April 16, 1946. J. O'D. SHEPHERD 2,398,755

COMMUNICATION SYSTEM

Filed June 17, 1943 2 Sheets-Sheet 1

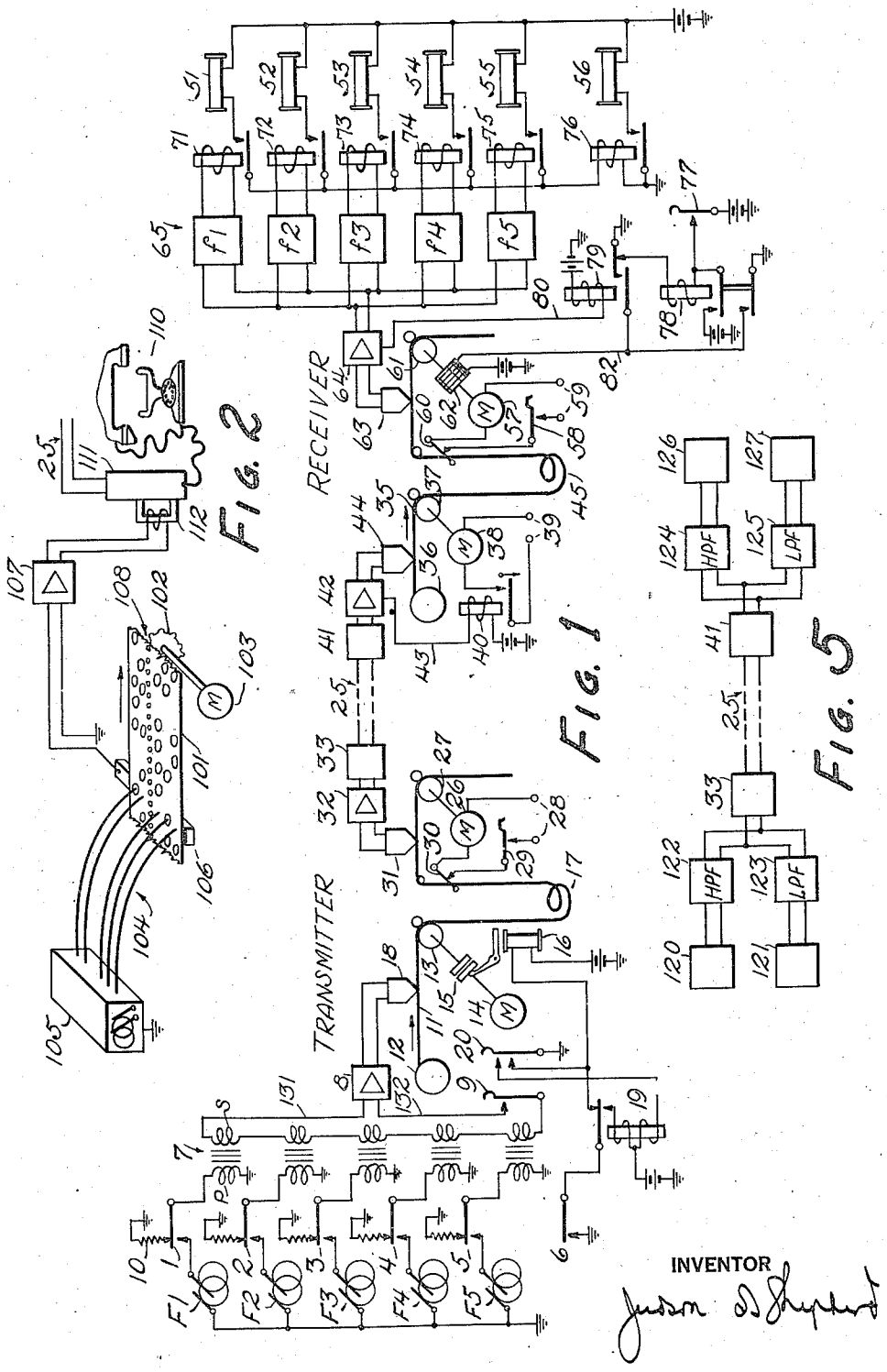


Fig. 1

Fig. 2

Fig. 5

April 16, 1946. J. O'D. SHEPHERD 2,398,755

COMMUNICATION SYSTEM

Filed June 17, 1943 2 Sheets-Sheet 2

FIG. 3

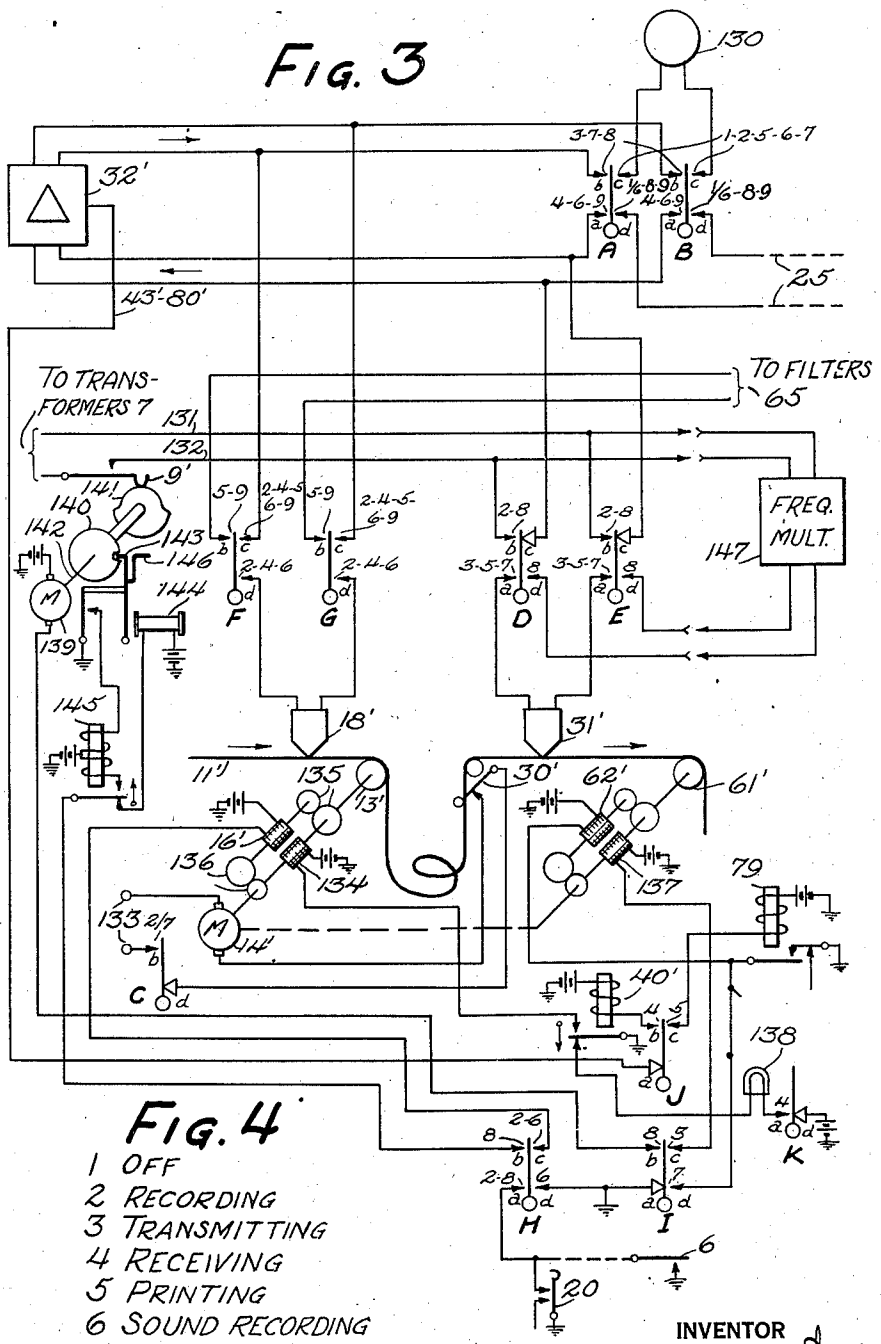


FIG. 4

1 OFF
2 RECORDING
3 TRANSMITTING
4 RECEIVING
5 PRINTING
6 SOUND RECORDING
7 SOUND REPRODUCING
8 SEND DIRECT
9 RECEIVE DIRECT

INVENTOR
Judson O'D Shepherd

Patented Apr. 16, 1946 2,398,755

UNITED STATES PATENT OFFICE

2,398,755

COMMUNICATION SYSTEM

Judson O'D. Shepherd, Atlanta, Ga.

Application June 17, 1943, Serial No. 491,087

24 Claims. (Cl. 179—4)

This invention relates to communication systems, particularly those in the field of teletypewriting and the like.

Conventional teletypewriter practice usually employs a transmitting machine and one or more receiving printers. The pressure of a keyboard key sets up signal conditions in accordance with a five place code. A start signal is then transmitted which starts distributors or the equivalent rotating in synchronism at the sending and receiving stations. The sending distributor transmits the signal conditions as marking or spacing impulses in sequence and the receiving station, by virtue of the synchronous operation of the distributors or the like, converts these sequential signals into a simultaneous signal condition for effecting printer operations.

The transmission of each character or machine operation requires at least two translations of the designating signal. Depression of a key sets up a simultaneous complex code combination. The characteristic of a conventional telegraph circuit requires this simultaneous complex code be spread out with respect to time so that it may be transmitted as simple current conditions of the marking and spacing type. At the receiving station these time-spaced impulses are accumulated and presented to a sensing or selecting mechanism as a complex code combination. It will be recognized that with a five place code the translation from a simultaneous to a time-spaced and back to a simultaneous code would be unnecessary if five separate signal channels are employed. In this case the complex simultaneous code could be transmitted and received as such.

One of the features of this invention is the transmission of character signals from the sending to the receiving station as simultaneous code combinations. This is effected by employing five (or more) frequency channels in the voice frequency range. Each character signal comprises one or more of five different frequencies with filter arrangements at the receiving station to separate the channels to effect the printer operations. Inasmuch as the signal frequencies are in the voice frequency range, a conventional telephone circuit may be employed for transmitting telegraph messages. This circuit may be of the commercial type used for telephone service as, for example, a local connection through one or more central offices and/or private branch exchanges, a toll connection over any suitable intertoll circuit such as a carrier channel, physical circuit or radio link, or a private line telephone circuit. Any two telephone stations in the world equipped in accordance with this invention and which may be interconnected telephonically may be employed for transmission and reception of written messages.

The transmission of the several code elements simultaneously will enable each complete character to be sent in approximately the same length of time as required for the transmission of each elemental signal of the conventional sequential code without decreasing the length of the individual signal elements. Omitting for the moment the limitation of sending and receiving machine speeds, such a rapid rate of transmission, or the even more rapid one considered below, would enable the economical use of relatively costly telephone facilities for telegraph purposes since the holding time would be much shorter than feasible with conventional telegraph circuits.

Where a speed of signal transmission is employed which is too high for production by direct operation of a keyboard and/or for the direct operation of a teletypewriter printer, it is necessary, in order to make the most effective use of the transmission channel, to divorce the keyboard and printer with respect to time from the communication circuit. That is, the keyboard may be operated at one speed, transmission effected at a much higher speed and the printer actuated at a reduced speed which may be in the order of the keyboard speed. Another feature of this invention is the method of and means for the accomplishment of this result. In the preferred embodiment of this invention, the character signals are frequency combinations which are recorded on a record medium which is driven at a certain speed. A communication channel such as a telephone circuit is established to a distant receiving station provided with a recorder. The record at the sending station is driven at, say, five or ten times the speed of recording and the signals are reproduced therefrom. These are transmitted to the receiving station where they are recorded at preferably the same speed as they are transmitted. It will be recognized that if the reproduction at the sending station is at five times the speed of recording, for example, the transmission time will be one-fifth as long as the recording interval and the frequencies of the signal elements will be five times as high as those recorded. The distant medium bearing the record of received signals may then be driven at substantially the recording speed at the transmission station and signals reproduced therefrom to operate a printer at substantially the speed at which the original record was made.

Still another feature of this invention are ar-

rangements whereby a telephone connection may be established over commercial telephone facilities and the connection employed in part for a telephone conversation and in part for transmission of a telegraph message at high speed. The telephone conversation and telegraph message transmission may be either in sequence or simultaneous. In the latter case a portion of the voice frequency spectrum is employed for the telegraph channel by filter arrangements to separate it from the telephone frequency band.

Teletypewriter exchange service is now commercially furnished from special switchboards to which patrons provided with teletypewriters are connected, usually by independent cable pairs. These switchboards are interconnected by telegraph channels which enable a nationwide switched telegraph service to be furnished. It will be recognized that this generally parallels on a smaller scale the nationwide telephone facilities. One of the principal features of this invention is that it permits a nationwide teletypewriter service to be offered as an adjunct to telephone service and without special central office switchboards, inter-exchange telegraph channels and separate telegraph loops between the central offices and the patrons' premises. By merely equipping commercial telephone stations with apparatus in accordance with this invention, switched exchange and toll telegraph service may be furnished between them without any special central office, trunk or intertoll facilities whatever above those normally provided for telephone service. It may further be observed that with sufficient speed of message transmission the higher tolls for telephone in comparison with telegraph channels per minute of use may be completely or more than offset. With a five to one telegraph transmission speed, a connection may be established and used for two minutes for a telephone conversation and one minute for transmission of a high speed telegraph message, in which time a message five minutes long at normal speed may be sent.

The provision of telegraph arrangements in accordance with this invention in conjunction with commercial telephone service may be effected, as a feature of this invention, without physical connection between the telephone instrument and the telegraph apparatus. Means are well known which will permit the inductive coupling of the two sets. It also is apparent that they may be acoustically coupled.

One embodiment of this invention sets out arrangements whereby high speed or direct telegraph operation may be selectively employed. The latter corresponds generally to conventional teletypewriter practice and permits two-way written communications such as questions and answers.

An additional feature of this invention is that relatively inexpensive recorders may be provided at a comparatively large number of telephones in a business or other large organization. If, incident to a telephone conversation, it is desirable to record a telegraph message this may be done with the associated recorder. The record may then be sent to separate printer arrangements such as contemplated herein for transcription.

Likewise, a comparatively inexpensive recorder-transmitter may be provided which will permit telegraph messages to be sent back to a center. Such a recorder-transmitter in portable form would enable newspaper reporters on assignments, for example, to prepare and transmit copy over conventional telephone facilities to their papers or agencies at high speed. Another example of such application is in connection with commercial telegraph service where the customers may be provided with a recorder-transmitter so that they can prepare messages and transmit them to the telegraph office over a commercial telephone circuit for retransmission over usual telegraph facilities. Arrangements are set out herein which will enable the frequency character signals to be automatically translated into conventional teletypewriter signals or punched teletypewriter tape without decoding. This will enable a frequency record to be made of a message at the telegraph office and that record employed to actuate conventional telegraph arrangements.

A still further feature is the provision of multiplex telegraphy using a telephone circuit. This may be effected by making a plurality of message records in accordance with this invention, simultaneously translating them at different speeds into electrical frequency signals, combining them and transmitting them simultaneously over a single communication circuit. Filter arrangements enable each band of signals to be separated and separately recorded. By reproducing each record at an appropriate speed, each may be printed. A further modification of the latter arrangement enables a single record to be made at the receiving point and effecting the printing of the separate channels by reproducing the record successively at different speeds to provide signals of appropriate frequencies for the filters associated with the printer.

Still another feature of this invention is inclusion of arrangements for recording telephone conversations. Inasmuch as the recording arrangements provided for use in conjunction with transmission and receipt of telegraph messages are provided to record frequencies in the voice range, they may be employed to make a record of telephone conversations.

Additional features will be understood from the drawings and specification.

Illustrative embodiments of this invention are set out schematically by two sheets of drawings including five figures as follows:

Figure 1 shows a transmitting and a receiving station for telegraphic communication,

Figure 2 indicates arrangements which may be used for translating conventional teletypewriter perforated message tape into frequency combination signals and impressing them on a conventional telephone circuit,

Figure 3 shows a combined transmitter and receiver which may be used, together with certain special features,

Figure 4 is a list of functions of Figure 3 which are selectable, and

Figure 5 shows a multiplex arrangement which may be employed with this invention.

Figure 1 shows schematically a transmitting and receiving station interconnected by conventional telephone line **25**.

A keyboard machine which may be similar to the simultaneous code producing elements of a conventional teletypewriter of familiar type is provided at the transmitter. It has five keyboard contacts **1** to **5**, inclusive, which are actuated in accordance with a five place code, which may be the conventional teletypewriter code, in response to the depression of any character or

operation designating keyboard key. Contacts 6 are closed upon operating any keyboard key and provide a start signal. Keyboard machines adapted to provide the above operations are known to the art so the showing of one here is considered unnecessary for the clear understanding of this invention.

Reference below will be made to characters. It will be understood that the term characters may be generic of information units transmitted and may mean letters, numerals or machine operations generally known as stunts.

Sources of five different frequencies are indicated schematically as F1 to F5, inclusive. These sources may be inductor alternators, oscillators, vibrators or any other appropriate means for producing regulated frequencies, preferably pure sine waves. These are connected individually to front contacts of the keyboard contacts so that the operation of any key will connect one or more of the sources to a frequency combining circuit. This combining circuit may consist of five transformers similar to 7 with their primaries connected individually to the keyboard contacts. The secondaries are connected in series to amplifier 8 through contacts 9, when the latter are closed, and conductors 131 and 132. Each keyboard contact is normally connected to a resistance of which 10 is shown so connected to contact 1. This provides an idle circuit termination for the primaries of the transformers such as 7 so that the impedance characteristic of the secondary circuit will be substantially constant during character transmission irrespective of the number of keyboard contacts operated. It will be understood that any suitable frequency combining circuit and means may be employed.

Means are provided to make a record of the character designating signals. This comprises a recording arrangement of any suitable type including a record medium. This medium may be a disc or cylinder record, a magnetic tape or wire, a birefringent or optically active filament such as set out by my pending application Serial Number 423,450, filed December 18, 1941, a photographic film or any other suitable type having recording and reproducing response for the frequency ranges contemplated below. It will be understood that the recording and reproducing element or elements used will be appropriate for the type of record medium employed, and that different types may be used at the transmitting and the receiving stations. It will be assumed, for the purpose of this description, that a magnetic tape or wire will be used for a record medium since such arrangements are so well known, although the birefringent filament arrangement mentioned may be economically and otherwise preferable. It is designated 11 and supplied from reel 12. It is driven by pulley 13 which, in turn, is driven by constant speed motor 14 when clutch 15 is engaged. The latter may be engaged by energizing magnet 16. The medium 11 bearing a signal record is accumulated in any suitable manner as, for example by a loop, coil or the like at 17, or it may be wound on a takeup reel.

The output of amplifier 8 actuates the recording element 18 which is appropriate for the recording medium employed, which, in this illustrative case, is a magnetic tape. Consequently, as the tape is being driven in a manner to be described while the keyboard keys are being operated, there will be recorded on the tape the frequency combinations corresponding to the characters to be transmitted.

The operation of any keyboard key closes contacts 6 as stated. This completes a circuit from ground, contacts 6, armature and back contact of relay 19, winding of clutch magnet 16 to battery, causing this magnet to be operated to engage clutch 15. Cam means not shown are operatively associated with pulley 13, so that as soon as the pulley starts revolving contacts 20 are closed. The upper contact of 20 is grounded to operate relay 19 over an obvious circuit including the lower winding of that relay. This relay locks up via its front contact and upper winding to ground at contacts 6. The lower contact of 20 provides a multiple circuit to maintain magnet 16 operated after the back contact of relay 19 has been opened and as long as contacts 20 are closed. The latter contacts are closed substantially for the period required for the tape to be driven for the recording of a single character and then opened. This arrangement is to assure that only one character will be transmitted even if a keyboard key is held down, since with contacts 6 held closed, relay 19 will remain locked up and magnet 16, and therefore the clutch, will be released upon opening of contacts 20.

Contacts 9 also are closed by cam or other means, not shown, actuated in conjunction with pulley 13 for a measured interval after the tape has been brought up to speed as it is driven, with the interval terminated prior to the opening of contacts 20. This assures that each transmitted character signal is of the same length and recorded with the tape moving at the same speed.

It will be understood that arrangements familiar to the practice of the teletypewriter art may be employed to accomplish their expected desirable function. For example, known arrangements may be included to assure that a keyboard key once operatively depressed will be so maintained until after the character signal has been recorded. Interlocking arrangements which are well known may also be provided to prevent more than one key being simultaneously operated.

After the message has been recorded on tape 11 and it is desired to transmit it, a communication channel is established to the distant receiving point. This is schematically indicated as the wires 25 although it is to be understood that any type channel which will transmit properly the employed frequency band of signals may be used. This may be a physical telephone circuit, as shown, a phantom circuit, a carrier channel, a radio circuit or combinations of these, and may include an acoustical path. Circuit or other elements, including repeaters, cord circuits, switching devices or other elements conventional to the transmission of telephone messages and switching of such circuits may be included.

Motor 26 drives pulley 27 which in turn drives the tape at a predetermined speed. The motor is supplied from an appropriate power source at terminals 28. Closure of switch 29 will start the motor by an obvious circuit including normally closed limit switch 30 which is opened upon exhaustion of the loop of tape. The speed of medium 11 past reproducer 31 preferably is several times faster than it was driven past recorder 18 to result in signals of higher frequencies and a shorter transmitting time than was required for recording.

The reproducer or pickup 31, which is appropriate for the type of record medium, translates the record into an alternating or undulatory current corresponding to the recorded signals. This current is extended through conventional amplifier

32 and is placed on the communication circuit 25 by coupling means 33. This coupling means may be of any suitable type as, for example, a coil adapted to be coupled magnetically with the induction coil of a conventional telephone set. It may comprise an element to convert the electrical signals into acoustical ones to cooperate with the transmitter of a conventional telephone instrument. It may be a direct connection between the amplifier 32 and the circuit conductors, or any other appropriate means for placing the character signals on the communication circuit 25.

At the receiving station a record medium 35, which may be similar to transmitting medium 11, but not necessarily so, is supplied from reel 36. Pulley 37 drives the record medium, here again assumed to be a magnetic tape, and is in turn driven by constant speed motor 38 powered from a source connected to terminals 39. The armature of relay 40 is connected in this motor circuit so that upon operation of this relay the motor will be operatively energized. The speed at which medium 35 is driven past recorder 44 is preferably the same as that of medium 11 past reproducer 31, although it may be different as will be understood.

A coupling element 41, which may be similar to the corresponding transmitter element 33, is provided to interconnect the communication circuit with the receiving apparatus. The output of element 41 is connected to the input of amplifier 42 to bring the signals to a proper level for the recording operation.

A component of the received signals is rectified and extended by conductor 43 to relay 40. It is contemplated that a start signal will be sent from the transmitting station just prior to the message. This may, for example, be the signal corresponding to the letters stunt of the teletypewriter code. Receipt of this, or another appropriate signal, will cause relay 40 to be operated to start the motor to drive the tape. Relay 40 is slow to release to maintain the motor circuit closed between character signals.

The signals are delivered at proper level to recorder 44, which may be similar to recorder 18, to cause the received signals to be recorded on the record medium. To assure a proper recording level of the various frequencies, amplifier 42 may be provided with conventional automatic volume control means and an equalizing network. At the end of the message the suspension of received signals will cause relay 40 to release to stop the motor.

Instead of employing a special start signal, a delay circuit may be provided ahead of recorder 44 so that at the beginning of a message the first character signal will start the motor by operating relay 40 and that signal will be delivered to the recorder after sufficient delay for the tape to be brought up to full speed.

The tape bearing the record of the received signals may be stored on a takeup reel or, as shown, as a coiled loop 45.

The printer for use with the present invention may be similar to conventional teletypewriters employing a five place code. It will be assumed, but not as a limitation, that five code magnets 51 to 55, inclusive, trip five corresponding code bars in combinations in response to received character signals to select a character. A start magnet 56 is provided to start the machine after the character or stunt has been selected to cause that character to be printed or that stunt to be effected. Such arrangements are familiar to the teletypewriter art.

When a received message has been recorded on medium 35, the motor 57 may be started by closure of switch 58 which connects it to a suitable power supply at terminals 59. This motor circuit extends through limit switch 60, which stops the motor when the loop of recorded tape is exhausted. Motor 57 drives pulley 61 which in turn drives the tape. A normally disengaged clutch 62 is interposed between the motor 57 and the pulley. This clutch arrangement may be similar to clutch 15 with magnet 16.

The signals on the record medium will be picked up by an appropriate reproducer 63 and converted into an alternating or undulating current corresponding to the record signals. This is passed through amplifier 64 which brings it to a proper level as alternating current. This current is supplied to five band pass filters 65, each designed to pass one of the frequencies $f1$ to $f5$, inclusive. For the purpose of the immediate description, it may be assumed that frequency $f1$ passed by the upper filter is the same as F1 produced by the upper source at the transmitter; $f2$ is the same as F2 and so on. This further assumes that the speed of tape 35 at the reproducer 63 is the same as that of tape 11 at recorder 18; and that of tape 35 at recorder 44 is the same as 11 at reproducer 31.

Each filter is connected to a corresponding relay of the group designated 71 to 75, inclusive. Whenever a frequency element of a reproduced signal passes one of filters 65 it will operate its corresponding relay. Consequently, for each character signal which is made up of a combination of one or more of the appropriate frequencies there will be a corresponding relay, or relays, 71 to 75 operated. It will be understood that the band pass filters may be made up of any appropriate elements including crystals and may include amplifying and equalizing arrangements so that the proper energy level may be delivered to each of relays 71 to 75, inclusive. Rectifier elements may be included in these relay or filter circuits so that direct current type relays may be employed.

Contacts of relays 71 to 75, inclusive, are connected respectively to windings of code magnets 51 to 55, inclusive. If relay 71 is energized, for example, a circuit may be traced from battery, winding of magnet 51, contact and armature of relay 71, winding of start relay 76 to ground, resulting in the latter relay and magnet 51 operating in series. Relay 76 may be slightly slow to operate to assure the complete operation of all magnets required for multi-element character signals. Start magnet 56 is operated over an obvious circuit in response to the operation of relay 76. A similar start operation will result from operation of any of relays 71 to 75, inclusive, or a combination thereof over a circuit or circuits similar to the one traced. The operation of magnet 56 will cause the printer operation corresponding to the combination of magnets 51 to 55, inclusive, which was operated.

The printer and transmitter operations are separated with respect to time so that synchronizing problem usually present with teletypewriter arrangements is not involved herein. Synchronization or coordination of the printer and the reproduced signals is provided. If the printer operates faster than the character signals are picked up by reproducer 63, each character will be printed and the printer will stop until

the next signal is received. This arrangement would require pulley 61 to be continuously driven. Such an arrangement would not be economical of time or recording medium, and a more appropriate one in which the printer is operated at its maximum speed and a minimum amount of medium is used per unit of message time is indicated. This is effected by having the printer control the advance of the medium past reproducer 63.

Contacts 77 are provided to be closed momentarily and then opened by the printer just before the latter completes a printing or stunt operation and indicates that it is ready for a new code signal. It completes an operating circuit for relay 78 which may be traced from battery, contacts 77, winding of relay 78 to ground at a back contact of relay 79, causing relay 78 to operate. At its lower front contact the latter completes an obvious circuit including conductor 82 to operate clutch 62 to cause the tape to be driven. Relay 78 locks up at its upper front contact under control of relay 79 so that it will remain operated after contacts 77 are opened. A component of the signal energy picked up by 63 and amplified by 64 is extended as a current condition over conductor 80 to operate relay 79. The operation of relay 79 releases relay 78 but simultaneously grounds conductor 82 to maintain clutch 62 operated for the duration of the character signal. As soon as the pickup of that signal is completed, relay 79 will be released to release the clutch to stop the tape between signal positions. It will be recognized that the recordings on the tapes may be for definite intervals separated from each other by blank spaces. The tape will remain stopped betwen signal positions with respect to reproducer 63 until the above operation is started over by closure of completion contacts 77. This will result in the printer operating at approximately its highest feasible speed since it calls for a new character signal as soon as it completes, or is about to complete, each operation.

When the printer is to be started to print a message, switch 58 is closed to start motor 57 and it is necessary to close manually switch 77, or a switch in multiple with it, to simulate the completion of a previous operation. Other means may, of course, be provided to furnish a momentary operating circuit for relay 78 as, for example, incident to the manual closure of switch 58. The switch 77 or other means for starting the tape drive may be maintained manually operated until the portion of tape 35 carrying signals reaches pickup 63 as evidenced by the printer starting operating.

It will be recognized that the contacts of relay 79 may be added to relay 76 and relay 79 dispensed with since relay 76 is operated for the duration of each signal. A separate relay 79 is shown, however, to be indicative of a high speed control element for certain embodiments of this invention, which may comprise an electronic circuit to maintain the clutch 62 energized directly by an amplified component of the signal energy.

The operations described above in connection with Figure 1 contemplated that the record medium speed at recorder 18 and reproducer 63 would be the same and, likewise, the same medium speed is employed at reproducer 31 and recorder 44. This is not necessarily true since selection of signal frequencies for use at the transmitter keyboard contacts and choice of printer filters will enable wide choice to be made in the recording and reproducing speeds as may be desirable in the practicing of this invention.

It will be understood that the printer arrangements to the right of the medium loop 45 may be located at some distance from the portion of the receiver to the left of this loop. With such an arrangement, the medium bearing a record may be transported to the reproducing and printing elements. This will permit a plurality of incoming message recorders to be provided with a single reproducer and printer. Likewise, at the transmitter station, a plurality of record preparers such as indicated to the left of loop 17 may be provided for each reproducer 31 and associated elements. This will be desirable in certain applications of this invention since the speed of transmitting signals over line 25 will be several times faster than a keyboard may be operated.

It will be recognized that these arrangements are well adapted to message secrecy. The communication channel 25 may include, at the two terminals, telephone secrecy equipment which would make enormously difficult the deciphering of an intercepted message, particularly if the secrecy equipment is of such type as to periodically vary the frequency band inversions or the like. It also will be recognized that the connections of contacts 1 to 5, inclusive, at the transmitting station may be shifted after each character in accordance with a pattern and the circuits between contacts of relays 71 to 75, inclusive, and magnets 51 to 55, inclusive, may be simultaneously shifted in accordance with the same pattern. Both of these types of secrecy arrangements could, of course, be simultaneously used. They are well known to the art and the showing thereof is unnecessary for clear understanding of their use in connection with this invention.

This invention may be practiced using conventional perforated teletypewriter tape at the transmitter. This tape may be prepared by familiar perforating means which provide character codes consisting of combinations of holes made on a five place code basis. Such a tape is indicated in Figure 2 as 101. This tape may be driven at uniform speed by sprocket wheel 102 which, in turn, is driven by constant speed motor 103. The sprocket wheel cooperates with a row of sprocket holes 108 in the tape. Instead of a sprocket driven continuously by a constant speed motor, an appropriate intermittent or step-by-step drive may be employed to advance the tape. The code punchings in the tape are sensed by any appropriate means shown here as five contact springs. These contact springs are connected individually to five different sources of frequency generally indicated at 105, and which may be similar to the five elements indicated as generators F1 to F5, inclusive, of Figure 1.

Under the tape is a contact member 106 in opposition to the ends of springs 104. As the tape, which conventionally is made of paper, is driven, contact is made between one or more of the springs 104 and member 106 for each character by virtue of the holes in the tape to result in character or stunt designating signals, each consisting of one or more of five different frequencies in accordance with the code. The contact of frequency bearing springs in combinations with member 106 is merely a schematic presentation to indicate any suitable means of controlling the transmission of frequency combinations in response to a tape record. This record may

be any suitably marked tape with appropriate sensing means to control the frequency transmission. If the specific arrangement shown is employed, the five separate frequency sources may be of relatively high impedance in comparison with the output circuit including member 106 so that the variation of signal level by several in comparison with one frequency being transmitted will not be great. Amplifier 107 may be provided to bring the signals to a proper level.

It is apparent that frequency signals may be converted into a punched tape record. For example, in Figure 1 the magnets 51 to 55, inclusive, represent the selector magnets of a printer. Instead of these magnets, corresponding ones of a tape perforator may be connected to contacts of relays 71 to 75, inclusive, to prepare a punched teletypewriter tape. The input to the filters need not come from a record reproducer, as shown, but may come from any source of appropriate signals as, for example, directly from line 25. Modification of the described arrangements to effect this are believed to be well within the sphere of the skilled. It will further be recognized that the contacts of relays 71 to 75 may be employed to actuate directly a telegraph transmitter of substantially conventional type whereby these relays may place on the distributor segments thereof the character codes for transmission as conventional teletypewriter signals. Such an arrangement would be particularly useful in connection with receipt of frequency code messages by a commercial telegraph company from its patrons for transmission over its telegraph facilities since the frequency record of the message made in the telegraph office need not be decoded before transmission. It may be used in its received form as a frequency signal record to actuate conventional teletypewriter circuits.

Figure 2 also indicates the employment of a transmitter in conjunction with conventional telephone station apparatus. This station may comprise a handset telephone 110 with a subset or bell box 111 containing the usual elements including an induction coil. Inductor 112 is arranged parallel to and as close as may be to the induction coil in such manner that they will be inductively coupled so that a transformer action will result, of which the winding of inductor 112 is the primary and the winding of the induction coil of the subset is the secondary, so that appropriate signals reaching inductor 112 from amplifier 107 will be repeated into the telephone circuit represented by 25 which extends to the distant receiving station via intermediate circuit links which may be of various conventional types.

It will be recognized that this arrangement of an inductor 112 and subset 111 represents one form of coupler 33 of Figure 1 as set out above. It also will be understood that a similar arrangement may be used at the receiving station for coupler 41. Likewise, various other known means may be employed to place the signals from amplifier 107 on a suitable communication circuit and to pick them up therefrom at a distant point. For example, a telephone receiver, or the like, may be substituted for inductor 112 and placed over the transmitter of the telephone instrument.

It will also be understood that the receiving station used in conjunction with the transmitter of Figure 2 may be identical with the receiver of Figure 1.

Where a private line extends between the transmitter and receiver, the transmisison of a start signal will condition the receiving equipment for a message and the latter may then be transmitted. Where commercial telephone facilities are employed, a telephone call may be placed in the usual manner over telephone instrument 110. This may be a local connection established manually or by dialing, or a toll connection including the various elements conventionally included in such facilities, including radio links.

When the distant telephone is answered, advice may be given orally that a message is to be transmitted so that receiving equipment such as shown at the right of Figure 1 may be operatively connected. The transmitter may then be started and the message sent. It is apparent with this arrangement that when the telephone connection is established it may be used partly for a telephone conversation and partly for the transmission of a telegraph message. This likewise is true with respect to Figure 1 where the coupling arrangements 33 and 41 may be provided with telephone instruments. It will be obvious that instead of inductive coupling, switches may be provided at the sending and receiving stations normally arranged to connect telephone instruments to the communication circuit represented by wires 25, said switch being adapted to disconnect the telephone instruments and connect at the transmitting station the sending apparatus at the left of Figure 1 and, at the receiving station, the apparatus at the right of Figure 1.

Figure 3 shows schematically an embodiment of this invention which enables a single recording and reproducing arrangement to be employed at a station adapted to send and receive telegraph messages. Other features of this invention are also set out by this figure.

The arrangements of Figure 3 include a manually operable selector switch having nine positions or operation selections. This switch may be of any suitable form to selectively interconnect a plurality of separate conductors for this number of positions. For the purpose of this description, cams of the sequence switch type familiar to the telephone art are schematically shown. Each of these comprises an insulated disc having conducting surfaces which may be cut to effect circuit completions between four brushes for certain positions to which the cam may be rotated. All of the cams are affixed to, but insulated from, a common shaft which may be rotated manually to any of nine positions, and appropriate indicating means may be provided so that the operator may observe readily the position the cams occupy. The circuit convention of these cams with their brushes may be described with reference to cam D. A circuit to brush *a* is completed in cam positions 3, 5 and 7. Brush *c*, being shown as an open face arrow, indicates that it is completed for all cam positions. Brush *d* completes a circuit in position 8 only. Cam C indicates another convention. Brush *b* is completed in positions 2 through 7, inclusive. Similar conventions are used throughout this figure to indicate the cuttings of the various cams. The description of the figure will be separated for reference by cam positions in accordance with the operations which they control as set out by Figure 4.

Figure 3 combines certain of the elements of the two halves of Figure 1. Where a specific element of Figure 1 appears in Figure 3, it bears the

same designation. Where there is substantial correspondence, a corresponding designation with a prime mark is used. For example, a single record medium is employed which, as will be described, serves for the purposes of both media 11 and 35 of Figure 1. It is designated 11' in Figure 3.

Position 1.—Off

In this position, a circuit may be traced from telephone line 25, brushes c and d of cams A and B to conventional telephone instrument 130. It is assumed that telephone circuit 25 is a conventional one terminating at a manual switchboard or dial telephone office, and may normally be used for either exchange or toll telephone purposes. Telephone 130 may, therefore, be dial, manual common battery or magneto type, or an extension from a private branch exchange to which circuit 25 may be connected. In position 1, as well as certain others, it may be used conventionally for telephone service.

Position 2.—Recording

In position 2, a telegraphic record may be prepared. Conductors 131 and 132 are indicated by Figure 1 as being connected to the secondaries of transformers 7 through switch 9. The preparation of the record is similar to that of Figure 1 with a somewhat different circuit arrangement now to be described.

The drive motor 14' has a circuit closed for it from lower power terminal 133 brushes b and d of cam C, limit switch 30', motor 14' to the upper terminal of power supply 133, thereby causing the motor normally to be operated in position 2. The latter circuit may also contain another switch so that the operation selection may be effected by positioning the cams and the actual start of the motor controlled by the additional switch.

Parallel circuits may be traced from conductors 131 and 132, brushes b and c of cams D and E to the input of amplifier 32'. The output of the amplifier may be traced in parallel through brushes c and d of cams F and G to recorder 18'. The operation of the keyboard will, as described, place frequency combinations of code signals on conductors 131 and 132 and each character to be transmitted will result in start contacts 6 being closed. A circuit may be traced from ground at momentarily closed contacts 6, brushes a and c of cam H, the winding of clutch magnet 16' to battery and ground. The motor 14' is adapted to drive the pulley 13' at a slow or fast speed depending on which of two clutches 16' or 134 is engaged, said difference in speed being effected by gearing 135 and 136 interconnecting pulley 13' and motor 14' through a counter shaft in which normally disengaged clutch 16' is placed for slow speed or by direct drive through clutch 134, which is also normally disengaged, for relatively high speed for operations subsequently to be described. The operation of clutch 16' will, therefore, cause the recording medium 11' to be driven intermittently at a speed corresponding to the recording speed for the keyboard as set out with respect to Figure 1. Contacts 20 will be closed immediately after pulley 13' starts rotating to assure the complete registration of the character and that only one code signal will be produced for each character as previously described.

These operations are repeated until the complete message is recorded. It will be noted that telephone 130 may be used while recording is taking place since it is connected to line 25 via brushes c and d of cams A and B.

Position 3.—Transmitting

When it is desired to transmit the message, a connection to the distant station is established, if commercial telephone service is used, and the cams are turned to position 3. In this position, reproducer 31' is connected to the input of amplifier 32' by brushes a and c of cams D and E. The output of the amplifier is connected to line 25 by brushes b and d of cams A and B. The amplifier may have a supervisory bridge in its output circuit to hold equipment associated with line 25.

The recording medium carrying the record is driven past reproducer 31' by pulley 61' which may be driven at high speed by motor 14' with clutch 137 engaged. An operating circuit to engage this clutch may be traced from ground and battery, the winding of clutch magnet 137, brushes a and c of cam I to ground. The message will, therefore, be transmitted at an appropriate high speed until it is completed or the transmission is stopped by manually rotating the cams to another position.

Position 4.—Receiving

When it is desired to receive a message at high speed incoming over line 25, the cams are rotated to position 4. This connects line 25 to amplifier 32' via brushes a and d of cams A and B. It will be understood that the input circuit of the amplifier may include a repeating coil, or other suitable bridge may be provided, to maintain a supervisory condition on line 25 when the amplifier is connected to the line. The output of the amplifier is connected to recorder 18' via brushes c and d of cams F and G. A component of the signal energy is extended from the amplifier over conductor 43'—80', brushes a and b of cam J to operate relay 40'. This relay closes an obvious circuit to operate clutch magnet 134 to drive medium 11' at high speed. The recording operation continues as long as incoming signals are received and is stopped automatically by the release of slow release relay 40' upon suspension of such signals for a predetermined interval.

When relay 40' is released, a circuit may be traced from ground, back contact of relay 40', lamp 138, or other appropriate signalling device such as a bell, brushes a and d of cam K to battery, thereby indicating the completion of the message.

Position 5.—Printing

When the incoming message has been recorded and it is desired to print it, the cams may be rotated to position 5. This will connect reproducer 31' to the input of amplifier by circuits through brushes a and c of cams D and E. The output circuit of the amplifier is connected to the filters 65 of the printer via brushes b and c of cams F and G.

It will be recalled with reference to Figure 1 that the start of printing is effected by manual closure of contacts 77, or the equivalent, until the record is presented to the reproducer. This operation is contemplated with Figure 3, and when the signals from the record are received by amplifier 32', a component thereof is extended over conductor 43'—80', brushes a and c of cam J to operate relay 79. This relay in conjunction with completion contacts 77 and relay 78 of Figure 1 intermittently operate clutch magnet 62' to drive the record medium 11' in a series of steps each of

controlled speed substantially as previously described with respect to the printing operations of the apparatus of Figure 1.

It may be noted that telephone 130 is useable while the printing operation is taking place.

Position 6.—Sound recording

Inasmuch as this invention employs the recording and reproduction of frequencies within the voice range it is well adapted to be used for recording and reproducing telephone conversations. Position 6 is provided for the purpose of sound recording.

In this position, the line 25 is connected through brushes *c* and *d* of cams A and B with telephone 130, and also via brushes *a* and *d* of these cams with the input of amplifier 32'. The output of this amplifier is connected via brushes *c* and *d* of cams F and G with recorder 18'. Clutch magnet 16' is energized by a circuit traceable from battery, winding of magnet 16', brushes *c* and *d* of cam H to ground thereby causing the medium to be driven at slow speed. This will result in a record being made of the telephone conversation.

Suitable arrangements known to the art of recording telephone conversations may be employed, including means to record both ends of the conversation at substantially the same level.

Position 7.—Sound reproducing

When it is desired to play back the recorded conversation, the cams are moved to position 7. This will result in reproducer 31' being connected with the input of amplifier 32' via brushes *a* and *c* of cams D and E, and the output of the amplifier being connected to telephone 130 via brushes *b* and *c* of cams A and B. In position 7, clutch magnet 62' is energized by a circuit which may be traced from battery, winding of this magnet, brushes *a* and *d* of cam I to ground, causing the recording medium 11' to be driven at the same slow speed at which the recording was made. This will enable the recorded conversation to be reproduced in telephone 130. It will be evident that modifications of these described arrangements will enable the recorded message to be reproduced through a loud speaker or over a telephone connection established over line 25.

Position 8.—Send direct

It may be desirable to send and receive messages at normal typing speed as with conventional teletypewriter practice. This will enable questions to be sent and answers received, for example. The sending operation is effected with the cams in position 8.

In this position the conductors 131 and 132 from the transformers 7 are connected to the input of amplifier 32' via brushes *b* and *c* of cams D and E. The output of the amplifier is connected to line 25 via brushes *b* and *d* of cams A and B.

A keyboard motor 139 is provided to control the keyboard operations. It will be recalled that in connection with Figure 1 it was mentioned that the operation of the recording medium and the keyboard may be coordinated by a suitable mechanism driven by motor 14. In sending direct as presently being described, driving the medium is not required, so a separate arrangement is shown for this keyboard control purpose, although the motor 14' with suitable arrangements obviously may be employed. Motor 139 is energized by a circuit which may be traced from battery, motor 139, brushes *a* and *b* of cam I to ground. This motor drives two cams 140 and 141 which are adapted to rotate together but are frictionally mounted on shaft 142. Cam 140 has a slot and is normally held against rotation by the shaft by detent 143. This detent may be withdrawn by energization of magnet 144, thereby permitting cams 140 and 141 to be rotated by their shaft. A circuit to energize this magnet may be traced from ground, keyboard contacts 6, brushes *a* and *b* of cam H, back contacts of relay 145, winding of magnet 144 to battery. Consequently, the magnet withdraws detent 143 permitting the rotation of cams 140 and 141 whenever a keyboard key is operated. When detent 143 is withdrawn, the associated contacts complete an obvious circuit to operate relay 145 over its upper winding. The latter opens, at its back contacts, the operating circuit for magnet 144. This relay may be slightly slow to operate to permit cam 140 to rotate its slot from a position opposite detent 143, so that upon release of magnet 144 the detent will ride on the surface of cam 140 and thereby maintain the associated contacts closed. Cams 140 and 141 will be stopped after one revolution by detent 143 engaging the slot of cam 140. This will be irrespective of whether the keyboard key has been released or held down. If the key has been released, contacts 6 will be open so that magnet 144 will continue to be deenergized upon release of relay 145 at the completion of a revolution. If contacts 6 are maintained closed, relay 145 will be held over its lower winding upon completion of a revolution of 140, thereby preventing the reenergization of magnet 144 until after contacts 6 are opened and closed again.

Cam 141 closes contacts 9', which may be contacts 9 of Figure 1, or a pair in parallel therewith, to partially complete a circuit from transformers 7, to provide a code signal of predetermined length.

Another detent or the like 146 is also operatively associated with detent 143 and is adapted, when 143 is withdrawn incident to transmitting a character, to engage the code bars or other appropriate keyboard element to assure the transmission of the character signals for a proper interval and to prevent the operation of another key until transmission is completed. Detent 146 may, of course, be actuated by another cam to provide a different locking characteristic with respect to the signal transmission.

It is contemplated that motor 139 will be driven at a regulated speed which will be somewhat slower than the normal speed of the receiving printer to obviate a synchronizing problem. The latter printer will pause briefly after each operation until the next character signal is received. In this connection, means may be provided for certain stunts such as carriage return or tabulating to maintain relay 145 operated for sufficient added time to assure that the distant printer has completed its operation before the next character is sent.

This arrangement will result in the frequencies of F1 to F5 being transmitted directly. It may be that in practicing my invention, these frequencies will be too low for satisfactory transmission over telephone circuits. In this case I may employ a conventional frequency multiplier designated 147 to increase the frequencies for transmission. The output of this multiplier may be connected to brushes *d* of cams D and E and the closure cutting for position 8 may be omitted for brushes *b* of these cams. The input of 147 may

be connected to conductors 131 and 132, to result in a multiple of the generated frequencies being transmitted. It will be recognized that the input of multiplier 147 may be connected to conductors 131 and 132 through additional cams when they are in position 8 only.

If the frequencies F— are supplied by rotating generators, the speed of rotation of these may be increased by any suitable means including gearing to directly produce the proper frequencies for transmission.

Position 9.—Receive direct

In position 9 of the cams, the arrangement of Figure 3 is adapted to receive signals direct from a transmitter which may be of the type described above in connection with position 8. The line 25 is connected to the input of amplifier 32' via brushes *a* and *d* of cams A and B. The output of the amplifier is connected to filters 65 via brushes *b* and *c* of cams F and G. The operation of the printer will be substantially in accordance with the description thereof in connection with Figure 1 omitting, of course, the operations concerned with the record medium which will not be driven in this position.

If, for reasons pointed out above, it is appropriate to use in sending directly a higher frequency than is furnished by generators F— for other operations of the device, it may be necessary to employ a separate set of filters 65 tuned to these particular higher frequencies. It is obvious that additional cams may be provided connected in the filter circuits to disconnect those designated 65 and substitute a set properly designed for the frequencies employed.

With reference again to Figure 1, it will be recognized that the frequencies to which filters 65 are tuned need not be the same as provided by sources F—. Let it be assumed that they are respectively tuned to frequencies which are four times that of their corresponding sources F—. The speed of pulley 61 when rotating may be four times that of the recording speed at the transmitter as determined by the speed of pulley 13. It will be recalled that filament 35 at the reproducer 63 is driven in a series of steps, each step being at a controlled speed and the steps themselves controlled jointly by the signals and the printer so that the record is advanced to reproduce each signal separately and is stopped to await the completion of the printing or other operation controlled by that signal. With the record being advanced at four times the recording speed of the transmitter, it follows that the frequency picked up by reproducer 63 will be four times that previously recorded by 18 assuming, of course, that the speed of other elements will have the relation previously contemplated. This arrangement is well adapted to direct reception with the modification of Figure 3 to include the frequency multiplier 147, in which case the latter would multiply the frequency by four. If this arrangement is provided with other features set out by Figure 3, it will be necessary to have another clutch arrangement in addition to 62' and 137 since the slow speed drive of pulley 61' will be four times that of the slow speed drive of pulley 13' as controlled by clutch 16' and the associated gearing. This third speed of pulley 61' would have to be such as to drive medium 11' at the same speed as used for recording with the cams in position 6 for the proper reproduction of voice recording of telephone conversations. It is believed that the addition of a third clutch and gearing to accomplish this will be obvious to the skilled, as well as the minor circuit rearrangement to effect the operation of this latter clutch in position 7 of the cams.

It will be understood in connection with Figure 3 that additional cams not shown may be provided to effect such circuit changes or adjustments in connection with the amplifier as may be required for its proper operation under the various conditions of its use as determined by the several cam positions. These circuit changes or adjustments may include gain control, output or input impedance matching and provision of a supervisory bridge on either the input or output circuit when they are connected to line circuit 25.

It will be further recognized that where the type of medium and record employed will permit a combined recorder-reproducer to be used, the arrangements described with respect to Figure 3, and also Figure 1, may be modified by the skilled in accordance therewith within the spirit and scope of this invention. Likewise, a single keyboard machine similar to a conventional teletypewriter may be used both as a sending machine and as a printer.

This invention is well suited to multiplex operation by several different arrangements. Figure 5 is a schematic of means to provide duplex operation. Two transmitter equipments such as shown by the left portion of Figure 1 or by Figure 2, excluding the coupling facilities, are conventionally indicated as 120 and 121. The frequency band employed by transmitter 120 may be higher than that of 121 so that each of the two bands may be separated as a whole from the other by filters. Transmitter 120 is connected to coupler element 33 by high pass filter 122 and transmitter 121 is similarly connected by low pass filter 123. These two filters are indicative of any appropriate means of combining the frequencies of the two transmitters for transmission over line 25. At the receiving station the coupling element 41 receives the signals which are separated by filters 124 and 125 into two groups corresponding to the frequency bands of 120 and 121, respectively. These two bands are supplied to receivers 126 and 127, respectively.

Each of these receivers may be similar to the right hand portion of Figure 1 excluding the coupling element. It is to be understood that the speed of the recording media and the frequencies employed by 120 and 126 must be appropriately coordinated and likewise must those of 121 and 127. It will also be understood that more than two channels may be employed by using additional bands of signal frequencies which may be separated by suitable filters, with a separate band assigned to each channel, as will be explained more fully below.

The arrangement shown by Figure 5 may be employed for a simultaneous telephone and teletypewriter connection. Conventional telephone instruments may be substituted for transmitter 121 and receiver 127. Filters 123 and 125 may be arranged to pass frequencies below 2000 cycles, for example, which provides a generally satisfactory voice frequency band for telephone service. Filters 122 and 124 may pass frequencies above 2000 cycles which are suitable for teletypewriter purposes in accordance with this invention and which may be produced by transmitter 120.

Band splitters are familiar to telephone practice. They enable a single broad band telephone channel to be employed for two narrow band independent telephone circuits. Band splitting ar-

rangements, which are located at each terminal of a line, eliminate all frequencies above about 1700 cycles of the two telephone circuits. It applies through a low pass filter such as 123 (Figure 5) the band from one of the circuits to the broad band telephone channel. The frequency band of the other telephone circuit is shifted above approximately 1700 cycles and applied to the line by a high pass filter such as 122. At the receiving station the two bands are separated and the upper one shifted back to its proper place in the frequency spectrum. This is an illustrative description since two-way conversations are provided. This band splitting arrangement may be employed to receive two separate channels which may be used for independent telephone or teletypewriter channels in accordance with this invention. Likewise, each of these channels may be used for a plurality of teletypewriter channels by proper adjustment of speeds of the transmitting and receiving record media.

There is a wide choice of frequencies which may be employed at the several stages of the transmitting and receiving arrangements. The choice of frequencies of sources F1 to F5, inclusive, may depend upon the characteristics of the medium 11 which may be employed in view of recorder 18 and reproducer 31, and the speed at which the medium is driven. Another factor entering into this choice will, of course, be the ratio of speed of the medium for message transmission to that of recording at recorder 18. Still another factor is the frequency transmission characteristics of communication circuit 25. If, for example, the upper useable frequency limit of circuit 25 is 2,800 cycles per second, and a speed ratio of eight to one is employed, the maximum frequency of sources F1 to F5, inclusive, will be 350 cycles.

The speed of medium 35 must be appropriate for recording the signal frequencies received over line 25. On the assumption that medium 35 will be driven intermittently with a movement for each signal followed by a stop while that signal is being printed, it is apparent that a wide choice of medium speeds at this reproducing point may be employed. The latter will depend upon the effective band separations of filters *f1* to *f5*, inclusive, which are employed.

An example of frequency and media speed relations which may be employed will be illustrative on the basis of certain assumptions taken from the wide choice available. Let it be assumed, with reference to Figure 1, that the filters *f1* to *f5*, inclusive, are tuned to 1,000, 1,100, 1,200, 1,300 and 1,400 cycles per second, and each will attenuate to ineffectiveness the other frequencies. Let it also be assumed that the effective transmission band of circuit 25 is 250 to 2800 cycles per second; also that a speed ratio of transmission is eight to one and the speed of the recording medium 11 at recorder 18 is one foot per second and at reproducer 31 it will be eight feet per second to yield this ratio.

The upper frequency of sources F1 to F5, inclusive, will be 350 cycles so that the speed ratio will not result in the upper limit of line 25 being exceeded. For direct transmission as set out by Figure 3 without a frequency multiplier, the lower frequency will be 250 cycles and the five sources may provide 250, 275, 300, 325 and 350 cycles. Consequently, the frequencies transmitted over line 25 will be 2,000, 2,200, 2,400, 2,600 and 2,800 cycles per second.

It may also be assumed that the speed of receiver medium 35 at recorder 44 is eight feet per second. The speed at reproducer 63 will then be four feet per second which will supply the filters *f1* to *f5*, inclusive, with the five signal frequencies to which they are tuned. This is premised, as stated, on the medium being driven in steps, one step for each signal, at this speed.

Arrangements were described above with respect to Figure 5 whereby multiplex telegraphy may be provided with respect to this invention. While there are several methods of effecting this, an extension of the example immediately above including certain fundamental assumptions therein will be illustrative of one based upon securing filterable frequency separations of each channel by speed control of the media employed. This extension contemplates four channels which may be employed simultaneously. Let it be assumed that there are four transmitting and four corresponding receiving units for the four channels. The signals from the four reproducers 31 may be combined at coupler 32 or otherwise simultaneously placed on line circuit 25. At the receiving station the four channels may be separated by four suitable band pass filters tuned to the four channel frequencies which may be located ahead of four amplifiers 42, whereby each recorder 44 will be supplied only the frequency band of its channel.

Illustrative relationships between the frequencies and media speeds of the wide choice which may be used in the practice of this invention are set out in the following table:

a. Channel	#1	#2	#3	#4
b. Speed ratio	1:1	2:1	4:1	8:1
c. Media speed at 18 (f. p. s.)	1	1	1	1
d. Media speed at 31 (f. p. s.)	1	2	4	8
e. Frequencies of the five signal elements over line 25	250	500	1000	2000
	275	550	1100	2200
	300	600	1200	2400
	325	650	1300	2600
	350	700	1400	2800
f. Media speed at 44 (f. p. s.)	1	2	4	8
g. Media speed at 63 (f. p. s.)	4	4	4	4

Such an arrangement premised on a keyboard or recording operation of 60 words per minute will enable 900 words per minute to be transmitted over communication circuit 25, consisting of 60 for channel #1, 120 for channel #2, 240 for channel #3 and 480 for channel #4.

It is obvious that the four channels need not be used simultaneously. They may be cut into and out of service at will. It also will be recognized that the four transmitters may be located at separate points and the signals combined at a central point where the line 25 terminates. Likewise, the four channels at the receiving station may be separated and the signals thereof supplied to four receivers and printers. It will further be understood that some channels may be transmitting in one direction while others are sending in the other.

Where the above multiplex arrangement is employed in connection with systems having more than four transmitters which are intermittently used, each transmitter may be adapted to transmit the signal frequencies of any of the four channels so that it may be used in connection with any channel when it becomes idle. This may be accomplished by driving the medium at reproducer 31 thereof at either one, two, four or eight feet per second, depending on which channel is employed. Likewise, the channels at the receiving station may be switched to various receivers. These receivers may be arranged, in conformity with the illustrative table above, to drive medium

35 at recorder thereof at one, two, four or eight feet per second, depending upon the channel with which it is used. This switching may be effected manually or automatically in response to signals sent from the transmitting point to the distant termination of the circuit, said signals may comprise a long impulse of a combination of the frequencies of that channel to operate a combination of relays similar to 71 to 75, inclusive, supplied through five band pass filters such as 65 designed to pass the five frequencies of that channel. The operated combination of these relays may indicate a desired station or effect a switching operation to test a line to it for an idle condition and to connect it to the channel if it is available. It is contemplated that when a channel becomes idle, appropriate filters and their relays may be connected to it to await a station selective signal. If the station is available, a similar signal may be returned to the transmitter to indicate that the station is ready to receive and the message may be started. This will enable any station out of a maximum of 31 to be selected. Making selections by operating a combination of relays and returning a start signal when a ready condition prevails is well known to the communication arts and the application thereof to the present invention is believed to come well within the sphere of the skilled in this art in view of the teachings herein.

Where there is a varying volume of originating traffic to a distant point from various transmitters, the assignment of channels may be effected whereby the station with the most traffic or longest message may be assigned the high speed channel and those with smaller amounts of traffic may be assigned other channels in accordance with their needs. It will also be understood that a plurality of lines 25 to various distant points may be terminated at a center and any transmitter or receiver may be arranged to use any channel of any line.

Where a combined transmitter-receiver such as set out by Figure 3 is employed with a selective multiplex system such as described, it may be obviously modified to provide the various media speeds at the recorder and reproducer points required depending on the particular operation and channel employed. These speeds may be selected by appropriate means and effected by suitable means which may include additional clutch and gear arrangements similar to those shown.

As a further illustration of the flexibility of this invention to meeting various communication needs, a single recorder with one set of filters and a single printer may be used with a modification of the multiplex arrangement set out above. With this arrangement the receiving medium 35 is employed to record the frequency of the signals of all four channels. The printing of the messages of each channel may then be accomplished by driving the medium 35 at the reproducer 63 at the proper speeds to provide the filters *f1* to *f5*, inclusive, with the proper frequencies to operate the printer for each message in succession. That is, the record of received signals will be reproduced four times, each time at a different speed appropriate for that channel. Assume the use of channel frequencies set out by item *e* of the above table and the characteristics of the filters contemplated in that table, and a recording speed at 44 of two feet per second. In order to print channel #1, the reproducing speed at 63 will be eight feet per second, for channel #2 it will be four feet per second, for channel #3 two feet per second and for channel #4 one foot per second will be proper. This will translate the frequencies of the signals of each channel (except channel #3 which does not need it) to 1,000, 1,100, 1,200, 1,300 and 1,400 cycles for which the filters are designed. Consequently, each channel may be separately printed depending on the speed of reproduction. With this arrangement, it is necessary that the contacts of relay 79 be added to those of 76, or similar provisions made, since the combined record of the four channels will be substantially continuous and it is necessary that the start-stop operation of the medium be controlled solely by the signal channel being printed. Relay 76 will be operated only by the signals of this channel. It may also be appropriate to disable the circuit to the filters while the medium is being brought up to speed preparatory to a printer selection operation and stopped after that selection. That is, during this acceleration and deceleration interval, the signals of the other channels may be reproduced momentarily at the frequency of one of the filters which may result in a faulty selection. This disabling may be effected by having a relay or other arrangement which will be effective momentarily each time relay 78 operates and each time relay 76 releases said arrangement being adapted to open the circuit to the filters or otherwise disable it during the brief acceleration and deceleration interval.

Hybrid coil arrangements are familiar to the telephone art. They enable a two-wire telephone circuit used for two-way conversation to be converted into the four-wire type in which a separate circuit is employed for each direction of transmission. Such arrangements may be employed at the terminals of line 25, which may be assumed to be of the two wire type, to provide four-wire facilities at the terminals whereby a single communication circuit 25 may be used simultaneously to transmit and receive messages in accordance with this invention. Where a multiplex arrangement such as set out above is employed for four channels, with a maximum speed ratio of eight to one, a total of 1,800 words a minute may be transmitted, 900 in each direction.

Where this invention is used in connection with commercial telephone facilities in a large organization, a few transmitters and receivers, together with a printer or printers, may be located at a central point or points for use with any one of various telephones. For reception of a telegraph message incident to a telephone call incoming over a telephone line, the user may, by operating a key to pick up a common trunk line or by actuating a suitable switching mechanism or by direction to the private branch exchange operator, effect connection of the call to an idle recorder which will make a record of the message for subsequent printing. Likewise, a restricted number of transmitting arrangements may be provided so that a message may be recorded, the record placed in a transmitter and a connection established from any appropriate telephone in the organization to a distant telephone. The connection may, at the appropriate time, be switched to the transmitter which will then send the message at the proper speed. The transfer of telephone connections is a common practice in large and small organizations, and the known facilities therefor may be used to transfer or extend connections to a recorder or transmitter for the purposes set out.

An extension of this arrangement for use by the public may be effected for incoming calls by arranging to have the call transferred to a bureau equipped with recorders and printers in accordance with this invention so that telegraph messages may be recorded and printed thereat for subsequent delivery to the called party. This transference may be effected in the telephone central office by appropriate known means as, for example, by the inward toll operator changing a switchboard cord connection.

The practice of this invention is not limited to using signals comprising an impulse of a combination of frequencies. Each character signal may comprise a sequence of marking and spacing impulses as with conventional teletypewriter practice. A marking impulse may, for example, be 250 cycles and 300 cycles may be employed for spacing. A substantially conventional teletypewriter may be adapted to produce from frequency sources such signals. These may be recorded, translated at a higher speed, transmitted to a distant point, recorded thereat, again translated and separated by filters to provide conventional marking and spacing impulses to actuate a teletypewriter. Such signals may be used with various embodiments of this invention.

The arrangements set out are indicative of the substantial flexibility available for the practice of this invention whereby various communication needs may be met. Certain features of it described in connection with one embodiment may be employed as appropriate with another. It will be understood that this invention may be practiced within the spirit and scope of the appended claims with different apparatus elements and circuit arrangements than shown.

What is claimed is:

1. The method of communication which consists in producing information designating signals each comprising one or more predetermined frequencies in accordance with a code, recording said signals, translating said recording into signals corresponding to those recorded and preparing in response to said translated signals sensible information designations corresponding thereto.

2. The method of communication which consists in producing character designating signals, each signal comprising one or more of a plurality of predetermined frequencies in accordance with a code, translating said signals into corresponding signals having frequencies different from those produced and converting the latter said signals into recorded sensible characters corresponding to those designated by said produced signals.

3. The method of communication which consists in producing character designating signals to form a message, each signal comprising one or more predetermined different frequencies in accordance with a code, recording said signals at a particular recording speed, translating at a different speed the recording into electrical signals and printing the message in response to latter said signals.

4. The method of communication which consists in producing information designating signals, each signal comprising an impulse of one of a plurality of predetermined frequencies or a simultaneous combination of certain of said frequencies in accordance with a code, transmitting said signals to a distant point, receiving said signals at said point, recording said received signals, translating said recording into corresponding electrical signals and, in response to latter said electrical signals, preparing a sensible information designating record corresponding thereto.

5. The method of communication which consists in producing sequential character designating signals to form a message with each signal consisting of one or more predetermined frequencies in accordance with a multi-place code, translating said signals into corresponding electrical signals of higher frequencies, transmitting latter said signals to a distant point, translating, a signal at a time, the signals received at said point into other corresponding signals and printing the characters represented by last said signals whereby said message is reproduced.

6. The method of communication which consists in producing sequential character designating signals to form a message, each signal comprising a single impulse of one or more predetermined frequencies in accordance with a code, transmitting said signals over a communication channel to a distant point, recording at said point the message signals, translating the recorded signals one at a time into corresponding electrical signals, printing in response to each of latter said signals the character corresponding thereto to reproduce the message and controlling the translation of each signal in response to the printing of the character corresponding to the next preceding signal.

7. The method of communication which consists in producing information designating signals each comprising one or more predetermined frequencies in accordance with a code, recording said signals, translating said recorded signals into corresponding electrical signals, transmitting said electrical signals to a distant point, recording the latter signals at said distant point, translating the latter recorded signals into corresponding electrical signals and recording in response to last said signals sensible information designations corresponding thereto.

8. The method of communication which consists in producing character designating signals each comprising an impulse of one or more predetermined frequencies in accordance with a code to form a message, recording at a certain speed the message thus produced, translating at a higher speed the signal record whereby the signal frequencies are increased above, and the message interval is decreased below, the produced message, transmitting the message signals thus translated to a distant point, recording the latter signals at said distant point, translating latter said record into corresponding signals and printing said message in response to the last said signals.

9. The method of telegraphy employing record media upon which frequency signals may be recorded which consists in producing sequential spaced character designating signals to form a message, each signal comprising one or more predetermined frequencies in accordance with a code, driving a record medium for a predetermined interval at a particular speed for each character signal produced, recording the corresponding signal as the medium is being driven, subsequent to the recording of the message driving the medium continuously at a speed higher than that at which the recording was made, translating the recording into electrical signals as the medium is being continuously driven which, by virtue of the greater speed, will result in the translated signals being of higher frequencies than those produced and the translation time for a given mes-

sage being shorter than the recording time for the message, transmitting the translated signals to a distant point, recording the signals received at said point on a record medium driven continuously at a certain speed, driving latter said medium intermittently at a predetermined speed a signal interval at a time, translating each latter recorded signal into a corresponding electrical signal as the latter medium is being intermittently driven, printing the character corresponding to each latter said electrical signal to reproduce the message and controlling the intermittent drive of the latter medium to effect the translation of each signal in response to the printing of the character corresponding to the next preceding signal.

10. The method of communication which consists in establishing a telephone connection between two points, employing said connection for a telephone conversation and employing it for a telegraph communication, said telegraph communication being effected by producing character designating signals each signal of which consists of one or more predetermined frequencies in the voice frequency range in accordance with a code to form a message, transmitting said signals over said telephone connection from one of said points to the other of said points, receiving said signals at latter said point, making a record of said received signals and translating said record of received signals into corresponding sensible characters.

11. The method of telegraphy which consists in transmitting simultaneously a plurality of messages over a communication channel, each message comprising sequential character designating signals with each signal consisting of one or more predetermined frequencies in accordance with a code, said frequencies of the signals of a particular message lying within a frequency band individual to that message with the frequency band of each message occupying a separate portion of the frequency spectrum, recording the signals of said messages at the distant terminus of the communication channel, translating into electrical signals the record successively at particular speeds with each speed corresponding to one of said messages and adapted to cause the frequencies of the translated signals of the corresponding message to be within a predetermined frequency band and printing each message separately in response to the signals thereof being translated in latter said frequency band.

12. A communication system including a first station, a second station, a communication channel interconnecting said stations, means at the first station to produce sequential character designating signals, each signal consisting of one or more predetermined frequencies in accordance with a code; means to translate said signals into corresponding signals higher in the frequency spectrum, means for transmitting latter said signals to the second station over the communication channel and means at the latter station to print characters in accordance with the signals received thereat.

13. A communication system including a record medium, means to drive the medium at a certain speed, means to record on said medium as it is being driven information designating signals, each signal consisting of one or more predetermined frequencies in accordance with a code, means to drive the medium at a different speed from the recording speed, means to reproduce the signals corresponding to the recorded signals while the medium is being driven at latter said speed and means responsive to said reproduced signals to record information designations corresponding to them.

14. A communication system including a first station, a second station, a communication channel between said stations, means at said first station for producing sequentially character representing signals each of which comprises one or more predetermined frequencies in accordance with a code, a record medium, means to record said signals on said medium, means to translate said recorded signals into corresponding electrical signals, means for transmitting latter said signals to said second station over said communication channel and means at the second station responsive to latter said signals received over said communication channel for printing the characters corresponding respectively to latter said signals.

15. A communication system including a communication channel interconnecting two stations, means at one of said stations for producing sequential character designating signals, each signal consisting of an impulse of one or more predetermined frequencies in accordance with a code, a record medium, means to drive the medium for a predetermined interval for each character signal produced, means for recording each signal on the medium as it is being driven for that signal, means for driving the medium continuously, means for translating the record on the medium into corresponding electrical signals, means for transmitting latter said signals over the communication channel to the other said station and means at latter said station responsive to signals received over said channel for printing the characters corresponding to latter said signals.

16. A communication system including a communication channel between two points, means at one of said points for transmitting over said channel to the other of said points information designating signals, each signal consisting of one or more predetermined frequencies in accordance with a code, means at the other said point for recording the signals received over said channel and means for translating the recorded signals into corresponding sensible information designations.

17. A communication system including a communication channel between two stations, means at one of said stations for transmitting over said channel to the other station spaced information designating signals, each signal consisting of one or more predetermined frequencies in accordance with a code, a record medium at the other said station, means to drive the medium, means to record signals incoming over said channel on said medium as it is being driven, means to drive the medium intermittently, means to translate one of said recorded signals into a corresponding electrical signal each time the record is driven and means responsive to each of said electrical signals to record an information designation corresponding thereto.

18. A communication system including a first station, a second station, a communication channel between said stations, means to produce character designating signals to form a message, each signal of which consists of one or more predetermined frequencies in accordance with a code, a record medium, means to drive the record medium at a particular speed, means to record said signals on said medium as it is being driven,

means to drive the medium at a higher speed, means to translate said record into corresponding electrical signals as it is being driven at said higher speed, means to transmit said electrical signals over said channel to said second station and means at said second station to make a record of the signals received thereat.

19. A communication system including, a first station, a second station, a communication channel between said stations, means at the first station for producing sequential spaced character designating signals each consisting of an impulse of one or more predetermined frequencies in accordance with a code, a record medium, means to drive the record medium for a predetermined interval at a particular speed for each signal produced, means to record each signal on said medium as the medium is being driven for that signal, means to drive the medium continuously at a speed higher than the speed at which the recording was made, means to translate said record into corresponding electrical signals over the communication channel as the record is being driven at said higher speed, a record medium at said second station, means to drive latter said medium at a certain speed, means to record on latter said medium as it is being driven signals incoming over said communication channel, means to drive latter said medium bearing a signal record intermittently at a predetermined speed with each driving interval corresponding to the recording of one signal, means for translating each latter recorded signal into a corresponding electrical signal as the record is driven for that signal, means responsive to each latter said signal for printing the character corresponding thereto, and means responsive to the printing of a character to actuate latter said driving means to cause the medium to be driven for the next succeeding recorded signal to be translated into an electrical signal.

20. A communication system including a record medium, a telephone line, means to produce sequential character designating signals each signal consisting of one or more predetermined frequencies in accordance with a code, means to record said signals on said medium, means to translate said recorded signals on said medium into corresponding electrical signals, means to transmit latter said signals over said telephone line and means to record on said medium a telephone conversation over said telephone line.

21. The method of telegraphic communication which consists in producing character designating marking and spacing signals of different frequencies in accordance with a code to form a message, transmitting said signals to a distant point, receiving said signals at said point, making a recording of the frequencies of said signals, translating said recording into corresponding electrical marking and spacing signals and, in response to said electrical signals, printing the characters corresponding thereto to form a printed message.

22. The method of transmitting information over a communication channel which consists in producing a plurality of separate series of information representations, each series comprising a plurality of individual information designating signals with each signal consisting of one or more predetermined frequencies in accordance with a code, said frequencies of a particular series lying within a frequency band individual to that series with the frequency band of each series occupying a separate portion of the frequency spectrum, transmitting the signals of said plurality of series concurrently over said communication channel, recording the signals at the distant terminus of the channel, translating into electrical signals the record successively at particular speeds with each speed corresponding to one of said series and adapted to cause the frequencies of the translated signals of the latter series to occupy a predetermined frequency band and preparing a record of information representations of each series separately in response to the signals thereof being translated in latter said frequency band.

23. The method of communication which consists in producing a plurality of separate series of information designating code signals with each signal containing at least one predetermined frequency and with the frequency of signals of said separate series occupying separate portions of the frequency spectrum, concurrently recording the signals of said plurality of series at a certain recording speed, successively translating said recording into electrical signals at speeds corresponding to each series which will result in latter said signals for each series occupying a predetermined portion of the frequency spectrum and separately preparing from latter said signals information representations of each series.

24. The method of communication which consists in producing a plurality of separate series of information designating impulses, with each impulse comprising a combination of one or more frequencies in accordance with a code and with the frequencies of each series lying in a different portion of the frequency spectrum and with the frequencies of any series other than the series occupying the lowest employed portion of the spectrum bearing a common relation to corresponding frequencies of said lowest series, recording the impulses of said series concurrently at a certain recording speed, reproducing said recording successively at different speeds with each speed corresponding to one of the series of impulses and adapted to reproduce the frequencies of the impulses of said corresponding series within a predetermined band of frequencies, filtering each reproduced impulse into its component frequencies and preparing from latter said frequencies information representations.

JUDSON O'D. SHEPHERD.