Oct. 13, 1953 J. F. MARSHALL 2,655,069

MEANS FOR AND METHOD OF TUNING VIBRATING BARS OR RODS

Filed Oct. 6, 1950 3 Sheets-Sheet 1

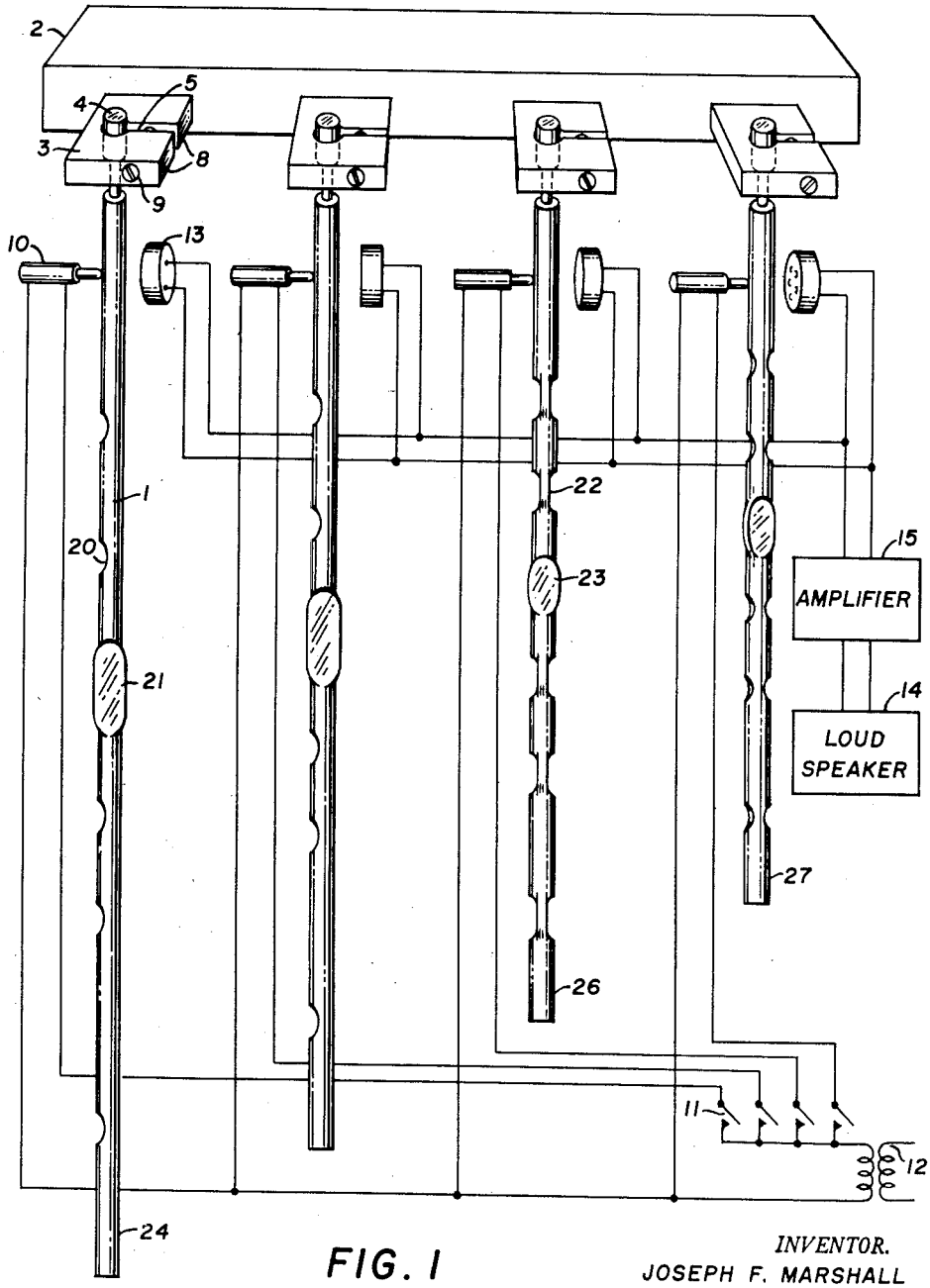


FIG. 1

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3 Sheets-Sheet 2

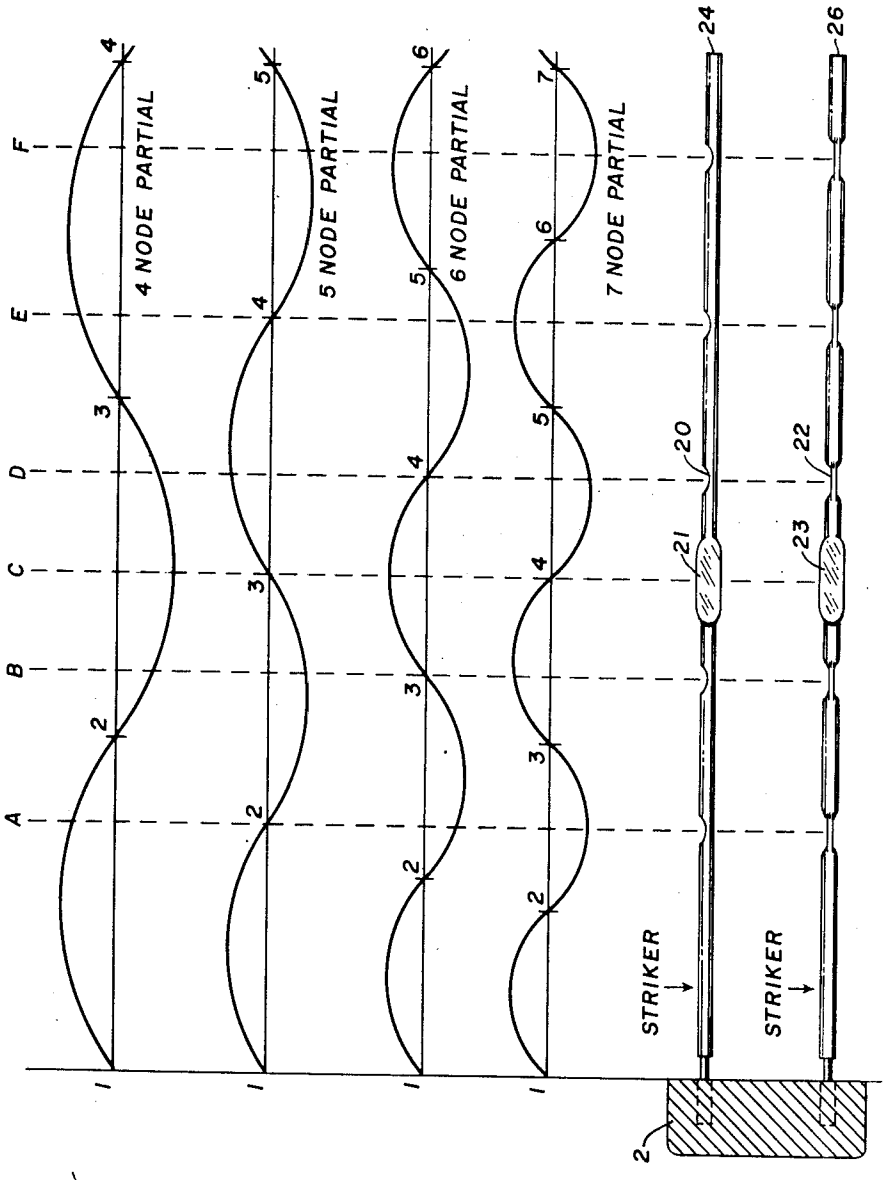


FIG. 2

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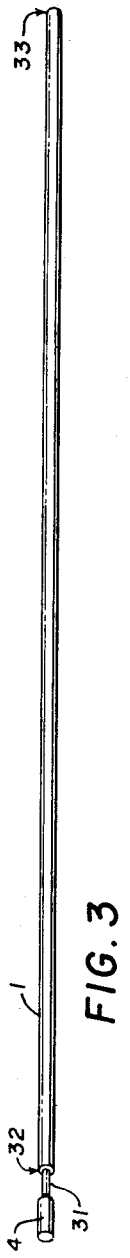


FIG. 3

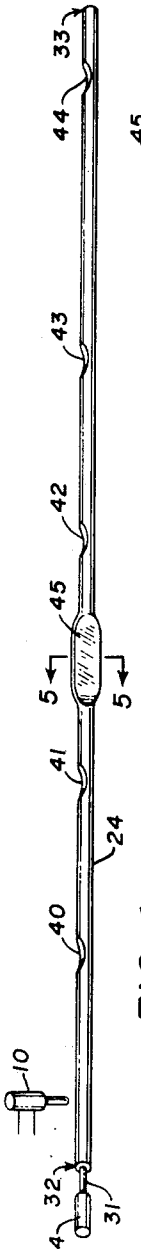


FIG. 4

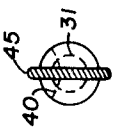


FIG. 5

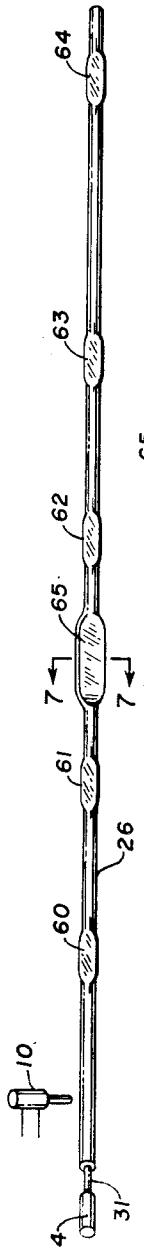


FIG. 6

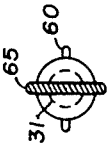


FIG. 7



FIG. 9

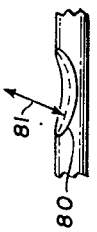


FIG. 8

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UNITED STATES PATENT OFFICE

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MEANS FOR AND METHOD OF TUNING VIBRATING BARS OR RODS

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Application October 6, 1950, Serial No. 188,823

11 Claims. (Cl. 84—404)

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My invention relates to the art of tuning vibrating bars. In particular I provide a means for and a method of tuning the partials to form a harmonious chord when the bar is struck.

It is well known that metal, when struck, will produce an inharmonious sound composed of a fundamental frequency and random or spurious overtones or partials. Also, it has long been known that it would be possible to tune such vibrating metal to produce harmonious chords. For example, see Journal of the Franklin Institute for July 1930, in which an article appeared treating vibrating bells. It was pointed out that the quality of the bells is usually determined by the first five partials. To tune these partials, metal may be cut away at points determined by the circular nodes. Morse, in Vibration and Sound, 1936, McGraw-Hill Book Company, Inc., deals with the subject of a non-uniform bar (with respect to which the density, cross sectional area or the radius of gyration of a bar changes with its length) and its relation to the tuning of fundamental and partial tones.

One object of my invention is to produce a new and improved method of tuning vibrating bars.

Another object of my invention is to provide an inexpensive method of tuning vibrating bars.

A further object of my invention is to provide a new and improved method of and means for individually tuning partials of the composite bar tone.

A still further object of this invention is to reduce the cost of producing bar type percussion instruments by providing means to sharpen as well as to flatten certain tones and to enhance the musical qualities of tones produced by controlling the plane and character of vibrant response in bars.

I have found that the above cited objects may be solved by altering the rigidity of vibrant bars at predetermined points along the length thereof. As pointed out above, a vibrating bar produces many partial tones in addition to the fundamental tones. Each of the partial tones must be changed in order to bring it into harmonic register with the fundamental tone. It has been found that little or no tuning effect is had upon any single partial if the bar is rendered more or less flexible at the exact node point of that particular partial. If the cross section and hence the rigidity or stiffness of the bar in the plane of striking is changed at any point other than the node, a change of pitch takes place. The degree of change of pitch is found to vary in dependence upon the relative distance between the node or the antinode of a given partial and the point at which the stiffness of the bar is altered. The maximum effect is produced when

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the altered portion of the bar and the antinode of the partial exactly coincide. Expressed differently, maximum effect is obtained when the altered portion of the bar is midway between adjacent nodes. Moreover, increased flexibility at other than the node points flattens, while increased rigidity at other than the nodes sharpens the tone.

Since striking a bar in one plane also restricts vibrations of the bar substantially to this same plane, I find it convenient to take advantage of this polarization of vibration in tuning a bar in several ways. In one embodiment of my invention I notch the bar perpendicular to the plane in which the bars are to be struck, and at right angles to the notches I swage the bars to form a stiffened area or areas. In a second embodiment of my invention, I swage the bars in two planes perpendicular to each other so as to produce desired harmonious vibrations in only one plane.

The term "swage" as used herein means to cause metal to flow or form into a flattened, squeezed or pinched portion the cross section of which has one dimension reduced and a second dimension taken at right angles to the first dimension increased without change in the desired length of the bar or rod. In short, a bar having a swaged section or sections will still be made up in the originally desired length. The bar is flattened to produce a portion having a cross section which is more or less an elongated rectangle or ellipse. The method of obtaining such a shaped portion is not material.

It is not important to my invention that the vibrant member be a rod, bar or have any particular shape; however for the sake of simplicity the vibrant member will herein be referred to as a "bar" it being understood that all equivalent shapes are to be included.

Other objects of my above described invention will become apparent from a detailed study of the accompanying specification and drawings.

Fig. 1 is an illustration of a musical instrument making use of vibrant tone bars, tuned in accordance with the present invention.

Fig. 2 is a diagram which shows the relationship between a bar and its partial tones, when the bar is tuned in accordance with the principles of my invention.

Fig. 3 illustrates a bar as it appears before tuning.

Fig. 4 is a view of one embodiment of my invention in which a bar is tuned by a combination of grinding and swaging.

Fig. 5 is an end view taken along the lines 5—5 of Fig. 4.

Fig. 6 is a modification of my invention in which tuning is accomplished by swaging alone.

Fig. 7 shows an end view taken along the lines 7—7 of Fig. 6.

Fig. 8 is an enlarged illustration of a ground portion of the rod or bar shown in Fig. 4.

Fig. 9 is a modified end view taken along the lines 7—7 of Fig. 6.

My invention is particularly suited for use in carillons or chimes such as illustrated diagrammatically in Fig. 1 wherein there is shown a plurality of differently pitched tone bars or rods 1 clamped at one end to a suitable mass element 2 by any suitable means, such as bifurcated clamping members 3, which receive the clamping ends 4 of the bars 1 in a suitable opening or slit 5 between the arms 8 of member 3 which may be drawn into clamping engagement with the rods, as by means of a suitable fastening device 9.

One or more of the bars is caused to vibrate in any suitable manner, as by means of electromagnetically operated strikers 10 connected by suitable switches 11, which may be operated from a piano-type keyboard, for example, to a source of potential 12 which may be 110 volts A. C., for example. The resulting vibrations are conventionally translated into electrical currents by electro-magnetic pickup coils 13 and reproduced by means such as a loudspeaker 14. If necessary a suitable amplifier 15 may be inserted between the pickup coils 13 and reproducing means 14.

Fig. 1 shows three types of tone bar designated by reference numerals 24, 26 and 27. The first of these bars is tuned to provide harmonious sound through proper tuning of the principal partials in which case metal is removed as by grinding, for example, to provide recesses, notches, or the like, at suitable locations on the side of the bar which is to be struck as indicated in Figs. 1 and 2 by the numeral 20 in order to render the bar 24 more flexible at these points and hence to flatten the partials involved, and the bar is swaged or pinched as indicated by numeral 21, at right angles to the plane of striking, to stiffen the bar and hence to sharpen the partials involved. The amount of flatting of any partial depends upon the distance of the recess or swaged section from the antinode and the depth of the recess or notch. The amount of sharping depends upon the degree of stiffening provided by the swaged section as well as the distance from the antinode. Bar 27 is another example of the first embodiment of my invention wherein notches are cut in both sides of the bars; however, as in the case of the single side notch bar 24, bar 27 is rendered more flexible in only the one plane in which the bar is struck. Bar 26 is shown to be tuned as indicated in Fig. 2 where a portion of metal is swaged at point 22 to render the bar more flexible in the plane struck and hence to flatten the associated partials. As in the case of bar 24 a portion 23 is swaged at right angles to the flexible plane to sharpen the partials involved. Each bar, 24, 26 and 27, is mounted in an end-clamped suspension wherein one end is securely clamped while the second end is free; however it is within the scope of my invention to mount the bar either in a free-free or a clamped-clamped suspension.

In the preferred form of my invention I first obtain or provide a bar of the shape shown in Fig. 3, in which bar 1 is of substantially the same cross section throughout its length except for annular neck 31 adjacent the clamping portion 4. This necking of the bar permits the use of a lighter mass 2 for anchoring the bars and virtually fixes the length of the bars independently of small variations in the position of the clamp 3 with respect to clamping end 4.

Referring to Fig. 2, I alter the diameter or cross section by swaging, grinding or other suitable manner at such distances with respect to the antinodes (or nodes) as is necessary to change the pitch of the partials in the desired amount. For example, when the bars of Fig. 2 are made flexible at the points A and E, little or no effect is had on the 5 node partial because the recesses appear at the nodes whereas the 4, 6, and 7 node partials are altered by flatting in pitch by varying amounts. The desired flexibility may be secured by providing recesses 20 or the like or by swaging so that the swaged section lies normal to the plane of the striker. Providing flexibility at points B and D affects the 4, 5 and 7 node partials but not the 6 node partials, the maximum effect being on the 5 node partial at point B and on the 7 node partial at D. Swaging at C so that the swaged portion lies in the plane of striking serves to stiffen the bar so as to sharp the 4 and 6 node partials to a degree depending upon the distance of point C from the antinode but the 5 and 7 node partials are not substantially affected inasmuch as the stiffening occurs substantially at the nodes. At F, I have shown a portion of altered flexibility in the plane of striking which serves to correct individually the 7 node partial since it exactly coincides with the antinode between the 6th and 7th nodes and has some effect on the 5 and 6 node partials. The provision of the necked portion 31 varies the effective length and hence the tone produced by the rod.

The tuning bars may be made of any suitable material. However, I prefer to use cold-rolled round steel rods which have been oil hardened and tempered, such as commonly used for drill rods. The length and diameter of these rods determine the pitch in a well known manner. In Figs. 4 and 5 there is shown one example of a suitable bar for producing a 5 node component tone "B" equal to 493.9 C. P. S. This bar is a drill rod of 0.125 inch in diameter having a support section, shown by reference numeral 4 in the various drawings, ⅜ inches long, a neck portion 31 of about ¼ of an inch long turned to .067 inch diameter, and over-all length from points 32 to 33 of about $19\frac{1}{32}$ inches. This bar is ground at points 40, 41, 42, 43 and 44 in the plane of the bar to be struck by striker 10. In the example given above for a 0.125 inch diameter rod, portion 40 falls approximately $4\frac{3}{32}$ of an inch from point 32, portion 41 at $6\frac{49}{64}$ inches, portion 42 at $11\frac{1}{4}$ inches, portion 43 at $13\frac{13}{32}$ inches, and portion 44 at $16\frac{29}{64}$ inches from shoulder or point 32. The swaged portion 45 is $8\frac{3}{32}$ inches from point 32 and is flattened to the dimensions of approximately ⅞ of an inch long, ¼ of an inch wide and .062 of an inch thick. The thickness of the bar at the center of the ground portions varies from .067 to .096 inches. Although these points of grinding may be made in many shapes, I have shown rounded hollows or recesses (see Fig. 8). The curve 80 is rounded with the radius 81 approximately ⅝ of an inch.

Figs. 6 and 7 illustrate a second embodiment of my invention in which tuning is accomplished by swaging alone. The swaging may be by press, vise or any other suitable method. However, I have found it suitable to flatten the bars as by

hammering them on an anvil, for example. The blank shown in Fig. 3 and used for the embodiment shown in Fig. 4, may be used for Fig. 6. It may become necessary to swage the bar at or near the neck **31**. Numerals **60**, **61**, **62**, **63**, and **64** designate flattened or swaged areas which serve to make the bar more flexible in the plane struck by striker **10**. Swaged or flattened area **65** serves to stiffen the bar at that point. Fig. 9 shows a slight variation from the 90° angle between the planes of swaging shown in Fig. 7. This may be desirable to produce a tremulous effect.

It is seen from the foregoing description that I have produced a new and improved means for and method of tuning vibrant bars which economically produces my desired results. It is possible to make use of more blanks with less waste of material than heretofore. Not all blanks are the same. Sometimes it is not possible to tune by merely grinding away material since some partials must be sharped. If in tuning, too much material is ground away, my method permits swaging to restore some degree of rigidity. If the blank is swaged by such an amount as to sharpen the tones too much, it is within the scope of my invention to grind or mill away part of the swaged areas. Further, by varying the location of the pick-up and striker along the length of the bar I can accentuate any desired partial.

While I have shown and described particular embodiments of my invention, it is obvious to those skilled in the art that changes and modifications may be made without departing from my invention in its broader aspects. I, therefore, aim in the appended claims to cover all such chances and modifications as fall within the true spirit and scope of my invention.

What I claim is:

1. A percussion musical instrument comprising; an elongated vibratable member for producing a tone, certain portions of the cross sectional dimensions of said member being shaped to increase the flexibility of said member in a given plane of vibrations, said portions being at spaced intervals along the length of said member, the length of the said intervals being determined by the occurrence of antinodes of partial tones to be flatted, sections of said member being swaged to increase the rigidity of said member in said given plane, said sections being spaced at distances along the length of said member; the length of the said distances being determined by the occurrence of antinodes of partials to be sharped.

2. The musical instrument defined in claim 1 in which the said portions are formed by removing a part of the material of said member.

3. The musical instrument defined in claim 1 in which the said portions are swaged, the said swages being oriented so that the widest cross sectional dimension lies in a plane normal to said given plane of vibrations.

4. The musical instrument defined in claim 1 in which the said portions are disposed at substantially the second and fourth nodes of the five node partial, at substantially the third and fourth nodes of the six node partial and at substantially the antinode between the sixth and seventh nodes of the seven node partial of the composite tone of the member.

5. The musical instrument defined in claim 4 in which the said swaged section is disposed at

substantially the fourth node of the seven node partial of the composite tone of the member.

6. The musical instrument defined in claim 1 in which the swaged section is disposed at substantially the fourth node of the seven node partial of the composite tone of the member.

7. A percussion musical instrument comprising; an elongated vibratable tone member having an initially uniform cross section, said member being formed to define swaged areas, a portion of said swaged areas being oriented to lie in a given plane, the remainder of the said swaged areas being oriented to lie in another plane positioned substantially perpendicular to said given plane.

8. A percussion member for use in a musical instrument comprising; an elongated vibratable member for producing a tone, swaged areas formed at spaced intervals along the said member, the said swaged areas being oriented in planes at other than 90°, with respect to each other, to produce a tremulous tone, the length of the said intervals being selected to bring the pitch of the partials into harmonious relationship with the predominate tone when the said member is struck in the said given plane.

9. A musical instrument comprising; a tone bar, said bar having flattened areas spaced at intervals along the length of the bar, said flattened areas oriented to lie in different planes, a striker for vibrating said bar, said planes positioned with respect to each other and with respect to said striker in such a manner as to vary the pitch of the individual partials of the resultant complex tone generated by the said bar.

10. A percussion musical instrument of the type comprising a mass member, a tone bar, and means for clamping said tone bar to said member; means for causing the said bar to vibrate in a given plane, said bar being formed at intervals along the length of said bar for stiffening the said bar in the said given plane, said bar being formed at different distances along the length of said bar for increasing the flexibility of the said bar in the said given plane, the length of the said intervals being determined relative to the occurrence of an antinode of a partial to be sharped, the length of the said distances being determined relative to the occurrence of antinodes of partials to be flatted.

11. A percussion musical instrument comprising; a tone bar clamped to a mass element, a striker for causing vibration in a given plane, and a pick-up and speaker connected to reproduce the vibrant tone, the said tone bar being swaged in said given plane at a point determined by an antinode of a partial to be sharped and the said tone bar being made more flexible in the said given plane at certain points determined by the occurrence of antinodes of partials to be flatted.

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