed phase relation to said sampling periods.

6. In a telemetering system, a plurality of instruments adapted to modulate a potential applied thereto in response to variations in a physical quality, means for connecting said instruments in cyclic serial order with a common output channel at a preselected periodic sampling frequency F for sampling periods not exceeding $1/Fn$ where n is the number of said instruments, and means for applying to said instruments a common alternating potential having a frequency not less than one-half F and having a fixed phase relation to said sampling periods.

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