Sept. 18, 1945. H. F. HOPKINS **2,385,279**

DISTANT TALKING LOUD-SPEAKER TELEPHONE SYSTEM

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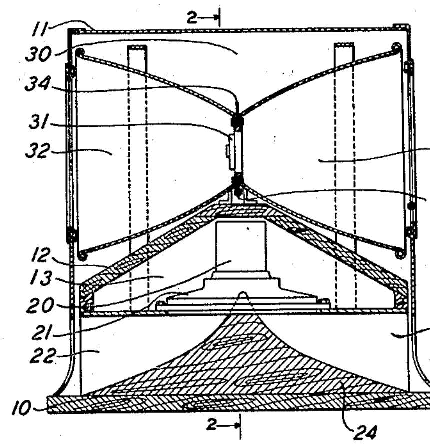

FIG. 1

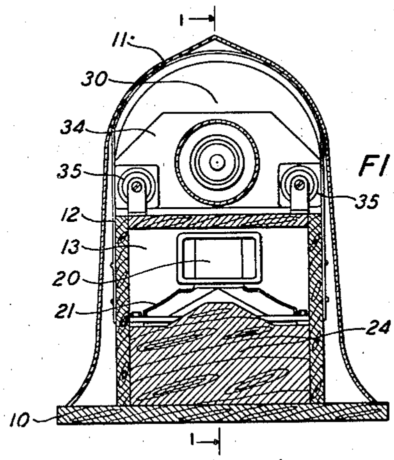

FIG. 2

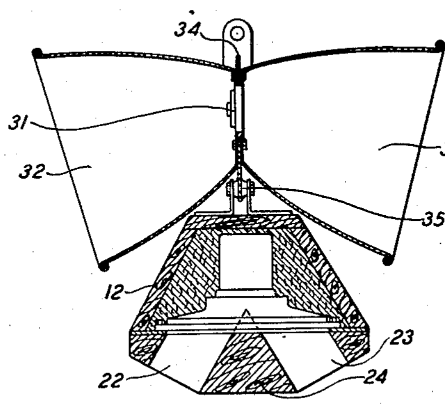

FIG. 3

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FIG. 4

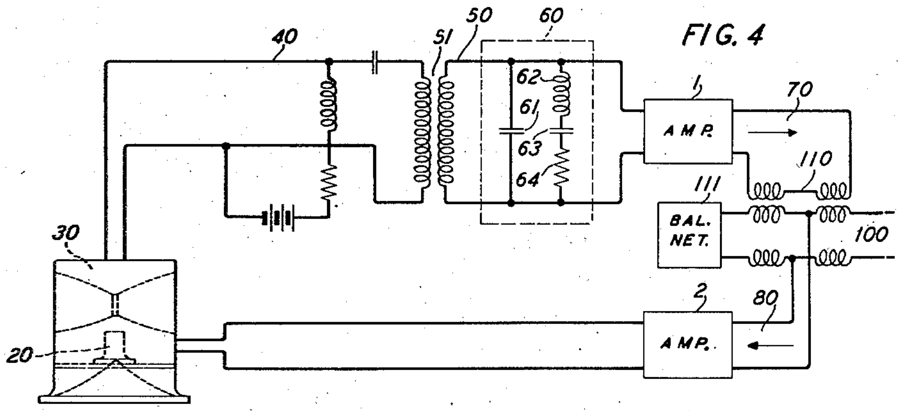


FIG. 5

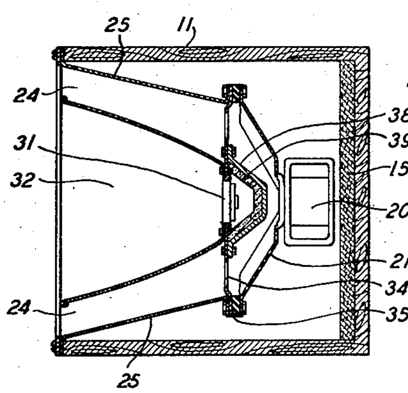
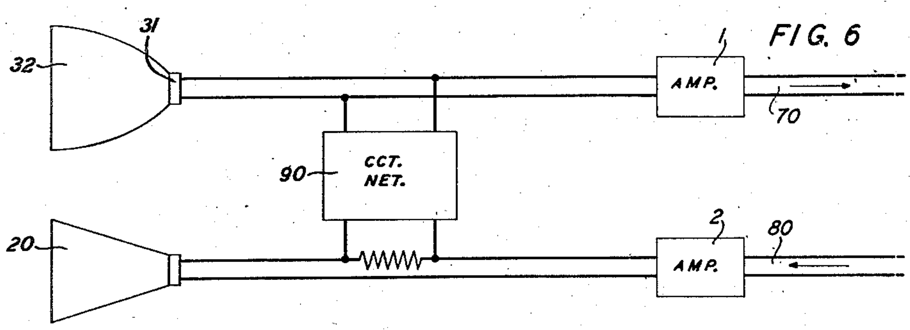


FIG. 6



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DISTANT TALKING LOUD-SPEAKER TELEPHONE SYSTEM

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19 Claims. (Cl. 179—1)

This invention relates to distant talking loud-speaker telephone systems and particularly to that class of system in which it is possible to transmit and receive sounds satisfactorily over air paths of relatively large attenuation.

An object of this invention is to provide an efficient acoustic balancing arrangement for juxtaposed transmitter and loud-speaking apparatus for balancing or greatly reducing acoustic feedback over a wide range of frequencies and increasing the transmission efficiency.

This object of the invention may be realized by providing acoustical balancing at the lower frequencies and an increase in the directivity of the transmitter at the higher frequencies.

An apparatus for accomplishing this comprises a bilateral transmitter provided with sound focussing reflectors associated with the opposite sides of a transmitter and a bilateral loud-speaker associated with the transmitter in such a manner that the sounds reproduced will be distributed equally in opposite directions and in paths substantially parallel to the axis of the sound focussing reflectors.

A modified apparatus for accomplishing this may comprise a solid back transmitter provided with a sound focussing reflector and a loud-speaker associated with the transmitter in such a manner that the sounds reproduced will be distributed in one general direction and in a path substantially parallel to the axis of the sound focussing reflector.

An important field of use for this invention is the provision of telephone subscribers with equipment involving distant talking telephone instruments. Such devices have obvious advantages for certain types of service. Several schemes have been proposed employing various means such as balancing out side-tone, utilizing voice operated relays, and other circuit feaures.

In the present invention the acoustic feedback is reduced over a wide frequency range, increasing the effectiveness of the system over that obtained by previous methods. In addition the increase in directivity tends to reduce the effect of room reflection on the efficiency of the system. A further advantage is an increase in the desired transmission from the transmitter.

In one arrangement, as more generally stated above, two sound collecting ellipsoidal reflectors and a carbon transmitter whose diaphragm is exposed on both sides are utilized. The ellipsoids are disposed so that one side of the transmitter diaphragm is exposed to a focal point of one ellipsoid and the other side of the transmitter diaphragm is exposed to a focal point of the other ellipsoid. The alternate foci of the ellipsoids are located at points a few feet distant from the instrument which is the approximate position of the speaker's mouth. A loud-speaker whose axis passes through the diaphragm of the transmitter is located below the transmitter and points downwardly onto a wedge-shaped dividing baffle which reflects the sound equally in two opposite directions generally parallel to the axes of the ellipsoids. When the speakers and listeners are below and at some distance from the instruments, suspended above them, both the input and the output sound channels of the apparatus are directed somewhat obliquely downwardly.

The dividing baffle may be modified to obtain more complete dispersion of the sound from the loud-speaker by using a conical spreader instead of a wedge-shaped spreader.

Other types of sound collectors may be used in place of the ellipsoid where different operating requirements are to be met. An ellipsoid is theoretically ideal for a single speaker located at the outer focal point of the ellipsoid. In cases where several speakers may be located at different distances from the transmitter, the parabola is theoretically preferable although in practice the differences are rather small. With the transmitter mounted in the focus of a collecting reflector, especially a parabolic reflector, with its diaphragm facing the reflector the efficiency is increased by the selective power of the reflector and due to the beam effect a considerable reduction is obtained in the amount of room noise transmitted.

In the modified arrangement above-mentioned only one sound collecting reflector is used. With the single reflector an electrical network, interconnecting the circuits of the transmitter and the loud-speaker, with such characteristics as to provide a phase delay proportional to the frequency of the lower frequency part of the transmitted band is employed. For a given length of acoustic path between the loud-speaker diaphragm and the transmitter diaphragm, the angular phase shift is proportional to frequency if there are no obstacles in the path which have a frequency discrimination in their reflecting properties. This is very generally the case for a limited frequency range. In the case of the mechanical and electrical phase shift within the instruments this may not be so generally true. However, since the acoustic phase shift is in most practical cases the preponderant factor, a system of this type can be made to work satisfactorily over limited frequency ranges. It is, of course, possible to design instruments for this specific purpose to minimize these difficulties. The delay provided by the electrical network should, in general, be equal to the acoustic delay between the loud-speaker and the microphone plus the mechanical phase delay in the instruments. At higher frequencies the directivity of the instruments prevents feedback. The voltage induced in the microphone circuit due to the network should be equal to and of opposite phase to that produced due to acoustical coupling. The alternative arrangement using one collecting reflector consists of a single ellipsoid or parabola, and a closed back transmitter, and a single loud-speaker in which reproduced sound is projected in one general direction parallel to the axis of the focussing collector. A network may then be provided, coupling the loud-speaker and transmitter circuits, which imposes in the transmitter circuit a voltage equal to and opposite in phase to that due to the sound picked up by the transmitter from the loud-speaker. This requires a network which will provide electrical transmission for the phase delay proportional to the frequency over at least one octave range. Such an arrangement would have a decided advantage over other proposed methods of application where such a system might be used in small places such as telephone booths.

A more detailed description of the embodiments of the invention chosen for illustration follows and is illustrated in the accompanying drawings:

Fig. 1 is a side and partial longitudinal vertical sectional view along plane 1—1 of Fig. 2 through the vertical and horizontal axes of a distant talking subset;

Fig. 2 is an end and partial transverse vertical sectional view along plane 2—2 of Fig. 1 through the vertical axis and normal to the horizontal axis of the distant talking subset;

Fig. 3 is a side and partial longitudinal vertical sectional view through the vertical and horizontal axes of a loud-speaker talking set arranged for overhead mounting:

Fig. 4 is a schematic circuit showing the elements of the distant taking subset in operative connection with an ordinary telephone line;

Fig. 5 is a side and partial longitudinal vertical sectional view of a modified distant talking subset designed for operation in one general direction and for use in smaller spaces; and

Fig. 6 is a schematic representation of the modified design of the distant talking subset for use in smaller spaces showing the apparatus and circuit elements.

Similar reference characters on the several figures of the drawings refer to similar parts of the apparatus.

Figs. 1 and 2 are side and end vertical partial sectional views along planes 1—1 and 2—2, respectively of the distant talking telephone subset. The bilateral loud-speaker apparatus 20 and the transmitting apparatus 30 are suitably mounted on the base 10 and surrounded by a housing 11 having sound input and output openings. The axis of the loud-speaker which is supported by frame 21 is vertically positioned and the sound is projected downwardly and through channels 22 and 23 having a suitably shaped wedge or cone 24 to spread the sound in different substantially horizontal directions. The wedge spreads the sound in two opposite or bilateral directions and the cone spreads it substantially equally in all directions around the set. The cross section of the spreader 24 as shown in Fig. 1 represents it either as a wedge or a cone, while in Fig. 2 it is shown as a wedge designed to direct the sound in two opposite directions and in general parallel with the axis of the transmitter 30 mounted above. The enclosing frame 12 located above and around the loud-speaker supports it and generally encloses it. Preferably the space 13 around the loud-speaker within the enclosing frame 12 is filled or lined with a sound deadening material.

The bilateral transmitting apparatus 30 comprises a microphone 31 and two ellipsoidal or parabolic or other suitably shaped sound collecting reflectors 32 and 33 all mounted in axial alignment on the support member 34. This support member 34 is in turn carried by vibration insulating support members 35 which are attached to the top of the loud-speaker enclosing frame 12. The microphone transmitter 31 is of the open back type capable of picking up sound from opposite directions. It is located at the foci of the two sound reflectors 32 and 33.

This arrangement of the sound collecting reflectors with reference to the transmitter and their symmetrical positioning with reference to the loud-speaker as referred to above provides an acoustic balance to reduce talk-back from the loud-speaker to the transmitter at low frequencies, and a directional pick-up for the transmitter to reduce the talk-back at higher frequencies. Also the mechanical impedance of the walls of the sound collecting reflectors over the range of the transmitted frequency band preferably should be so high relative to the impedance of the surrounding medium that practically all of the acoustic energy is reflected by the reflectors. This may be achieved by making the mass of the reflectors sufficiently large.

Fig. 3 is a side and vertical partial sectional longitudinal view through the vertical and longitudinal axes of a loud-speaker talking set arranged for overhead location. The apparatus elements here shown are similar to those of Fig. 1 but their arrangement is modified so that the axes of the sound channels are at an angle of less than 90 degrees with the vertical axis of the set, pointing downwardly for overhead operation. Sound channels 22 and 23 at the sides of the sound spreader 24 direct the reproduced sound downwardly and outwardly over a region of appreciable size, while the downwardly aimed sound collecting reflectors 32 and 33 pick up sound from the region below and in general alignment with them and focus the sound on the transmitter 31. The mounting of the apparatus parts and the sound insulation in this loud-speaker talking set is similar to that for the distant talking subset more fully described with reference to Figs. 1 and 2.

Fig. 4 is a schematic circuit showing the elements of the distant talking subset in operative connection with an ordinary telephone line. Improvement in the response characteristic of the set may be obtained by electrical equalization and this circuit discloses this feature. The telephone transmitter 30 is connected in the circuit 40 and with a source of direct current for energizing the microphone. The telephone signal is transmitted from this circuit through coupling coil 51 to circuit 50 connecting with amplifier 1. In this signal transmitting circuit 50 may be connected any suitable equalizing network 60. This network may consist of a capacitance 61 shunted across the circuit 50; and an inductance 62, a capacitance 63 and a resistance 64 connected in series, and the group in turn connected across the circuit 50. Other arrangements of such elements may be used depending upon the response characteristic of the subset apparatus. The circuit 80 leading to the loud-speaker 20 is preferably provided with an amplifier 2. Where the loud-speaker talking subset is used with a two-wire telephone line the microphone and speaker circuits may be connected with the telephone line 100 by means of the usual hybrid coil 110 and balancing network 111.

Fig. 5 is a side and partial longitudinal and vertical sectional view of a modified design of a distance talking subset designed for operation in one general direction, and for use in comparatively small spaces. This design positions the transmitting and receiving apparatus elements in a very compact arrangement. The elements are axially aligned and in general concentrically arranged. The subset apparatus mounted in housing 11 comprises a single focussing sound collector-reflector 32 and a closed back microphone transmitter 31 located at a focus of the collector, and a loud-speaker 20 arranged to project reproduced sound in one general direction or path through channel 24 enclosed by the horn 25. The transmitter apparatus is mounted on the spider 34 attached to the loud-speaker frame 21. A rubber gasket 35 is placed between the loud-speaker frame and the spider to prevent the transmission of objectionable vibrations. The spider support contains large openings so as not to obstruct the passage of reproduced sound emitted from the loud-speaker. The mechanical impedance of the sound collector walls over the transmitted frequency range should be so high relative to the impedance of the surrounding medium that practically all of the acoustic energy is reflected by the collector. A sound directing and insulating shield 38 is positioned between the two elements to prevent reproduced sound from reaching the microphone 31 and causing objectionable cross-talk. The necessary impedance may be given to the sound collector 32 and the shield 38 by designing them with sufficient mass to prevent the undesired air-borne sounds reaching the microphone through the back. A lining 39 of suitable material, such as petroleum tar, may be used in this connection with shield 38, and such a coating may be applied to the sound collector 32 though this is not especially shown in the drawings. The space within the housing 11 and outside of the loud-speaker apparatus may contain sound insulating filling or lining 15. While Fig. 5 shows the transmitter in the acoustic path of the loud-speakers their positions may be interchanged in which case the speaker apparatus is designed and positioned so as to obstruct as little as possible sound which should enter the collector-reflector and be focussed on the microphone.

Fig. 6 is a schematic representation of the modified design of the distant talking subset for use in relatively small spaces showing the apparatus and the circuit elements. This modified or alternative arrangement comprises the single sound collecting reflector 32 with a closed back transmitter 31 located at a focus of the sound reflector, and a loud-speaker 20 from which the sound is projected in one general direction substantially parallel to the axis of the sound collector-reflector associated with the transmitter such as is shown in Fig. 5. A circuit network 90 is provided coupling the loud-speaker and the transmitter circuits 80 and 70 which imposes in the transmitter circuit a voltage equal to, and opposite in phase to that produced by acoustical coupling due to the sound picked up by the transmitter from the loud-speaker. This network 90, designs of which are well known, provides electrical transmission between the loud-speaker and the transmitter with a phase delay between the loud-speaker and the microphone plus the mechanical phase delay in the instruments. At higher frequencies the directivity of the instruments substantially prevents feedback from the loud-speaker.

What is claimed is:

1. A distant talking loud-speaker telephone system comprising focussing sound collector-reflector means, a telephone transmitter positioned at a focus of said collector-reflector means, loud-speaker apparatus positioned adjacent, and with its axis passing through the center of, said transmitter for projecting reproduced sound, and means for directing reproduced sound laterally away from a plane passing through the focus of and substantially normal to the axis of said sound reflector means.

2. A distant talking loud-speaker telephone system comprising focussing sound collector-reflector means, a telephone transmitter positioned at a focus of said collector means, a loud-speaker having sound directive means arranged to project reproduced sound therefrom and having its axis passing through the center of said transmitter, and means for adjacently positioning the sound collector-reflector means and the loud-speaker sound directive means in such relationship that their respective acoustic channels are substantially oppositely operative.

3. In a distant talking loud-speaker telephone system, in combination a telephone transmitter, sound collecting-focussing reflector means whose axis is substantially normal to an acoustic face of said transmitter, and a loud-speaker positioned adjacent to and with its axis passing through the center of said transmitter and radiating reproduced sound in directions generally parallel to a plane containing the axis of said collecting-focussing reflector means.

4. In a distant talking loud-speaker telephone system, in combination a bilateral transmitter, sound focussing reflectors associated with opposite sides of the transmitter and a bilateral loud-speaker located adjacent the transmitter for directing the reproduced sound in opposite directions parallel to the axes of the sound focussing reflectors.

5. In a distant talking loud-speaker telephone system, in combination a bilateral transmitter, ellipsoidal reflectors associated with opposite sides of the transmitter diaphragm, a loud-speaker located adjacent the transmitter with its axis in the plane of the transmitter diaphragm and a baffle adjacent the mouth of the loud-speaker for directing the sound from it in opposite directions parallel to the axes of the ellipsoidal reflectors.

6. In a distant talking loud-speaker system, in combination a bilateral transmitter, ellipsoidal reflectors located upon opposite sides of the transmitter diaphragm and having their relative face located at a distance from the instrument corresponding to the position of the speaker's mouth for the best voice pick-up, a loud-speaker located below the transmitter with its axis in the plane of the transmitter diaphragm and a baffle for directing the reproduced sound from the receiver equally in opposite directions parallel to the axes of the ellipsoidal reflectors.

7. In a distant talking loud-speaker system, in combination a bilateral transmitter, a pair of

ellipsoidal reflectors located upon opposite sides of the transmitter and having their relative foci located approximately two feet from the transmitter diaphragm, a loud-speaker located below the transmitter with its axis passing through the plane of the transmitter diaphragm and opening downwardly, and a dividing baffle for reflecting the reproduced sound equally in opposite directions parallel to the axes of the ellipsoidal reflectors.

8. In a distant talking loud-speaker telephone system, in combination a bilateral transmitter, sound collecting-focussing reflectors associated with opposite sides of the transmitter, and a loud-speaker positioned adjacent to said transmitter and projecting the reproduced sound in substantially opposite directions generally parallel to and in regions at one side of a plane containing the axis of the said focussing reflectors.

9. In a distant talking loud-speaker telephone system, in combination a closed back telephone transmitter designed to receive sound from one direction, a sound collecting-focussing reflector positioned to focus sound vibrations entering the reflector against the vibrating element of the said transmitter, a loud-speaker juxtaposed to said reflector and having its axis of sound projection parallel to the axis of said reflector, and an electrical network coupling said loud-speaker and said transmitter circuits which imposes in the transmitter circuit a voltage equal to and opposite in phase to that due to the sound picked up by the transmitter from the loud-speaker.

10. In a distant talking loud-speaker telephone system, in combination a closed back telephone transmitter designed to receive sound from one direction, a sound collecting-focussing reflector positioned to focus sound vibrations entering the reflector against the vibrating element of said transmitter, a loud-speaker juxtaposed to said reflector and having its axis of sound projection substantially parallel to the axis of the said reflector, and an electrical circuit network coupling said transmitter and said loud-speaker circuit having such characteristics as to provide a phase delay proportional to the frequency in the lower frequency part of the transmitted signal band.

11. In a distant talking loud-speaker telephone system, in combination a closed back telephone transmitter designed to receive sound from one direction, a sound collecting-focussing reflector positioned to focus sound vibrations entering the reflector against the vibrating element of said transmitter, a loud-speaker juxtaposed to said reflector and having its axis of sound projection substantially parallel to the axis of said reflector, and an electrical circuit network coupling said transmitter and said loud-speaker circuit having such characteristics as to provide a phase delay proportional to the frequency in the lower frequency part of the transmitted signal band, the said delay being equal to the acoustic delay between the loud-speaker and the microphone plus the mechanical phase delay in the apparatus.

12. A distant talking loud-speaker telephone system comprising telephone transmitter apparatus receiving and focussing sound originating within a sound channel limited to a relatively small solid angle, loud-speaker apparatus effectively projecting reproduced sound within a sound channel limited to a relatively small solid angle, and means for adjacently positioning said transmitter apparatus and said loud-speaker apparatus in such relationship that the axis of the respective sound channels are substantially parallel.

13. A distant talking loud-speaker telephone system comprising telephone transmitter apparatus receiving and focussing sound originating with a sound channel limited to a relatively small solid angle, loud-speaker apparatus projecting reproduced sound within a sound channel limited to a relatively small solid angle, and means for adjacently positioning said transmitter apparatus and said loud-speaker apparatus in such relationship that the axes of the respective sound channels are substantially in alignment.

14. In a distant talking loud-speaker telephone system, in combination a closed back telephone transmitter designed to receive sound from one direction, a sound collecting-focussing reflector positioned to focus sound vibrations entering the reflector against the vibratory element of said transmitter, and a loud-speaker juxtaposed to said reflector and having its axis of sound projection parallel to the axis of the said reflector and projecting reproduced output sound opposite in direction to the input sound collected by said reflector.

15. A distant talking loud-speaker telephone system comprising an ellipsoidal sound collecting reflector, a telephone transmitter located at a focus of said reflector, a loud-speaker having sound directive means, and means for so positioning the said sound reflector and said sound directive means that their respective acoustic channels are substantially parallel.

16. A distant talking loud-speaker telephone system comprising a parabolic sound collecting reflector, a telephone transmitter located at a focus of said reflector, a loud-speaker having sound directive means, and means for so positioning said sound reflector and sound directive means that the respective acoustic channels are substantially parallel.

17. A distant talking loud-speaker system comprising a focussing sound reflecting collector, a telephone transmitter positioned at a focus of said collector, means for causing the mechanical impedance of the walls of said collector over the transmitted frequency range to be so high relative to the impedance of the surrounding medium that substantially all of the acoustic energy is reflected by the collector, a loud-speaker having sound directive means, and means for so positioning said sound collector and said sound directive means that their respective acoustic channels are substantially parallel.

18. A distant talking loud-speaker system comprising a focussing sound collecting reflector, a telephone transmitter positioned at a focus of said collector, a loud-speaker having sound directive means positioned in juxtaposed relationship to said transmitter, and an electrical equalizing circuit network in the transmitter circuit arranged to improve the articulation characteristics of the apparatus.

19. In a distant talking loud-speaker telephone system, the method of reducing the amount of extraneous sound transmitted which consists in collecting the sound originating within a channel limited to a relatively small solid angle and focussing the collected sounds on the diaphragm of a microphone and projecting reproduced sounds in directions generally opposite in direction to the collected sound.

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