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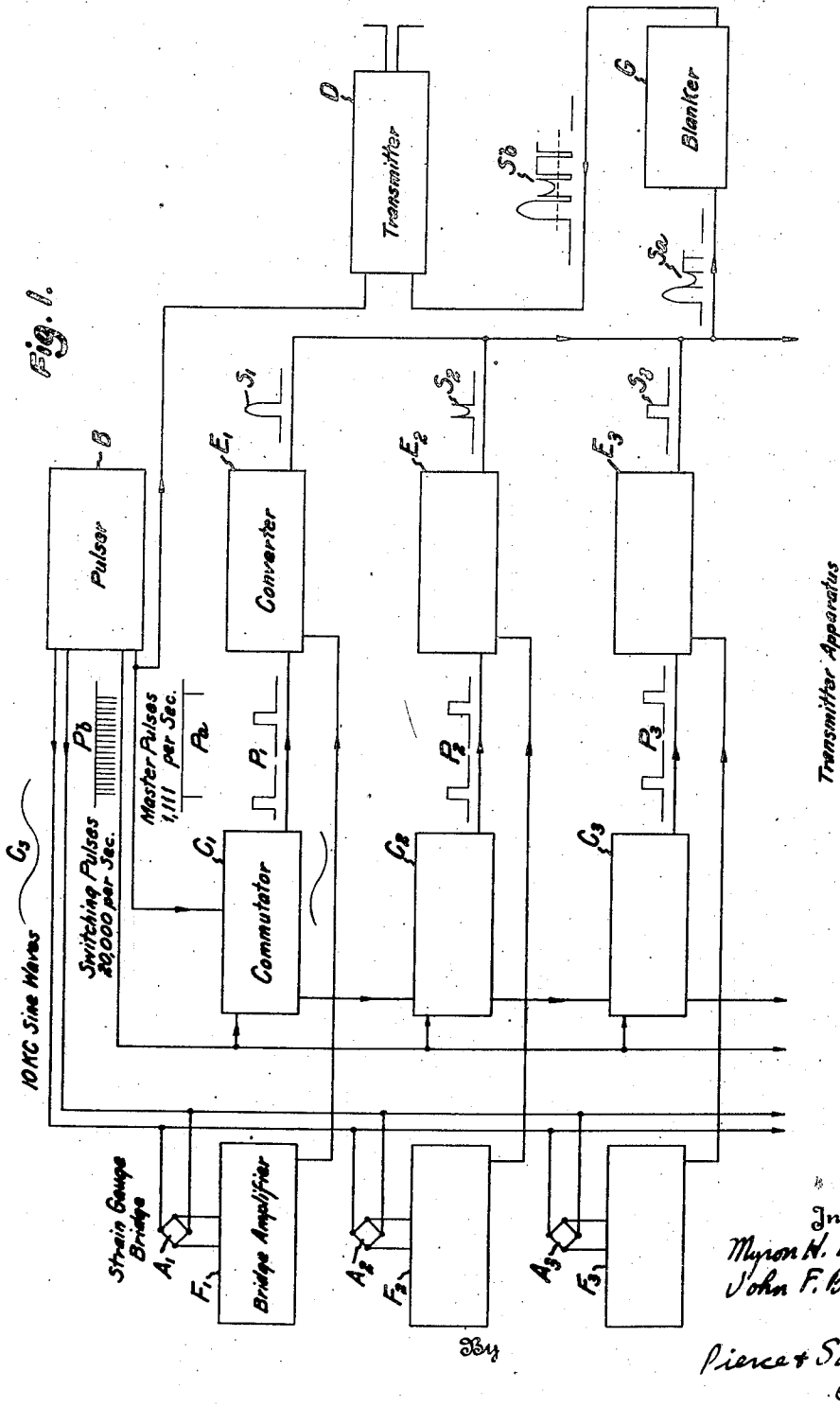
M. H. NICHOLS ET AL

2,444,950

MULTISIGNAL TRANSMISSION SYSTEM

Filed Oct. 30, 1945

8 Sheets-Sheet 1



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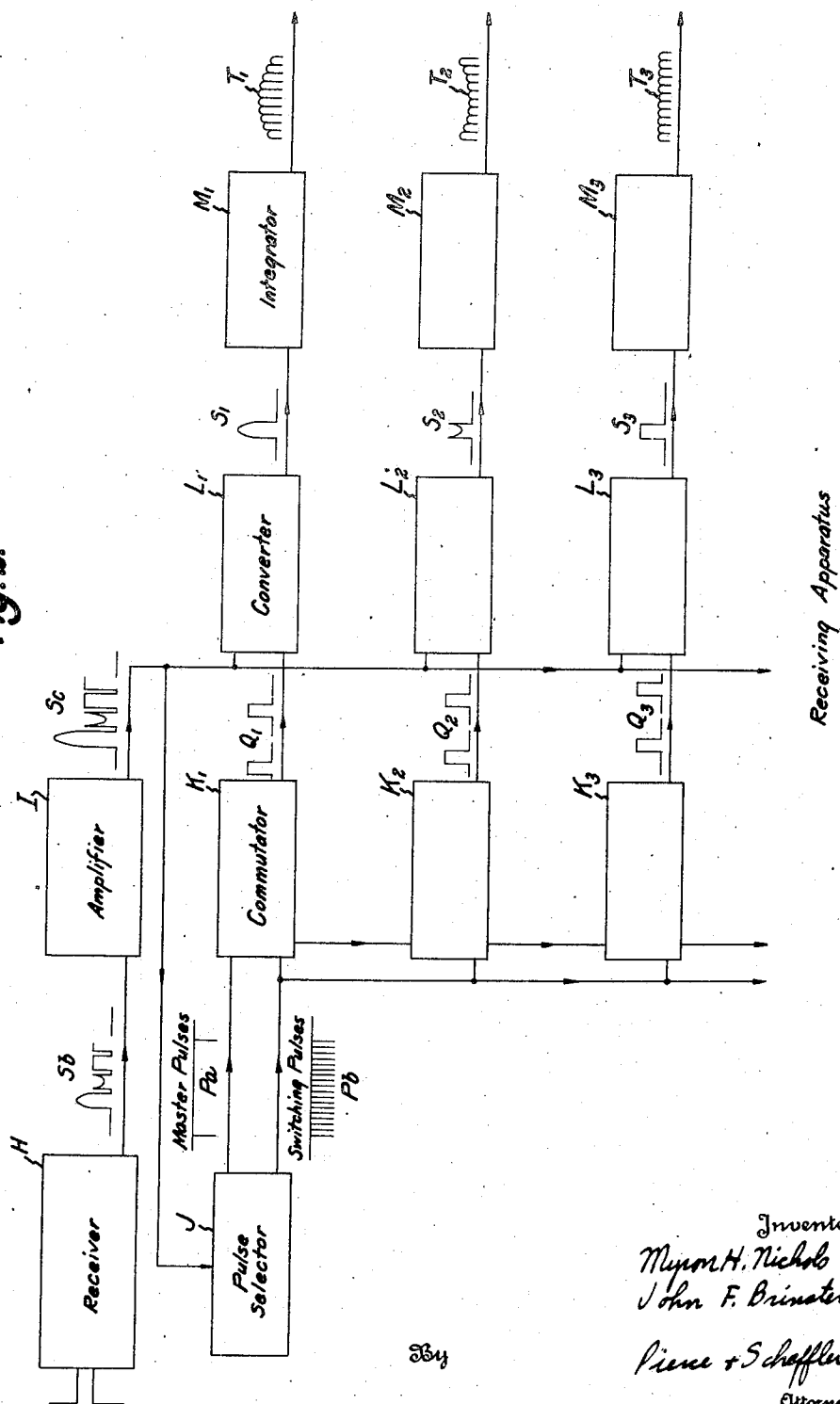
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Fig. 3



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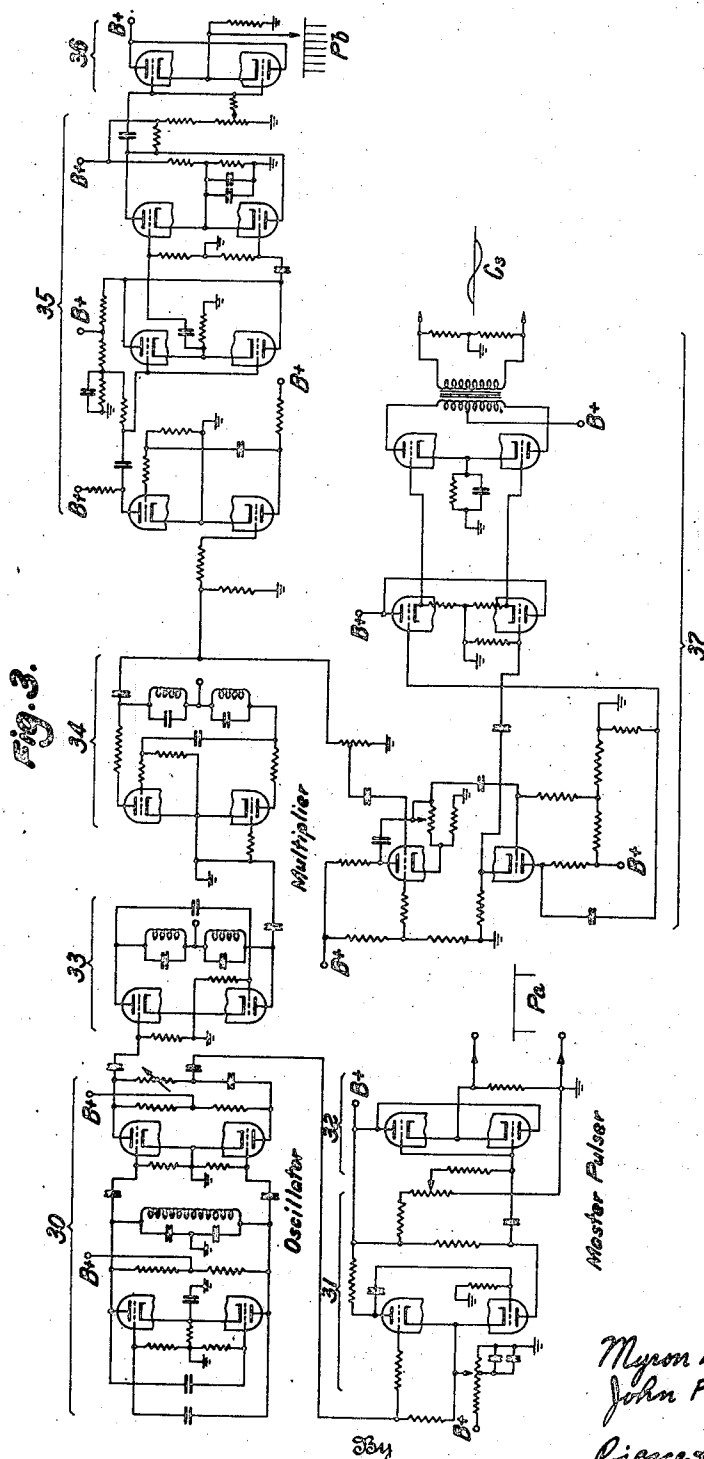
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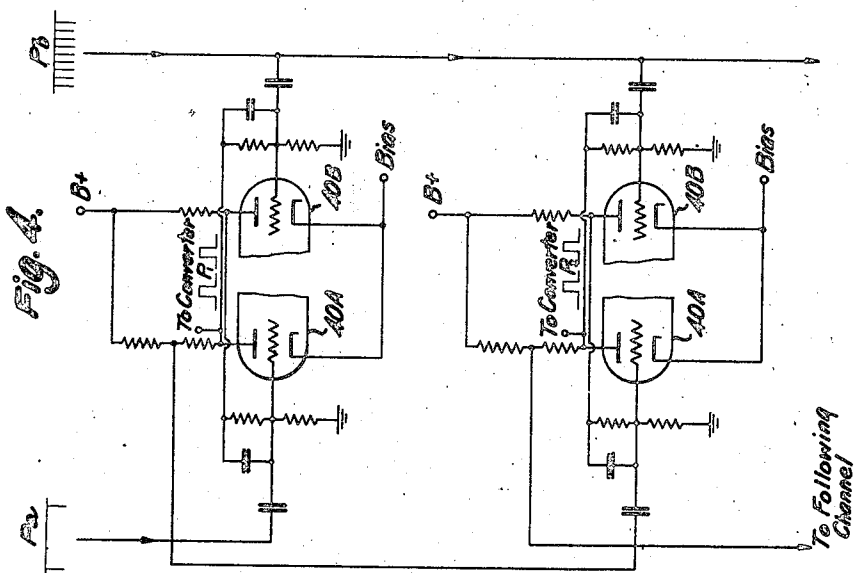
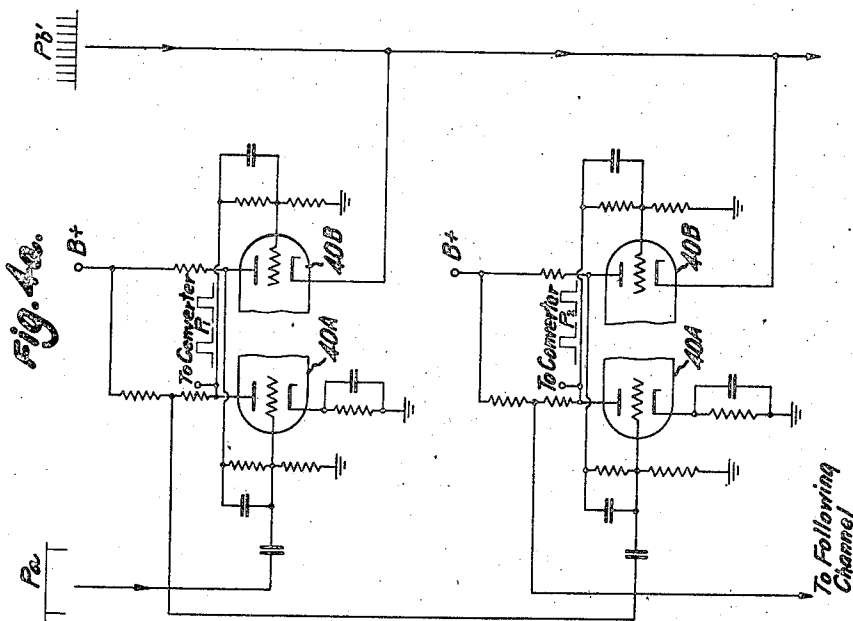
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MULTISIGNAL TRANSMISSION SYSTEM

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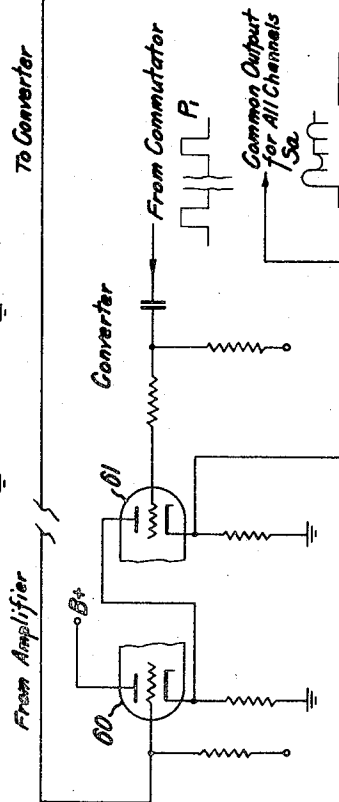
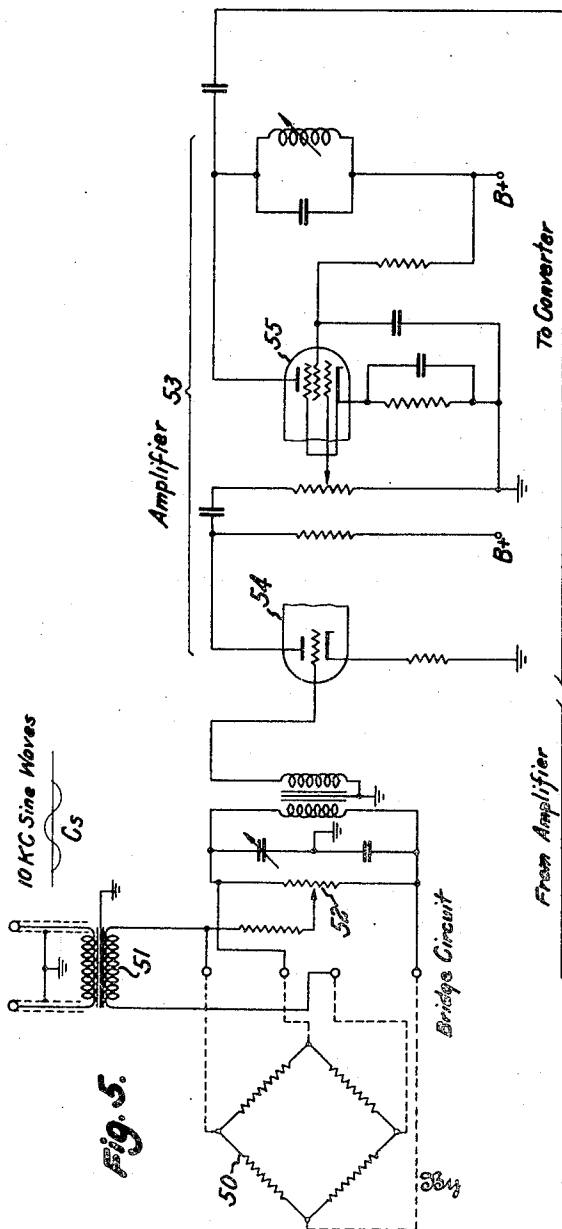
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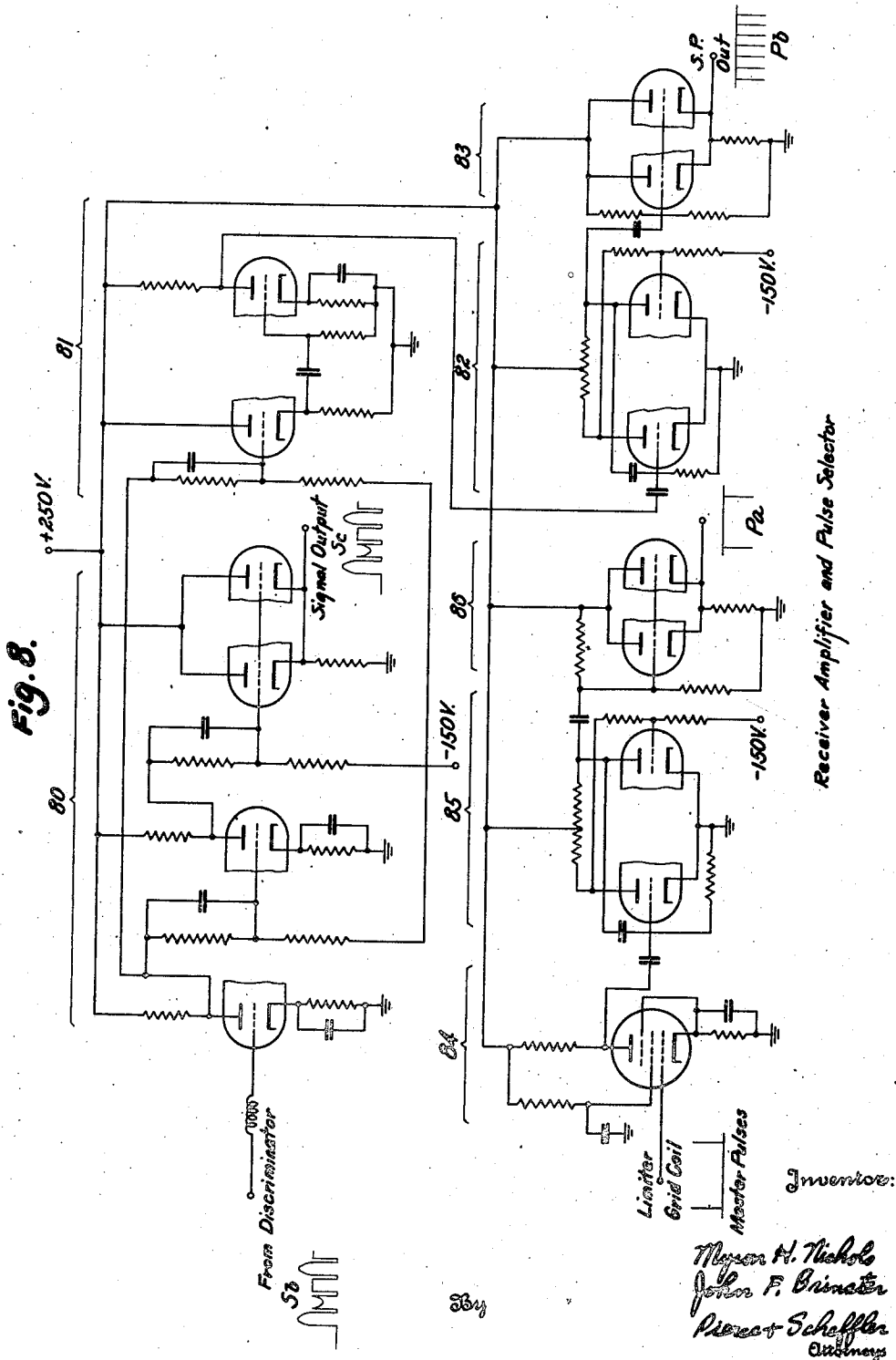
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MULTISIGNAL TRANSMISSION SYSTEM

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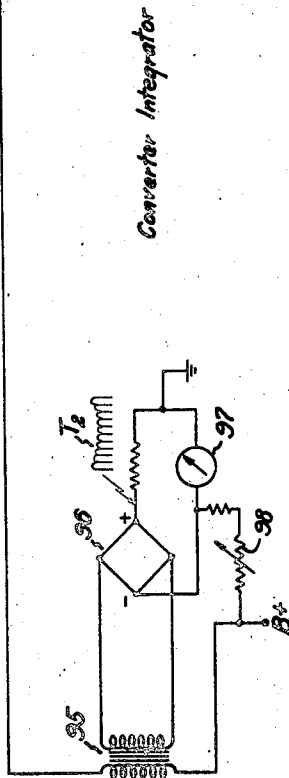
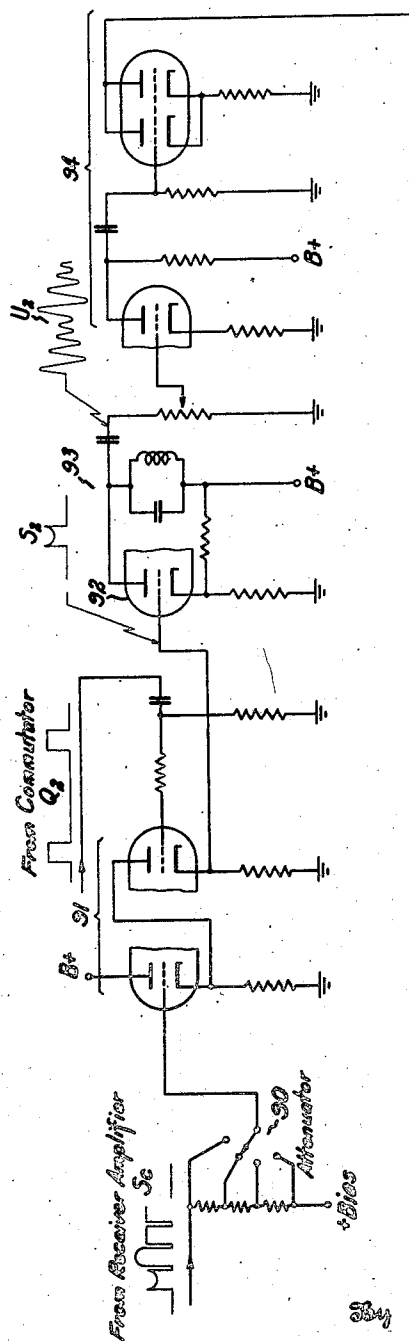
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MULTISIGNAL TRANSMISSION SYSTEM

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Fig. 9.



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UNITED STATES PATENT OFFICE

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MULTISIGNAL TRANSMISSION SYSTEM

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Application October 30, 1945, Serial No. 625,590

6 Claims. (Cl. 177—351)

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The invention relates to a multi-signal transmission system.

An object of the invention is the provision of a system for the transmission of a plurality of signals over a single radio channel.

Another object of the invention is the provision of an electronic commutator adapted to connect in cyclic serial order a plurality of signal channels with a single output channel for transmission, observation or recording.

A further object of the invention is the provision of a system for the transmission of a plurality of data from moving vehicles, such as aircraft, to a fixed station where the data can be recorded.

Other objects and advantages of the invention will be apparent from the following detailed description.

The transmission system of the invention is particularly advantageous for transmitting data, such as instrument readings, strain gauge and accelerometer indications and the like to ground stations for recording and, for the purpose of illustrating the principle 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.

The transmission system of the invention comprises an electronic commutator adapted to connect in cyclic serial order a plurality of 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 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 of the invention is 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 the signal channels.

The invention will be more particularly de-

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scribed with reference to the accompanying drawings showing an illustrative embodiment of the invention.

In the drawings:

5 Fig. 1 is a block diagram of a multi-signal transmitter embodying the principles of the invention;

Fig. 2 is a block diagram of a receiving system adapted for receiving and segregating the signals transmitted by the transmitter of Fig. 1;

10 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 commutator of the invention;

15 Fig. 4a is a circuit diagram of a modified form of the commutator;

Fig. 5 is a circuit diagram of the bridge circuit and amplifier of the system of Fig. 1;

20 Fig. 6 is a circuit diagram of the signal converter or modulator;

Fig. 7 is a diagram of the blanker circuit of the transmission system;

25 Fig. 8 is a diagram of the amplifier and pulse selector circuits of the receiving system of Fig. 2, and

Fig. 9 is a circuit diagram of the converter integrator of the receiving system.

The transmission system.

30 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 $A_1, A_2 \dots$ 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, shown in detail in Fig. 4, 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 $C_1, C_2 \dots$

Corresponding to each strain gauge bridge there is a converter circuit $E_1, E_2 \dots$, shown in detail in Fig. 4, to which the segregated signal pulses $P_1, P_2 \dots$ are fed from the corresponding switch circuits of the commutator at the rate of 1111 per second. The signals from the strain gauge bridges, amplified by the associated amplifiers $F_1, F_2 \dots$, are fed to the corresponding converters and emerge as modulated pulses $S_1, S_2 \dots$, having a frequency of 1111 per second and a pulse duration of $\frac{1}{20000}$ of a second.

The modulated pulses S_a are fed to the blanker G which broadens, and clips, the switching pulses

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and inserts them in the signal. The modulated pulses Sb are then supplied to the transmitter D.

The pulser

An effective pulsing circuit of the multiplier type is shown in Fig. 3. It is driven by a balanced LC 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 Pa.

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 Pb at 20,000 per second. The 10,000 cycle signal is also fed to circuit 37 to provide the 10,000 cycle sine wave Cs used to drive the strain gauge bridges.

The commutator

The commutator of the invention consists of a series of trigger circuits corresponding in number to the signal channels. The first two trigger circuits of the series are shown in Fig. 4. Each circuit comprises two triodes 40A, 40B. The switching pulses Pb are fed in common to every circuit. The first trigger circuit is fired by a master pulse Pa applied to the grid of tube 40A and is turned off by the subsequent switching pulse Pb applied to the grid of tube 40B. When the trigger circuit is turned off, a pulse is fed to the next trigger circuit in the series which fires that circuit and so on through the series. The signal pulses P₁, P₂ . . . taken off the plates of tubes 40A are fed to the corresponding converters. The signal pulses from each trigger circuit in the example illustrated are $\frac{1}{20000}$ of a second in duration and are $\frac{10}{20000}$ of a second apart. The signal pulse from each succeeding circuit follows immediately after the pulse from the preceding circuit in the series.

Since the first circuit of the series is fired only by the master pulses Pa, multiple switching cannot occur, as one complete sequence occurs between each master pulse. The master pulses thus effectively synchronize the signal pulse generation.

An advantageous modification of the commutator circuit is shown in Fig. 4a. In this form of the commutator positive switching pulses Pb' are supplied in common to the cathodes of tubes 40B, whereby they shut off that one of the trigger circuits which is firing thereby causing the generation of a pulse which fires the next circuit as in Fig. 4. The signal pulses P₁, P₂ . . . are taken from the plates of tubes 40A as in Fig. 4.

The bridge circuit

An illustrative bridge circuit and amplifier is shown in Fig 5. 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.

The converter

The output of the bridge amplifier is fed into the corresponding converter, shown in Fig. 6.

The converter comprises a double triode. The first triode unit 60 acts as a cathode follower which drives the plate of the second triode unit 61. The positive signal pulses P₁ tend to drive the grid positive but the grid resistances in unit 61 limit it to only a slightly positive value relative to the cathode. The tube thus acts simply as a resistance of finite value when the positive pulses occur but of very large value at other times. The cathode resistor of triode unit 61 is common to all channels and forms the common output to which all the channels feed the consecutive modulated signal pulses Sa for the radio transmission. In the specific embodiment of the invention shown in the figures, the duration of the positive pulses P₁, P₂ . . . from the converter 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 passing through zero and stops when the voltage is again passing through zero a half period later. Thus the bridge signal is sampled for half a cycle every eighteenth cycle. Other relations of the commutator pulse to the instrument signal may be used effectively. By making the commutator pulse duration equal to the period of the instrument signal a complete cycle is sampled. If the number of channels is odd instead of even, alternate or "up and down" sampling results. This has the advantage of not introducing D. C. components into the signal to be transmitted.

The blanker

When the receiving system includes a commutator for segregating the signals of the individual signals, the switching pulses should be transmitted. These may be introduced into the signal to be transmitted by the blanker shown in Fig. 7. This includes two double triode saturated amplifiers 70, 71 which broaden and clip the switching pulses. The widened pulses Pb are combined in blanker 72 with the signal Sa from the converter to provide a signal Sb. Blanker 72 is similar to the converter circuit shown in Fig. 6. On account of the cut-off action of the input cathode follower of the converter, the modulation from the strain gauges can never pass below the dashed line in the output signal from Sb. The pulses which extend below the dashed line are selected at the receiver for the switching pulses. The separation of the modulated pulses effected by the blanker also reduces the band width required of the transmitter in that it reduces the tendency of the channels to overlap.

A signal of this type can advantageously be transmitted by a reactance tube frequency modulated transmitter with a frequency swing of about 125 kilocycles at a carrier frequency of 69 mc. The master pulses for operating the receiving commutator may be inserted as amplitude modulation into the radio frequency carrier of the transmitter by feeding the master pulses through a cathode follower into the multiplier stage of the transmitter. This cuts off the carrier for a very short period and provides a pulse which can be extracted from the limiter of the receiver.

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 Sb taken from the discriminator of the receiver is fed to the

amplifier I and to the pulse selector J, shown in circuit diagram in Fig. 8.

The amplifier signal Sc is fed to the converters L₁, L₂ . . . , which are similar in arrangement and function to the converters described in connection with Fig. 6. The master pulse A from the pulse selector is supplied to the first trigger channel K₁ of the commutator, while the switching pulses B are fed in common to all of the channels of the commutator. The commutator is the same in arrangement and operation as the commutator described in connection with Fig. 4. It supplies timed pulses Q₁, Q₂ . . . serially to the converters in synchronism with the individual modulated pulses from the amplifier I. These individual modulated pulses S₁, S₂ . . . are then fed to corresponding integrators M₁, M₂ . . . , shown in detail in Fig. 9.

In the integrator the individual modulated pulses are grouped to form integrated signals T₁, T₂ . . . , having wave forms corresponding to the variations in the data of the instruments A₁, A₂ . . . of Fig. 1.

The receiver amplifier and pulse selector

The signal Sb from the discriminator of the receiver is fed to the direct coupled amplifier 80 of Fig. 8 where it is amplified with a gain of about 10 to give signal Sc which is supplied to the converters. From the amplified signal Sc the switching pulses are selected by feeding the signal to a saturated amplifier 81 which cuts off the intelligence part of the signal occurring above dashed line in signal Sb in Fig. 7. The pulses so obtained trigger circuit 32 which puts out the switching pulses B through a cathode follower 83.

The master pulses are taken from the limiter grid coil of the receiver, clipped in circuit 84 and fed into trigger circuit 35 which puts out the master pulses A through cathode follower 86.

Converter and integrator

A circuit diagram of the converter and integrator is shown in Fig. 9.

The output signal Sc of the receiver amplifier is fed, through an attenuator 90 which adjusts the intelligence level, to the converter of which the second channel 91 is shown in the figure. The segregated modulated pulse S₂ from the converter is fed through triode 92 to an LC circuit 93 tuned to about 7 kc. This tuned circuit oscillates freely, dying off exponentially until the next pulse strikes, as shown at U₂. This prolongs each pulse and also provides a signal which can easily be amplified by RC amplifier 94 and matched through transformer 95 to the low impedance copper oxide rectifier 96. Since the pulses from the converters are always positive, there is a D. C. component always present in the output T₂ to the recording galvanometer 97. This is balanced out by current taken through series resistance 98 from a dry battery.

Other types of integrator circuits may be used and the individual signal channels of the received signal may be segregated and integrated by other means than those shown.

For example, the received signal Sb may be impressed upon one or more cathode ray tubes, the sweep circuits of which are synchronized by the master pulses Pt. The individual signals may be segregated on the cathode ray tube screens by suitable masks and integrated, for example, by photographing the segregated trace on a film moving at a suitable speed. This aspect of inven-

tion is more particularly claimed in application Serial No. 643,320, of Myron H. Nichols, filed January 20, 1946.

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.

The signal converter of the system described herein is more particularly claimed in application Serial No. 640,080 of John F. Brinster and Jack Larsen, filed November 21, 1945, and the bridge energization system described herein is more particularly claimed in application Serial No. 632,578 of Lawrence Lee Rauch, filed December 3, 1945.

We claim:

1. A multi-signal transmission system comprising means providing periodic pulses having a frequency F equal to the rate at which each signal is to be sampled, means providing periodic pulses synchronized with said first pulses and having a frequency F_n where n is a whole number not less than the number of signals to be transmitted, a plurality of switch circuits corresponding in number to the several signals to be transmitted and interconnected in a linear series so that shutting off of any one of said switch circuits except the last switch circuit in the series actuates the next switch circuit in the series, means energized by said periodic pulses of frequency F to actuate the first switch circuit of said series, means connecting said periodic pulses of frequency F_n to said switch circuits in common to shut off the one of said switch circuits which is active upon arrival of a pulse, means for modulating the successive pulses from said switch circuits successively with the several signals to be transmitted, and means for transmitting the modulated pulses over a single channel.

2. A multi-signal transmission system comprising means providing periodic pulses having a frequency F equal to the rate at which each signal is to be sampled, means providing periodic pulses synchronized with said first pulses and having a frequency F_n where n is a whole number not less than the number of signals to be transmitted, a plurality of switch circuits corresponding in number to the several signals to be transmitted and interconnected in a linear series so that shutting off of any one of said switch circuits except the last switch circuit in the series actuates the next switch circuit in the series, means energized by said periodic pulses of frequency F to actuate the first switch circuit of said series, means connecting said periodic pulses of frequency F_n to said switch circuits in common to shut off the one of said switch circuits which is active upon arrival of a pulse, means for modulating the successive pulses from said switch circuits successively with the several signals to be transmitted, and means for transmitting the modulated pulses and the pulses of frequency F over a single channel.

3. A system for metering at a distance a plurality of vehicle-borne sources of intelligence comprising a vehicle-borne transmitting assembly including means providing periodic pulses having a frequency F equal to the rate at which the signal from each intelligence source is to be sampled, means providing periodic pulses synchronized with said first pulses and having a frequency F_n where n is a whole number not less than the number of signals to be transmitted, a plurality of switch circuits corresponding in number to the several signals to be transmitted and inter-

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connected in a linear series so that the shutting off of any one of said switch circuits except the last switch circuit in the series actuates the next switch circuit in the series, means energized by said periodic pulses of frequency F to actuate the first switch circuit of said series, means connecting said periodic pulses of frequency F_n to said switch circuits in common to shut off the one of said switch circuits which is active upon arrival of a pulse, means for modulating the successive pulses from said switch circuits successively with the several signals to be transmitted, and means for transmitting the modulated pulses and the pulses of frequency F over a single radio channel; and a receiving station assembly comprising a radio signal receiver tunable to said transmitting means, means for separately selecting from the received signal said periodic pulses of frequency F and periodic pulses of frequency F_n , a plurality of switch circuits connected in linear series corresponding in number and arrangement to the switch circuits of the transmitting assembly, means connecting the periodic pulses of frequency F to the first switch circuit in said series, means connecting the periodic pulses of frequency F_n in common to all of the switch circuits of said series, means actuated by the successive pulses from said switch circuits for transmitting in succession the successive modulated pulses of the received signal to a plurality of intelligence recording devices corresponding to the several sources of intelligence sampled by the transmitting assembly.

4. A system for metering at a distance a plurality of vehicle-borne sources of intelligence comprising a vehicle-borne transmitting assembly including means providing periodic pulses having a frequency F equal to the rate at which the signal from each intelligence source is to be sampled, means providing periodic pulses synchronized with said first pulses and having a frequency F_n where n is a whole number not less than the number of signals to be transmitted, a plurality of switch circuits corresponding in number to the several signals to be transmitted and interconnected in a linear series so that the shutting off of any one of said switch circuits except the last switch circuit in the series actuates the next switch circuit in the series, means energized by said periodic pulses of frequency F to actuate the first switch circuit of said series, means connecting said periodic pulses of frequency F_n to said switch circuits in common to shut off the one of said switch circuits which is active upon arrival of a pulse, means for modulating the successive pulses from said switch circuits successively with the several signals to be transmitted, and means for transmitting the modulated pulses and the pulses of frequency F over a single radio channel; and a receiving station assembly comprising a radio signal receiver tunable to said transmitting means, means for selecting from the received signal said periodic pulses of frequency F , and means actuated by said pulses of frequency F for segregating the received signal into periods synchronic with said pulses.

5. A system for metering at a distance a plurality of vehicle-borne sources of intelligence comprising a vehicle-borne transmitting assembly including means providing periodic pulses having a frequency F equal to the rate at which

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the signal from each intelligence source is to be sampled, means providing periodic pulses synchronized with said first pulses and having a frequency F_n where n is a whole number not less than the number of signals to be transmitted, a plurality of switch circuits corresponding in number to the several signals to be transmitted and interconnected in a linear series so that the shutting off of any one of said switch circuits except the last switch circuit in the series actuates the next switch circuit in the series, means energized by said periodic pulses of frequency F to actuate the first switch circuit of said series, means connecting said periodic pulses of frequency F_n to said switch circuits in common to shut off the one of said switch circuits which is active upon arrival of a pulse, means for modulating the successive pulses from said switch circuits successively with the several signals to be transmitted, and means for transmitting the modulated pulses and the pulses of frequency F over a single radio channel; and a receiving station assembly comprising a radio signal receiver tunable to said transmitting means, means for selecting from the received signal said periodic pulses of frequency F , means actuated by said pulses of frequency F for segregating the received signal into periods synchronic with said pulses, and means for integrating the segregated signal periods.

6. A commutator for periodically interconnecting a plurality of intelligence circuits successively with a common transmission circuit comprising means providing periodic synchronizing pulses of frequency F equal to the rate at which each intelligence circuit is to be connected with the transmission circuit, means providing periodic switching pulses of frequency F_n where n is an integer not less than the number of intelligence circuits, a plurality of electronic switch circuits corresponding in number to the intelligence circuits and interconnected in a linear series so that shutting off of any one of said switch circuits except the last switch circuit in the series actuates the next switch circuit in the series, means energized by said periodic synchronizing pulses to actuate the first switch circuit of said series, means connecting said periodic switching pulses to said switch circuits in common to shut off the one of said switch circuits which is active upon arrival of a pulse, and electronic circuits corresponding in number to said intelligence circuits severally connected to said intelligence circuits and said switch circuits and connected in common to said transmission circuit and successively actuated by impulses from the corresponding switch circuits to interconnect said intelligence circuits in cyclic succession with said transmission circuit.

MYRON H. NICHOLS.
JOHN F. BRINSTER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,378,395	Dickson	June 19, 1945
2,381,920	Miller	Aug. 14, 1945
2,403,890	Johnson	July 9, 1946

Patent No. 2,444,950.

July 13, 1948.

MYRON H. NICHOLS ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Column 6, line 12, for "Serial No. 640,080" read *Serial No. 630,080*; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of September, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

Certificate of Correction

Patent No. 2,444,950.

July 13, 1948.

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[**SEAL**]

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